

2025 PCI Big Beam Competition



Northern Arizona University
Steve Sanghi College of Engineering
Flagstaff, AZ

Team Members:

Payton Correia, Zachary Fukumoto, Isabella Velasco, Caitlin Yazzie

Faculty Advisor:

Dr. Ben Dymond

PCI Producer Sponsor:

Tpac
3052 S. 19th Avenue, Phoenix, AZ 85009

Table of Contents

1.0	Judging Form	1
2.0	Load-Deflection Graph.....	2
3.0	Certification Form	3
4.0	Shop Drawings	4
5.0	Concrete Mixture Analysis.....	5
5.1	Statistical Analysis of Mix.....	5
5.2	Mix Design.....	5
5.3	Concrete Cylinder Results	6
5.4	Concrete Mixture Evaluation.....	7
6.0	Structural Design Analysis.....	7
6.1	Preliminary Design	7
6.2	Decision Matrix	7
6.3	Design Selection	8
7.0	Beam Fabrication & Testing.....	9
7.1	Certification of Materials.....	9
7.2	Fabrication	9
7.3	Test Setup.....	13
7.4	Beam Test Results.....	14
8.0	Team Statements.....	16
8.1	Payton Correia	16
8.2	Zachary Fukumoto	16
8.3	Isabella Velasco	16
8.4	Caitlin Yazzie.....	17
References		18
Appendices.....		19
Appendix A	Material Reports.....	19
Appendix A.1	Certified Mill Test Report: No. 4.....	19
Appendix A.2	Material Certification of Compliance: 0.5 in. Strands	23
Appendix A.3	Material Certification of Compliance: 0.6 in. Strands	27

Appendix A.4 C-33 Test Data: Aggregates	31
Appendix A.5 Manufacturer’s Certification of Compliance: Type II/V, Low Alkali, Portland Cement.....	35
Appendix A.6 Summary Report for Annual Test of WCS Maricopa Aggregates.....	37
Appendix A.7 Pozzolan Test Report: Fly Ash Type F	38
Appendix B Admixture Data Sheets	39
Appendix B.1 ADVA CAST 575	39
Appendix B.2 DARASET 400-1	41
Appendix B.3 DARAVAIR 1000	43
Appendix B.4 RECOVER	45
Appendix B.5 VMAR 3	47
Appendix B.6 V-MAR F100.....	49
Appendix C Design Considerations.....	51
Appendix D Design Calculations.....	52
Appendix D.1 Mathcad	52
Appendix D.2 Deflection and Curvature through Virtual Work Method	65
Appendix E Alternate Designs.....	67
Appendix F Performance Multiplier Scoring	68
Appendix G Decision Matrix.....	69
Appendix H Shop Drawings	70
Appendix I Test Cylinder Analysis of Concrete Mixture	71
Appendix J Fabrication Reports.....	73

List of Tables

Table 1: Individuals who contributed to the fabrication of NAU's beam.....	v
Table 2: Statistical Analysis of Tpac's LW-5 mix (N=30) compared to NAU's test results.....	5
Table 3: Lightweight mix design compared to actual mix	6
Table 4: NAU Test Cylinder Results.....	6
Table 5: Decision Matrix Initial Score	8
Table 6: Concrete Test Results	11
Table 7: Comparison of Results and Predictions	15

List of Figures

Figure 1: Completed Judging Form.....	1
Figure 2: Deflection vs. Loading Graph	2
Figure 3: Completed Certification Form.....	3
Figure 4: NAU Beam Shop Drawings (also located to scale in Appendix H)	4
Figure 5 (Below): Cylinder Test Breaks corresponding to Table 4.....	6
Figure 6 (Left): Loading Configuration.....	7
Figure 7 (left): Design 5, chosen for production.....	9
Figure 8: Formwork with stirrups and prestressing strands.....	9
Figure 9: Top flange	10
Figure 10: 11 in. stirrup spacing.....	10
Figure 11; 7 in. stirrup spacing	10
Figure 12: Stirrup sample.....	10
Figure 13 (left): Double lifting loop identifying side with 7 in. stirrup spacing	11
Figure 14 (right): Single lifting loop identifying side with 11 in. stirrup spacing	11
Figure 15: Spread Test (setup: left, released: right)	11
Figure 16: Fabricated test cylinders in molds	12
Figure 17: Concrete pour, with Tpac employees ensuring no gaps.....	12
Figure 18: Beam after concrete poured	13
Figure 19: Overview of test setup.....	13
Figure 20: Detail of test set up with dimensions.....	14
Figure 21: Testing set up showing how deflection is visually measured	14
Figure 22: Deflection vs. Loading Graph	15
Figure 23: Photo of Payton Correia	16
Figure 24: Photo of Zachary Fukumoto	16
Figure 25: Photo of Isabella Velasco	16
Figure 26: Photo of Caitlin Yazzie	17

List of Abbreviations

Variable/Abbreviation	Meaning
AZ	Arizona
ASTM	ASTM International, (formerly known as American Society for Testing and Materials)
CY	Cubic Yard
In	Inch
Lbs	Pounds
PCI	Precast/Prestressed Concrete Institute
QAQC	Quality Assurance/Quality Control
Tpac	Precast/prestressed concrete manufacturing company located in Phoenix, Arizona; an EnCon United Company

Acknowledgments

We would like to express our sincere gratitude to everyone who has contributed to the success of our PCI Big Beam Competition project.

First and foremost, we extend our appreciation to Tpac, the precast/prestressed concrete producer, for their support and expertise in fabricating our beam. Tpac is in Phoenix, Arizona and is an EnCon United Company. Thank you to the following who contributed to the manufacturing process of the NAU team's beam and allowing us the opportunity to learn from you all.

Table 1: Individuals who contributed to the fabrication of NAU's beam

Individual	Position	Individual	Position
Jason Lien	Tpac/Encon Staff	Jose Aragon	Production
Marc Davis	Tpac/Encon Staff	Jason Aragon	Production
Elias Fink	Tpac/Encon Staff	Rodrigo Gutierrez	Production
Paul Kramer	Tpac/Encon Staff	Justin Hugen	Quality Control/Quality Assurance Manager
Paul Press	Tpac/Encon Staff	Terell Straughter	Mix Testing
Dane Lind	Tpac/Encon Staff	Jayce Murillo	Mix Testing
McKenzie Brooks	Tpac/Encon Staff	Tim Capaul	Pre-Inspection
Joshua Tourville	Production Superintendent	Earl Damper	Strength Testing
Frank Lujan	Production	Alec Contreras	Post Inspection

We are also grateful to our technical advisor, Dr. Benjamin Dymond, for the mentorship and technical insights throughout the project. His expertise has been instrumental in helping us navigate the complexities of prestressed concrete design and analysis.

Additionally, we would like to thank Northern Arizona University's Department of Civil and Environmental Engineering for providing the necessary resources and facilities to develop and test our beam. Their support has been essential in bridging the gap between theoretical knowledge and practical application.

Finally, we extend our appreciation to the Precast/Prestressed Concrete Institute (PCI) for organizing this competition and giving us the opportunity to gain hands-on experience in structural engineering and prestressed concrete applications.

This project would not be possible without the collaboration and support of these individuals and organizations. Thank you for your contributions to our learning and success.

1.0 Judging Form

PCI BIG BEAM COMPETITION 2024-2025

May 6, 2025

Date

Northern Arizona University

April 4, 2025

Student Team (school name)

Team Number

Date of Casting

Basic Information

1. Age of beam at testing (days) 18
2. Compressive cylinder tests*
- Number tested 3
- Size of cylinders 4"x8"
- Average (psi) 7,260
3. Concrete properties
- Unit weight of concrete (lb/ft³) 118.1
- Slump or spread (in.) 27.5
- Air content (%) 7.25
- Tensile strength (psi) 639
- Circle one: Split cylinder MOR beam
4. Pretest calculations
- a. Applied load (total) to cause cracking (kip) 22.8
- b. Maximum applied point load at midspan (kip) 34.9
- c. Anticipated deflection due to total live load application of 32 kips 1.09

Pretest calculations MUST be completed before testing.

* International entries may substitute the appropriate compressive strength test for their country.

Judging Criteria

Teams **MUST** fill in these values.

1. Center to center span (ft) 18
2. Actual maximum applied load (kip) 38.6
3. Measured cracking load (kip)[†] 22.7
4. Cost (dollars) 234.4
5. Weight (lb) 1,721
6. Largest measured deflection (in.) 2.7
- a. Measured deflection at applied load of 32 kip. 1.04
7. Most accurate calculations:
- a. Absolute value of (maximum applied load – calculated applied load)/calculated applied load 0.106
- b. Absolute value of (Measured deflection at 32 kips - calculated deflection) / (calculated deflection) -0.046
- c. Absolute value of (measured cracking load – calculated cracking load)/calculated cracking load -0.004
- Total of three absolute values (a + b + c) = 0.056**

[†] Measured cracking load is found from the "bend-over" point in the load/deflection curve. Provide load/deflection curve in report.

Test summary forms must be included with the final digital report, due June 13, 2025.

Sponsored by:



Figure 1: Completed Judging Form

2.0 Load-Deflection Graph

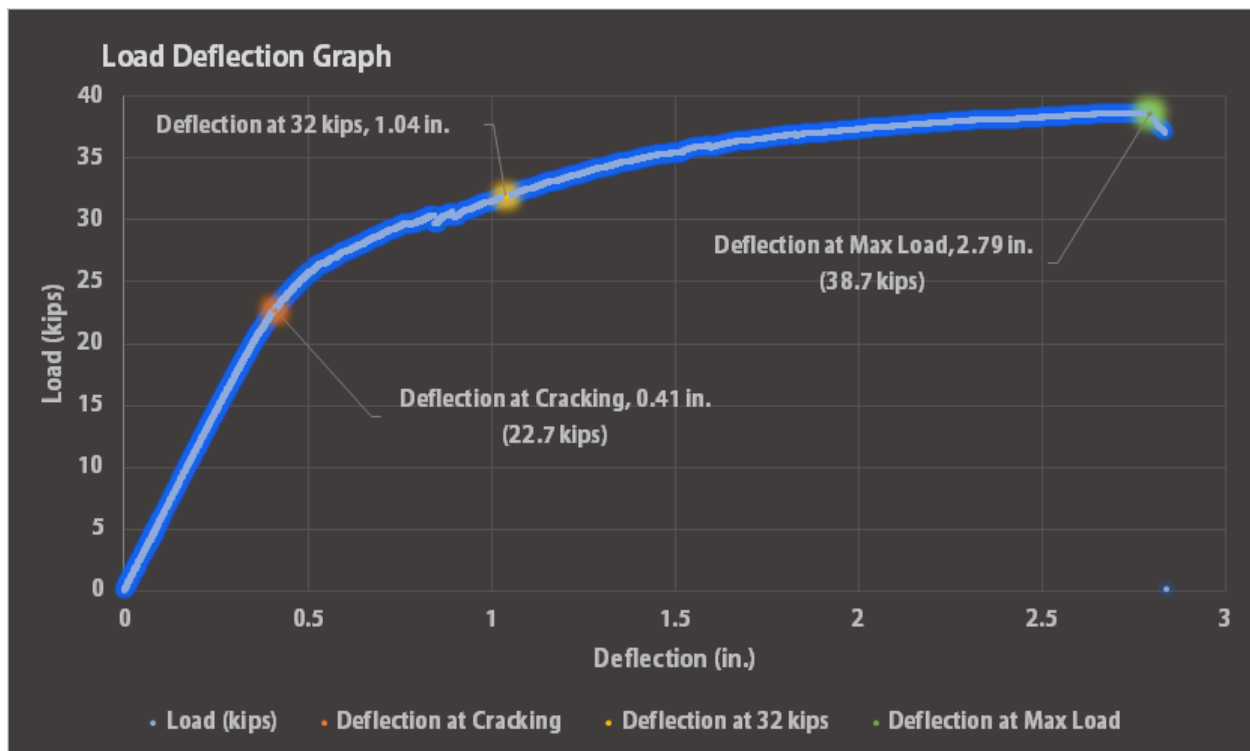


Figure 2: Deflection vs. Loading Graph

3.0 Certification Form



PCI BIG BEAM COMPETITION 2024-2025

CERTIFICATION

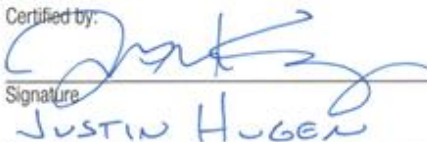
Tpac

As a representative of (name of PCI producer member or sponsoring organization)
Northern Arizona University

Sponsoring (name of school and team number)

I certify that:

- The beam submitted by this team was fabricated and tested within the contest period.
- The calculations of predicted cracking load, maximum load, and deflection were done prior to testing of the beam.
- The students were chiefly responsible for the design.
- The students participated in the fabrication to the extent that was prudent and safe.
- The submitted test results are, to the best of my knowledge, correct, and the video submitted is of the actual test.

Certified by: 

Signature
JUSTIN HUGER

Name (please print)

4/28/2025

Date

34.9 kip

Predicted maximum load

22.8 kip

Predicted cracking load

1.09 in.

Predicted deflection load at 32 kip

THIS CERTIFICATION MUST BE PART OF THE FINAL REPORT.

Sponsored by:



Figure 3: Completed Certification Form

4.0 Shop Drawings

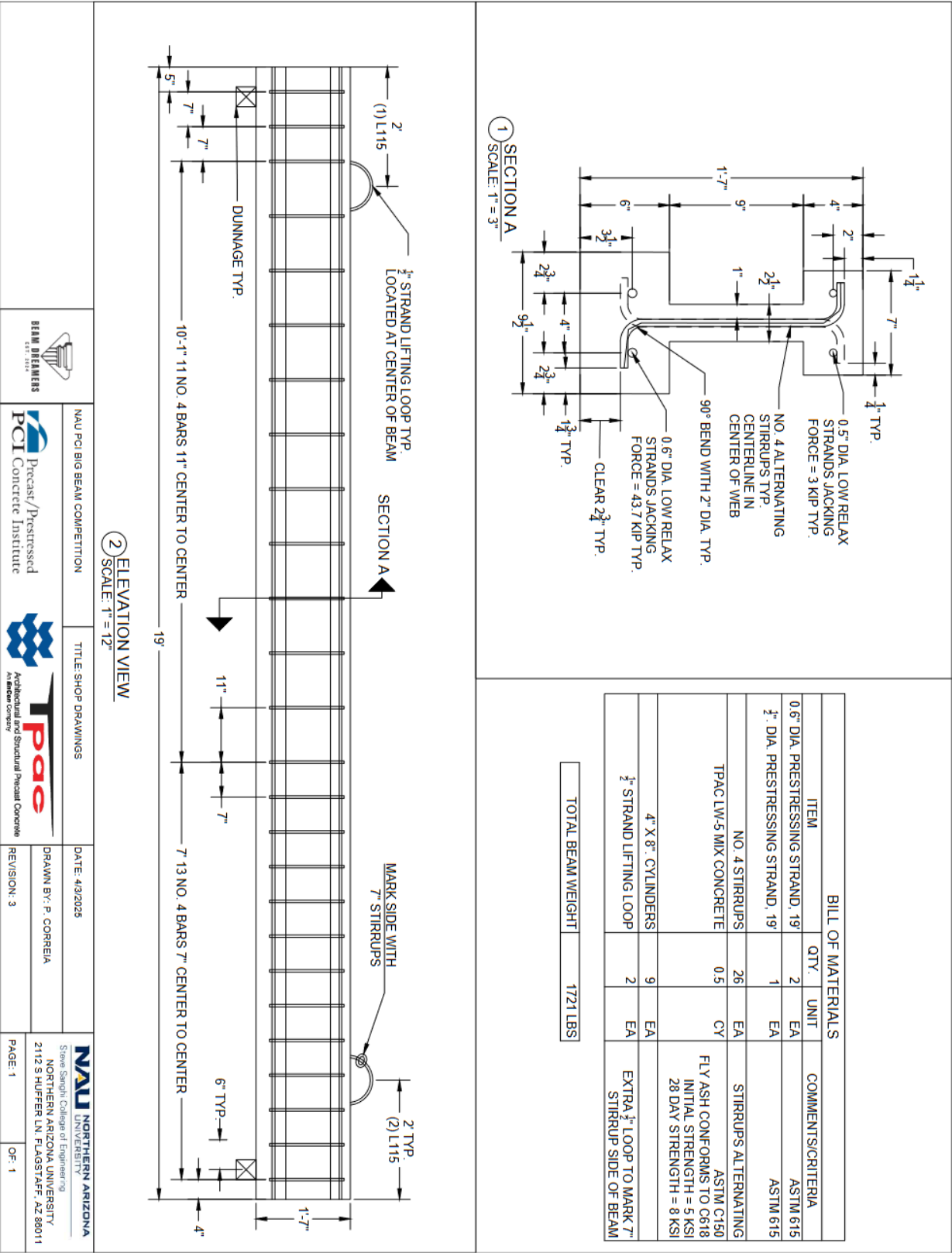


Figure 4: NAU Beam Shop Drawings (also located to scale in Appendix H)

5.0 Concrete Mixture Analysis

5.1 Statistical Analysis of Mix

Although Tpac offered the team a lightweight and normal weight concrete mix to use for the fabrication of the NAU beam, the team decided to use the lightweight. The lightweight mix has a lower design strength than the normal weight, but the team found that the strength was sufficient to stay within competition requirements and had the benefit of making the beam lighter.

The team also opted to select a mix instead of designing one in order to take advantage of the higher certainty associated with a robust set of historical data. The full data set can be found in Appendix A. The following table shows a statistical analysis of Tpac's lightweight mix.

Table 2: Statistical Analysis of Tpac's LW-5 mix (N=30) compared to NAU's test results

			Tpac LW 5 Test Results					
		NAU Test Results	Design Value	Mean	Median	Min	Max	Standard Deviation
Temperature	Air	69	--	72.8	70.0	50.0	93.0	12.35
	Concrete	67	--	96.48	75.0	63.0	91.0	7.92
Unit Weight (pcf)		118	121.6	125.4	125.6	119.7	129.6	2.2
Slump (in.)		27.5	27 ± 3 in	28.2	28.5	24.0	30.3	1.8
Air (%)		7.25	7.25	6.72	6.30	3.50	9.20	1.39
Age at Release		3	--	13	14	2	38	6.95
Compressive Strength	Release	5,080	5,000	5,400	5,370	4,160	7,690	896
	At Test	7,260	--	9,140	8,990	7,866	11,046	788

In Phoenix, Arizona, the temperatures can reach above 110 °F consistently, so the large range of concrete and air temperatures is not surprising. Curing temperatures lower than average may have delayed the setting time or reduced the strength, as the cement hydration reaction slows in lower temperatures; however, as the temperatures were not below freezing the effect would have been small.

Additionally, the air percentage is higher than average, and the unit weight is the lowest achieved with this mix; this led to an overall lighter beam. The average strength of this mixed design is higher than the design strength; extra strength will be helpful during the testing phase.

5.2 Mix Design

The above design elements are possible via the mix design data in Table 3 below.

The admixture data sheets for the lightweight mix can be found in Appendix A, and shows they meet ASTM C494 [1] per the 2024-2025 PCI Big Beam rules [2]. Additionally, the records for

the aggregates and pozzolans used in the concrete mix can be found in Appendix A and verify they meet ASTM standards per the rules.

Table 3: Lightweight mix design compared to actual mix

Material	Type	Theoretical lbs	Actual lbs	Difference
AZ Portland Cement	Type I-II-III/V	730	762.5	4.4%
Pozzolan Class	Class F (Fly Ash)	185	195	5.3%
Aggregate	WCS Maricopa	1286	1280	0.5%
	3/8" Expanded Shale (Utelite)	823	815	1.0%
Water	City Water	56 gal	56 gal	0%
Admixtures	Proprietary name	fl oz	fl oz	
Water Reducer	ADVA Cast 575	84	84	0%
Viscosity Modifier	V-MAR F-100	24	24	0%
Hydration stabilizer	RECOVER	20	19.5	2.5%
Rheology-Modifier	V-MAR 3	10	10	0%
Set Accelerator	Daraset 400	128	126	0%
Air Entrainment	Daravair 1000	15	15	0%

5.3 Concrete Cylinder Results

The team requested 9 test cylinders during the beam fabrication in order to attain accurate information on the specific concrete batch for the NAU beam. The compressive concrete strength was calculated using ASTM C39 [3], and the tensile strength was calculated using ASTM C496 [4]. The test cylinder data is shown in Table 4 below, and the test cylinder break is shown in Figure 5.

Figure 5 (Below): Cylinder Test Breaks corresponding to Table 4



Table 4: NAU Test Cylinder Results

	Test Date	Compressive Strength (psi)
2	4/28/25	7,120
3	4/28/25	7,390
Average value used in Predictions	--	7,260

5.4 Concrete Mixture Evaluation

Based on the statistical analysis in Section 5.1 above and the similarity of NAU's cylinder data to other mix's, the team decided on using the average of the second and third test cylinder results from Table 4 for final calculations.

6.0 Structural Design Analysis

6.1 Preliminary Design

The loading configuration for the 2024-2025 Big Beam Competition is shown in Figure 6 with applied load, $2P$, between the two-point loads [2].

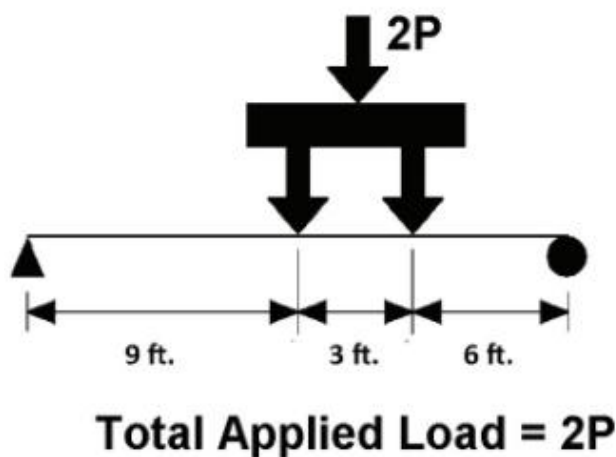


Figure 6 (Left): Loading Configuration

The beam must crack with applied load, $2P$, between 20 and 32 kips and fail between 32 and 40 kips. The goal is to produce a design to maximum deflection, minimize cost, and minimize weight while also meeting these constraints for cracking and failure capacity. The beams in the competition are assessed against one another for these categories by linear interpolation between the best and worst value [2]. The team is also awarded points based on the accuracy of calculation,

report quality, and practicality, innovation, compliance with code, and display of good engineering judgement.

While both a lightweight and normal weight mix design were considered, the team also kept in mind that the beam would be judged on weight, so the final designs used lightweight concrete.

The design considerations are outlined in Appendix C. The calculations were completed in Mathcad [5] and are shown in Appendix D, using the ACI Standard Code Book [6].

Deflection was calculated two ways; for the purpose of the decision matrix and ease of comparing multiple designs, the team calculated deflection using the FE handbook [7], along with the standard ACI 318-19 permissible limit in section ACI 24.2.3.5 [6]. Then, for the final predictions, deflection was calculated using Response-2000 curvature and moment data and the method of virtual work for analysis.

6.2 Decision Matrix

An iterative design process was performed to create a variation of designs fitting the competition criteria, then ranked using a decision matrix to optimally select the best performing beam. Each design rank is shown in Appendix E. From this, the team refined these designs by choosing the

attributes that preformed best and applying them when making new designs; for example, having the top flange have a width of seven inches. Designs four and five are refined from the best three designs.

These four cross-sections, shown in Appendix E, were selected from an initial pool of nine cross-sections. Five were eliminated from that preliminary based on criteria such as predicted cracking and breaking loads being too close to competition limits, excessive self-weight, and higher predicted cost.

Below is the decision matrix with all five designs ranked based on the three categories.

Table 5: Decision Matrix Initial Score

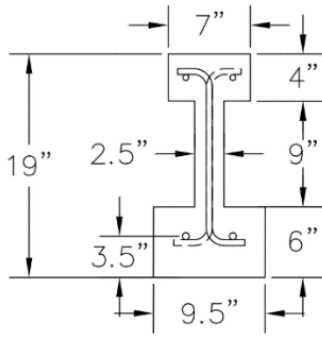
Design	Criteria						Initial Score (max: 3)
	Weight (lbs)		Deflection (in)		Cost (\$)		
	Value	Score	Value	Score	Value	Score	
1	1759	0.74	0.113	0.56	236.3	0	1.30
2	1849	0.13	0.117	0.72	234.4	0.50	1.35
3	1721	1	0.099	0	234.4	0.50	1.50
4	1868	0	0.124	1	232.5	1	2
5	1721	1	0.117	0.72	234.4	0.50	2.22

To account for penalization if the beam cracks or breaks close to the specified limits, the team developed a performance multiplier system to encourage predictions that remained towards the middle of the cracking range (at 26 kips), and the breaking range (36 kips). This approach added a factor of safety to the designs, as even if the team's calculations were not accurate, the risk of further penalties was reduced. The scores altered by the performance multiplier are shown in Appendix G, and the process for selecting the performance multiplier for the cracking and breaking load is shown in Appendix F.

6.3 Design Selection

Shear stirrup spacing was not a factor on the team's decision matrix because it would be roughly the same for all designs. Since one of the main design goals was to keep the beam as light as possible the web had room for only one stirrup leg.

The remaining four designs were refined through further analysis and comparison to improve structural efficiency and performance. Among all four designs, Design 4 had the lowest weight because it included only three prestressing strands, whereas the other designs used four.



When coordinating with Tpac regarding the shop drawings, the original stirrup design was not constructable as it had multiple different bend angles; additionally, the clear cover was excessive. Tpac helped the team better understand stirrup construction and detailing. As a result, the team decided to add another prestressing strand to hold the stirrup and reduced the height of the bottom flange. This led to design 5 (Figure 7).

Figure 7 (left): Design 5, chosen for production

7.0 Beam Fabrication & Testing

7.1 Certification of Materials

Per the competition rules, all materials must be fit to use per ASTM standards. The plant certification that the steel meets applicable ASTM codes is shown in Appendix A

7.2 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-produced shop drawings.



Figure 8: Formwork with stirrups and prestressing strands

As seen in the photos below, the formwork dimensions, stirrup spacing, and all other measurements were verified to be accurate according to the shop drawings (shown in Figure 4 and Appendix H).



Figure 9: Top flange



Figure 10: 11 in. stirrup spacing



Figure 11: 7 in. stirrup spacing

As seen in the shop drawings in Section 4.0, the stirrups were spaced differently in order to reduce the cost and amount of stirrups required, as the shear demand varies based on location. The stirrups have one leg extending the length of the web, with bends so that the stirrups are held in place by the prestressing strands throughout the concrete pour. A sample stirrup is shown in Figure 12.



Figure 12: Stirrup sample

Due to the difference in stirrup spacing, the team needed a way to ensure the beam was aligned properly to withstand the loading. To keep track of what side has the 7-inch stirrup spacing, Tpac placed two lifting loops on the corresponding side, also putting an in-house fabrication identifier on the same side.



Figure 13 (left): Double lifting loop identifying side with 7 in. stirrup spacing



Figure 14 (right): Single lifting loop identifying side with 11 in. stirrup spacing

After verification that the measurements were correct, Tpac's LW-5 concrete mix was made at a batch plant on site. Preliminary tests were conducted to verify quality. The spread test (shown in Figure 15 below) tested the flowability of the concrete mix and determined whether the in-situ concrete mixture was consistent with the mixture design.



Figure 15: Spread Test (setup: left, released: right)

The spread test showed that the concrete batch was very workable as it had an even radius. Tpac also tested the percentage of air in the freshly mixed concrete to determine the unit weight.

Table 7 below shows the values of these tests and resulting unit weight of the concrete.

Table 6: Concrete Test Results

Category	Test Results	Design Values
Spread	27.50 in	27 ± 3 in
Estimated air	7.25%	3%
Unit weight	118.1 pcf	124.1 pcf

Once the tests were completed and concrete quality was verified, the concrete was ready to be poured. Nine concrete cylinders, labeled NAU (shown in Figure 16), were poured so that the team could test the concrete's compressive and tensile strength (results are shown in Section 5.3

above). The cylinders were poured from the same batch, cured in the same conditions, and tested before the Big Beam test to ensure accuracy of results.



Figure 16: Fabricated test cylinders in molds

Throughout the pour, Tpac production employees (Figure 17) ensured there were no air bubbles and that the concrete filled in the formwork completely.

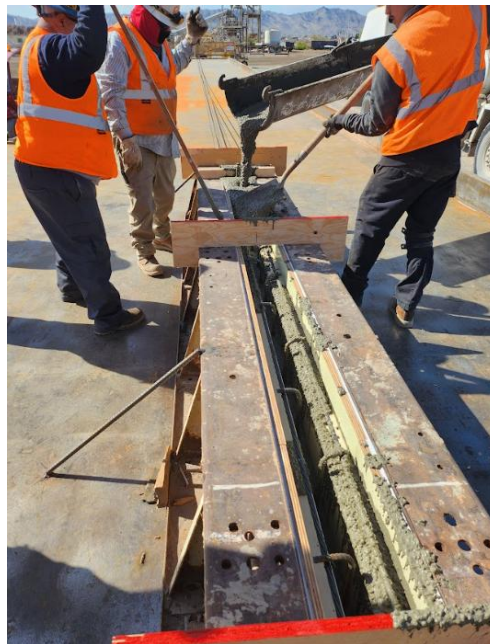


Figure 17: Concrete pour, with Tpac employees ensuring no gaps

To ensure the concrete would set evenly and have a nice look, the top was smoothed out. Tpac let the concrete cure for three days before verifying that the concrete strength was greater than the required 5,000 psi and cut the strands. The initial strength of the concrete at release was 5,077 psi on the third day.



Figure 18: Beam after concrete poured

Tpac shipped the beam to NAU on April 16th, 12 days after being fabricated. All reports from fabrication are shown in Appendix J.

7.3 Test Setup

Upon arrival, the beam was transported into the NAU concrete lab.

The team proceeded to position the beam properly according to the PCI Big Beam rules [2], as seen in Figure 19 below. The green steel support beams and load actuator were moved to position and load the beam correctly.

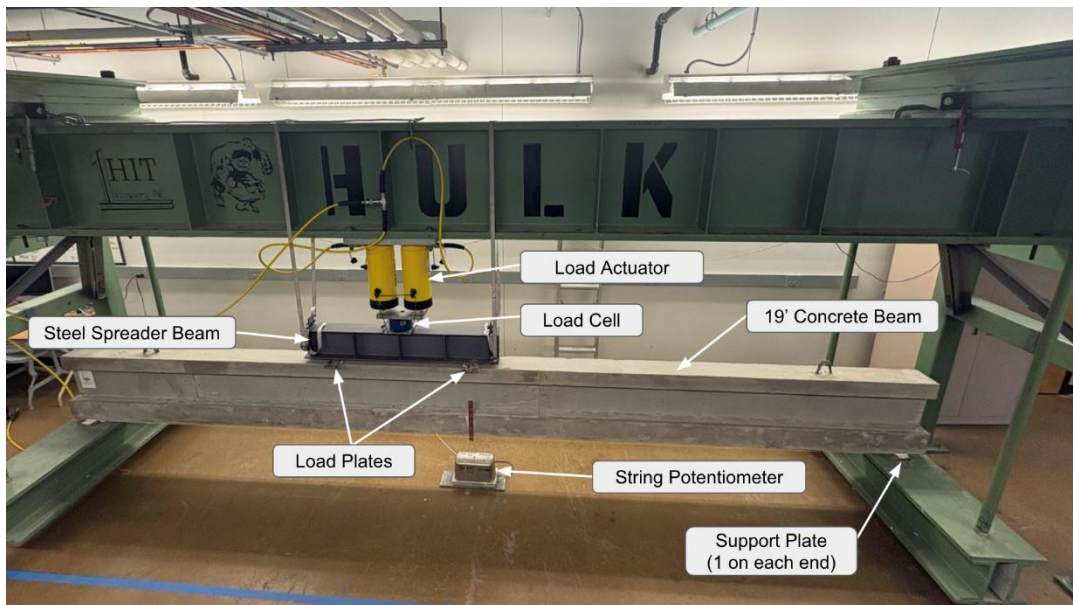


Figure 19: Overview of test setup

The beam was measured and marked at the support plate locations to ensure it was centered properly, the point load locations where load plates would transfer the load to the beam. Areas where steel load plates made contact with the concrete beam were grouted to ensure contact and load transfer.

The centers of the load plates were placed 6-inches from the end of the beam, creating an 18-foot span length. Once everything was in place, the team added the steel load plates, steel spreader beam, load cell to measure the load during testing, a transfer plate, and the load actuator, as shown above in Figure 19. The dimensions of the beam, support plates, load plates, and string potentiometer can be seen below in Figure 20.

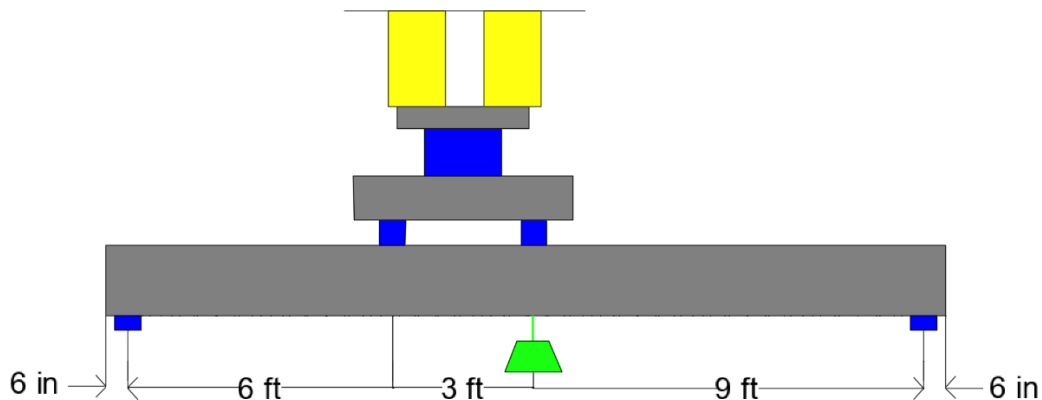


Figure 20: Detail of test set up with dimensions

Mason's string was placed spanning the entire length of the beam, with a ruler attached to the beam, behind the string, to visually show deflection during testing, as shown below in Figure 21 below. Due to the low visibility of the string in the image, a red line was drawn to show the location of the string shown in Figure 21.

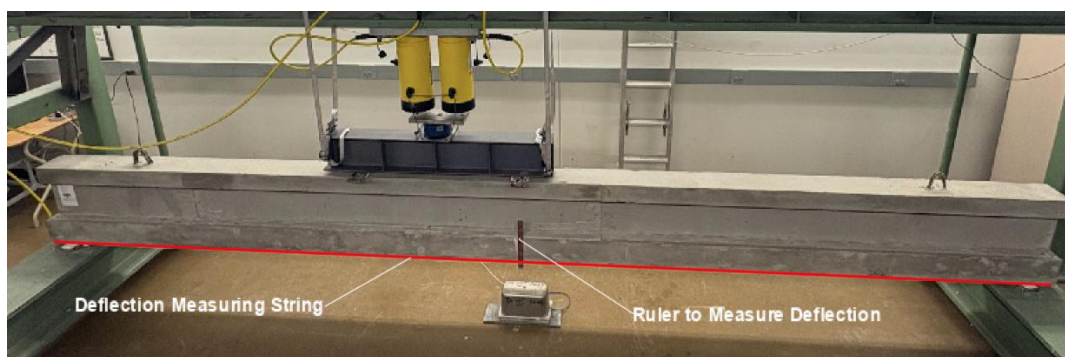


Figure 21: Testing set up showing how deflection is visually measured

7.4 Beam Test Results

The NAU Big Beam test was conducted on 4/28/2025 following the cylinder tests and certification of predictions. The test included plotting applied load and deflection calculated at midspan. The following graph contains the test data.

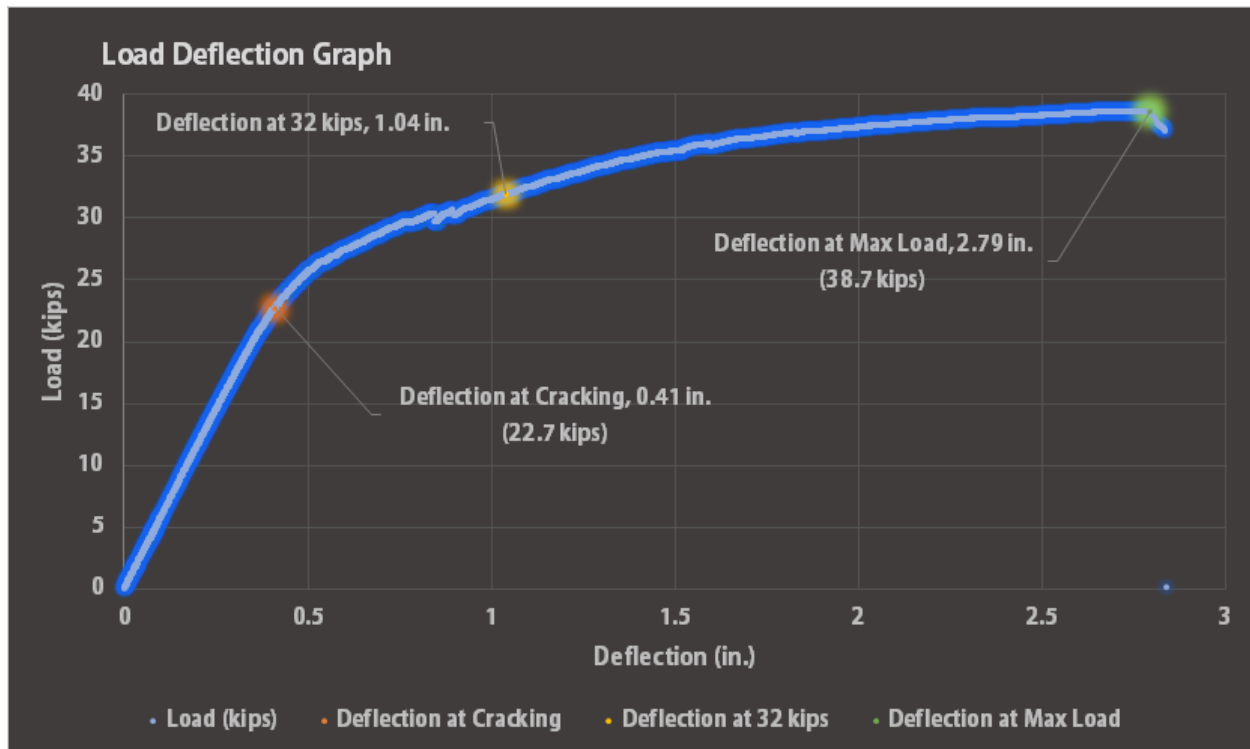


Figure 22: Deflection vs. Loading Graph

The following table shows how the predictions are compared to the actual results.

Table 7: Comparison of Results and Predictions

	Predicted Value	Actual Value	% Difference
Cracking	22.8 kips	22.7 kips	-0.4 %
Breaking Load	34.9 kips	38.7 kips	+11 %
Midspan Deflection (32 kips)	1.09 in	1.04 in	-4.7 %
Midspan Deflection (Max)	1.9 in	2.7 in	+50 %

Overall, our predictions are close to our actual values. Our breaking load prediction was likely due to suboptimal cylinder test results. Ideal cylinder breaks show a cone shape. As seen in Figure 5, the cylinder breaks only have a chunk broken off. This likely led to our concrete strength being lower than anticipated in our predictions, leading to the concrete having higher strength and failing under a higher load.

In the future, the team will conduct more cylinder tests to have a larger sample size in case of user error in using the testing equipment.

8.0 Team Statements

8.1 Payton Correia



Figure 23: Photo of Payton Correia

This competition was incredible because it allowed me to apply what I've learned throughout my academic career to a tangible project. I really enjoyed challenging myself to learn the specifics of designing with prestressed concrete, the logistics of fabricating a beam, and communicating with a variety of professionals and learn from their experiences. Completing the design work with Isabella Velasco, one of my best friends, was a joy and I was thrilled to get the opportunity to challenge ourselves technically. I am extremely proud of the work we have put into this project, the skills we have learned, and our improved understanding of prestressed concrete design. I feel confident in my abilities to use precast/prestressed concrete in my career.

10931 East Bella Vista Drive Scottsdale, AZ 85259

8.2 Zachary Fukumoto

Figure 24: Photo of Zachary Fukumoto



Participating in the PCI Big Beam Competition was a great learning experience in my academic and professional journey. I gained a deeper understanding of structural behavior, specifically in prestressed concrete design and testing, through this competition. Being able to design our beam and then actually test it brought our engineering skills to life. This competition taught me the importance of teamwork, problem-solving, communication, and time management. I am grateful for my team members and being able to work on this project.

94-227 Kuhana Place, Waipahu, HI, 96797

8.3 Isabella Velasco



Figure 25: Photo of Isabella Velasco

This competition opened my eyes into the precast and prestressed concrete world. Our school curriculum only has a regular concrete class so when we got this project we met with our technical advisor, Dr. Dymond, weekly to learn about prestressed concrete. This whole experience was very fun and challenging to go through. We learned new software's to make calculations and predictions that I would have never learned if not in this project. I am considering a career now in prestressed and precast concrete because I really loved this project. It was overwhelming at first but once we started, I was able to dive in and put my all into it. This project was a full rounded project where we got to see the entire process it takes to make prestressed precast

concrete. Payton Correia, who is one of my best friends, and I would always joke about how this project was our baby so much, so it wasn't a joke anymore. We even named our beam Stacy because we loved our beam and it was a visual representation of all the hard work we had put into designing her.

1492 S. Vine St. Gilbert, AZ 85233

8.4 Caitlin Yazzie

Figure 26: Photo of Caitlin Yazzie

The PCI Big Beam Competition has provided me with an invaluable, hands-on introduction to civil engineering that I would not have gained elsewhere. Through this project, I learned the fundamentals of concrete mix design and came to understand the principles of prestressed concrete, how it is intentionally compressed before loading to improve its structural performance. I was actively involved in the full process, from interpreting shop drawings and coordinating with our sponsor on material requirements to overseeing the concrete pour and witnessing firsthand how the beam was constructed and tested to failure. These experiences not only deepened my technical knowledge but also taught me the importance of communication and planning within a team, especially while balancing coursework and jobs. I am grateful for this opportunity, and the skills and insights I've gained will have a lasting impact on both my academic and professional journey.



PO Box 272, Rock Point, AZ 86545

References

- [1] ASTM International, "ASTM C494: Standard Specifications for Chemical Admixtures for Concrete," *ASTM International*, 2024.
- [2] PCI, "2024-2025 Big Beam Rules," 2024-2025. [Online]. Available: https://www.pci.org/PCI/PCI/Education/Student_Competitions.aspx..
- [3] ASTM International, "ASTM C39: Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens," *ASTM International*, 2021.
- [4] ASTM International, "ASTM C496: Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens," *ASTM International*, 2017.
- [5] PTC, *MathCAD Prime10*, PTC.
- [6] ACI 318-19: Building Code Requirements for Structural Concrete, American Concrete Institute, 2019.
- [7] FE Reference Book, NCEES, 2020.
- [8] J. Huguenot, "Concrete Mix Design," 19 March 2025. [Online].

Appendix A.1 Certified Mill Test Report: No. 4



CUSTOMER COPY

[illegible]

DRIVER'S SIGNATURE/AGENT

NOTICE TO RECEIVERS:

NOTICE TO RECEIVERS: *Shirley S. Smith*
Please check each item on this shipping bill carefully. CMC will not be responsible for any exceptions to goods unless notified within twenty four hours and noted on this document.

RECEIVED BY :

DATE: 1-27-25

TIME :

Page 1 of 2

CMC STRAIGHT BILL OF LADING-SHORT FORM ORIGINAL-NON NEGOTIABLE #76372133



MATERIAL DETAILS									
Cust PO No.	CMC SO.PO	Del. No.	Material Description.	Customer Material No.	Heat No.	Tag No.	Pcs/Bundle	Net Weight	UCM
			A615/A706-60						
MR250079	6673542	86118314	REBAR 16MM (#5) 60'0"		4145654	AZ02174153	98	6133	LB
			A615/A706-60						
MR250079	6673542	86118314	REBAR 16MM (#5) 60'0"		4145654	AZ02174154	98	6133	LB
			A615/A706-60						
TOTAL							1008	49220	LB

RECEIVED, subject to the classifications in effect on the date of the issue of the Bill of Lading, the property described above, in apparent good order, except as noted (contents of packages unknown), marked, consigned, and destined as indicated below, which said carrier (the word carrier being understood throughout this contract as meaning any person or corporation in possession of the property under the contract) agrees to carry to its usual place of delivery at sea destination, if (a) its route, destined to deliver to another carrier on the route to said destination, it is mutually agreed as to each carrier of all or any said property over all or any portion of said route to destination, and as to each party at any time interested in all or any of said property, that every service to be performed hereunder shall be subject to all the terms and conditions of the Uniform Domestic Straight Bill of Lading set forth in Official Southern, Western and Texas Freight Classifications in effect on the date hereof, if this is a rail or a rail-water shipment, or (b) in the applicable motor carrier classification or (c) if this is a motor carrier shipment, the carrier hereby agrees to be familiar with all the terms and conditions of the said bill of lading, including those on the back thereof, set forth in the classification of said carrier which governs the transportation of this shipment and the said terms and conditions are hereby agreed to by the shipper and accepted by himself and his assigns. This is to certify that the above articles are properly described by name and are packed and marked and are in proper condition for transportation according to regulations by the Interstate Commerce Commission. * If the shipment moves between two ports by a carrier by water, the law requires that the bill of lading shall state whether it is a carrier's or shipper's weight. Shipper's weights in lieu of stamp, not a part of bill of lading approved by the Interstate Commerce Commission. NOTE: Where the rate is dependent on value, shippers are required to state specifically, in writing, the agreed or declared value of property. The agreed or declared value of the property is hereby specifically stated by the shipper to be not exceeding. WARNING: This product can expose you to chemicals which are known to the State of California to cause cancer, birth defects or other reproductive harm. For more information go to www.P65Warnings.ca.gov. Note: In the case of Customer Pkg. No. the Ship To Address indicated above has been provided by the entity specified in the bill of lading. CMC and its employees are not responsible for transporting the property described above from the CMC facility to Customer's designated ship to address. Alternatively, if Customer does not provide a Ship To Address, the Ship To Address above will reflect the CMC facility.

DRIVER'S SIGNATURE/AGENT : _____

NOTICE TO RECEIVERS:

Please check each item on this shipping bill carefully. CMC will not be responsible for any exceptions to goods unless notified within twenty four hours and noted on this document.

RECEIVED BY :

DATE :

TIME :

Page 2 of 2



CMC STEEL ARIZONA
11444 E. GERMANN RD.
MESA AZ 85212-9700

CERTIFIED MILL TEST REPORT
For additional copies call
830-372-8771

We hereby certify that the test results presented here
are accurate and conform to the reported grade specification


Jacob Selzer - CMC Steel

Quality Assurance Manager

EAT NO.:4146230 ECTION: REBAR 13MM (#4) 60"0" 615/A706-60 RADE: ASTM A615&A706-24 GR60 ualGr OLL DATE: 01/22/2025 IELT DATE: 01/22/2025 ort. No.: 86118314 / 146230F396	S O L D T O	EnCon Arizona LLC dba Tpac 3052 S 19TH AVE PHOENIX AZ US 85009-6926 6022621360 6022621374	S H I P T O	EnCon Arizona LLC dba Tpac 3052 S 19TH AVE PHOENIX AZ US 85009-6926 6022621360 6022621374	Delivery#: 86118314 BOL#: 76372133 CUST PO#: MR250079 CUST P/N: DLVRY LBS / HEAT: 24688.000 LB DLVRY PCS / HEAT: 616 EA
--	----------------------------	--	----------------------------	--	--

Characteristic	Value	Characteristic	Value	Characteristic	Value
C	0.25%	Tensile Strength 1 (metric)	677MPa		
Mn	1.33%	Elongation test 1	17%		
P	0.012%	Elongation Gage Lgth test 1	8IN		
S	0.041%	Tensile to Yield ratio test1	1.35		
Si	0.29%	Bend Test 1	Passed		
Cu	0.28%	Rebar Deformation Avg. Spaci	0.334IN		
Cr	0.14%	Rebar Deformation Avg. Heigh	0.025IN		
Ni	0.10%	Rebar Deformation Max. Gap	0.148IN		
Mo	0.020%	Bend Test Diameter	1.500IN		
V	0.004%	Uniform Elongation test 1	12.1%		
Cb	0.002%	Deform radius/height ratio 1	2.76		
Sn	0.011%				
Al	0.002%				
B	0.0006%				
N	0.0061%				
Carbon Eq A706	0.50%				
Yield Strength test 1	72.7ksi				
Yield Strength test 1 (metri	502MPa				
Tensile Strength test 1	98.1ksi				

The Following is true of the material represented by this MTR:
*Material is fully killed and is Hot Rolled Steel
*100% melted, rolled, and manufactured in the USA
*EN10204:2004 3.1 compliant *Contains no weld repair
*Contains no Mercury contamination
*Manufactured in accordance with the latest version of the plant quality manual
*Meets the "Buy America" requirements of 23 CFR635.410, 45 CFR 6
*Warning: This product can expose you to chemicals which are known to the State of California to cause cancer, birth defects or other reproductive harm. For more information go to www.P65Warnings.ca.gov

MARKS : MEETS THE SUPPLEMENTARY REQUIREMENTS OF A706-22A FOR EARTHQUAKE-RESISTANT STRUCTURES. ALSO MEETS AASHTO M31
EASE EMAIL CMC_AZ_QUALITY@CMC.COM WITH ANY FEEDBACK, QUESTIONS, OR CONCERNS



CMC STEEL ARIZONA
11444 E. GERMANN RD.
MESA AZ 85212-9700

CERTIFIED MILL TEST REPORT
For additional copies call
830-372-8771

We hereby certify that the test results presented here
are accurate and conform to the reported grade specification


Jacob Selzer - CMC Steel

Quality Assurance Manager

EAT NO.:4145654	S	EnCon Arizona LLC dba Tpac	S	EnCon Arizona LLC dba Tpac	Delivery#: 86118314
ECTION: REBAR 16MM (#5) 60"0"	O		H		BOL#: 76372133
615/A706-60	L	3052 S 19TH AVE	I	3052 S 19TH AVE	CUST PO#: MR250079
RADE: ASTM A615&A706-24 GR60	D	PHOENIX AZ	P	PHOENIX AZ	CUST P/N:
ualGr		US 85009-6926		US 85009-6926	DLVRY LBS / HEAT: 24532.000 LB
OLL DATE: 01/03/2025	T	6022621360	O	6022621360	DLVRY PCS / HEAT: 392 EA
IELT DATE: 01/03/2025	O	6022621374		6022621374	
ort. No.: 86118314 / 145654F013					

Characteristic	Value	Characteristic	Value	Characteristic	Value
C	0.26%	Tensile Strength 1 (metric)	646MPa		
Mn	1.19%	Elongation test 1	17%		
P	0.008%	Elongation Gage Lgth test 1	8IN		
S	0.032%	Tensile to Yield ratio test1	1.30		
Si	0.20%	Bend Test 1	Passed		
Cu	0.36%	Rebar Deformation Avg. Spaci	0.406IN		
Cr	0.13%	Rebar Deformation Avg. Heigh	0.039IN		
Ni	0.13%	Rebar Deformation Max. Gap	0.146IN		
Mo	0.024%	Bend Test Diameter	1.875IN		
V	0.004%	Uniform Elongation test 1	10.8%		
Cb	0.003%	Deform radius/height ratio 1	2.29		
Sn	0.011%				
Al	0.001%				
B	0.0005%				
N	0.0125%				
Carbon Eq A706	0.49%				
Yield Strength test 1	72.2ksi				
Yield Strength test 1 (metri	498MPa				
Tensile Strength test 1	93.6ksi				

The Following is true of the material represented by this MTR:
*Material is fully killed and is Hot Rolled Steel
*100% melted, rolled, and manufactured in the USA
*EN10204:2004 3.1 compliant *Contains no weld repair
*Contains no Mercury contamination
*Manufactured in accordance with the latest version of the plant quality manual
*Meets the "Buy America" requirements of 23 CFR635.410, 49 CFR 6
*Warning: This product can expose you to chemicals which are known to the State of California to cause cancer, birth defects or other reproductive harm. For more information go to www.P65Warnings.ca.gov

MARKS : MEETS THE SUPPLEMENTARY REQUIREMENTS OF A706-22A FOR EARTHQUAKE-RESISTANT STRUCTURES. ALSO MEETS AASHTO M31
EASE EMAIL CMC_AZ_QUALITY@CMC.COM WITH ANY FEEDBACK, QUESTIONS, OR CONCERNS

Appendix A.2 Material Certification of Compliance: 0.5 in. Strands

INSTEEL [®] WIRE PRODUCTS						INSTEEL WIRE PRODUCTS COMPANY UNIFORM STRAIGHT BILL OF LADING ORIGINAL - NOT NEGOTIABLE		Bill of Lading No. 00402547-10137053 Date: 29-OCT-24 Stop 1 of 1 Page 1 of 1	
SHIP FROM						CARRIER			
Name: INSTEEL WIRE PRODUCTS COMPANY Address: 11020 TANNER ROAD HOUSTON, TX 77041						ANNETT HOLDINGS INC 4335 PAYSPIRE CIRCLE CHICAGO, IL 60674			
SHIP TO DESTINATION (CONSIGNEE)						FREIGHT PAYMENT METHOD			
Name: ENCON ARIZONA LLC Address: DBA TPAC 3052 S 19TH AVENUE PHOENIX AZ 85009-6926						☒ Prepaid ☐ Customer Truck			
SPECIAL INSTRUCTIONS/COMMENTS									
Chris Holt 602-262-1308 Receiving hours 5:00am - 12:00pm; ck3127Chris Holt 602-262-1308 Receiving hours 5:00am - 12:00pm; AZ DOT , must add binding statement One heat per load; Must have letter of domestic origin w/each load.									
CARGO						NOTE: Wire carriers, if used, remain Insteel's property. To return, please call 1-336-719-9000			
Hazardous Material	Units	Package Type	Sales Order No.	Unit Weight	Weight	Commodity Description, Special Marks, Exceptions			
	89880 FT	PACKS	571139	.5206	46792	591-041869 1/2 (12.7mm) 7W 270 LR ASTM A416 PO: CH241303 Load Securement PC Strand: Cargo Strapping is the preferred securement device but, if chains are used, chain protectors must be applied to protect the coil packs			
Total Weight: 46,792 LBS									
RECEIVED, subject exclusively to the Terms and Conditions stated herein to the exclusion of any rates, classifications, or tariffs established or maintained by the Carrier. The Carrier has received from the Shipper, the property described above in actual good order and condition, except as noted, at the location noted in the "SHIP FROM" Box above and will properly and carefully load, handle, carry, keep, care for, and deliver it to the destination noted in the "SHIP TO" Box above, in exchange for certain freight charges, the adequacy of which is hereby acknowledged by the Carrier. Notwithstanding the fact that Shipper may provide recommendations and personnel to assist in loading the Cargo on Carrier's vehicles, Carrier and its agents and employees remain solely responsible for proper arrangement of the Cargo on Carrier's vehicles. It is mutually agreed by and between the Shipper and Carrier that every service to be performed hereunder is subject to the Terms and Conditions hereof. The Carrier hereby certifies that it is familiar with all of those Terms and Conditions and that it irrevocably agrees to them for itself and its assigns.						NOTE QUANTITY & QUALITY EXCEPTIONS AT DESTINATION HERE			
						NOTE: Failure to specify exceptions at destination here does not affect the Shipper's rights against the Carrier.			
						Carrier Signature / Pick Up Date			
Shipper Signature / Date <i>Arturo Villalobos</i> 10-29-24						Customer Signature / Delivery Date			
Shipper certifies that the property described above is properly packaged, marked, and labeled and in proper condition for transportation according to the applicable regulations of the DOT.						Customer acknowledges receipt of the property described above in actual good order and condition, except as noted.			



MATERIAL CERTIFICATION OF COMPLIANCE

11020 Tanner Road
Houston, TX 77041
336-719-9000

ENCON ARIZONA LLC
DBA TPAC
PHOENIX AZ 85009-6926

Bill of Lading: 00402547
Order Number: 571139
PO Number: CH241303

Insteel Wire Products Company hereby certifies that the specimens taken from production lot(s) consisting of one or more of the following Lot/serial numbers were tested in accordance with and met the specification requirements of ASTM A416-18. The attached test report(s) represent the result of such test(s).

1/2 (12.7mm) 7W 270 LR ASTM A416

Test Report Number: 37241028114303

Lot/Serial Numbers

120137494035

120137494037

120137494038

120137494039

120137494040

120137494041

120137494042

Heat Number

OT0069440

The products listed in this certification were manufactured and fabricated in the United States of America.

Insteel Wire Products Company hereby certifies that the prestressing strand described above meets or exceeds the minimum bonding requirements as currently accepted in the NASP (North American Strand Producers) pull-out test and the Moustaffa block pull-out test.

All Domestic Prestressing Strand was made from steel rod that was melted, manufactured, and processed completely in the United States of America. The rod was then manufactured into PC Strand in the United States at Insteel Wire Products Company plant in either Sanderson, FL; Houston, TX; or Gallatin, TN. The material meets the "Buy America" requirements of 23 CFR 635.410.

The products listed in this certification were manufactured in the U.S.A. from wire rod which was manufactured in the U.S.A.

Quality Assurance Manager:


Jorge Alvarez

Date: 29-OCT-2024

The individual above has the authority to make this certificate legally binding for Insteel Wire Products Company.



PACKING LIST
Houston, TX

ENCON ARIZONA LLC
DBA TPAC
PHOENIX AZ 85009-6926

Bill of Lading: 00402547
Order Number: 571139
PO Number: CH241303
Date: 29-OCT-24

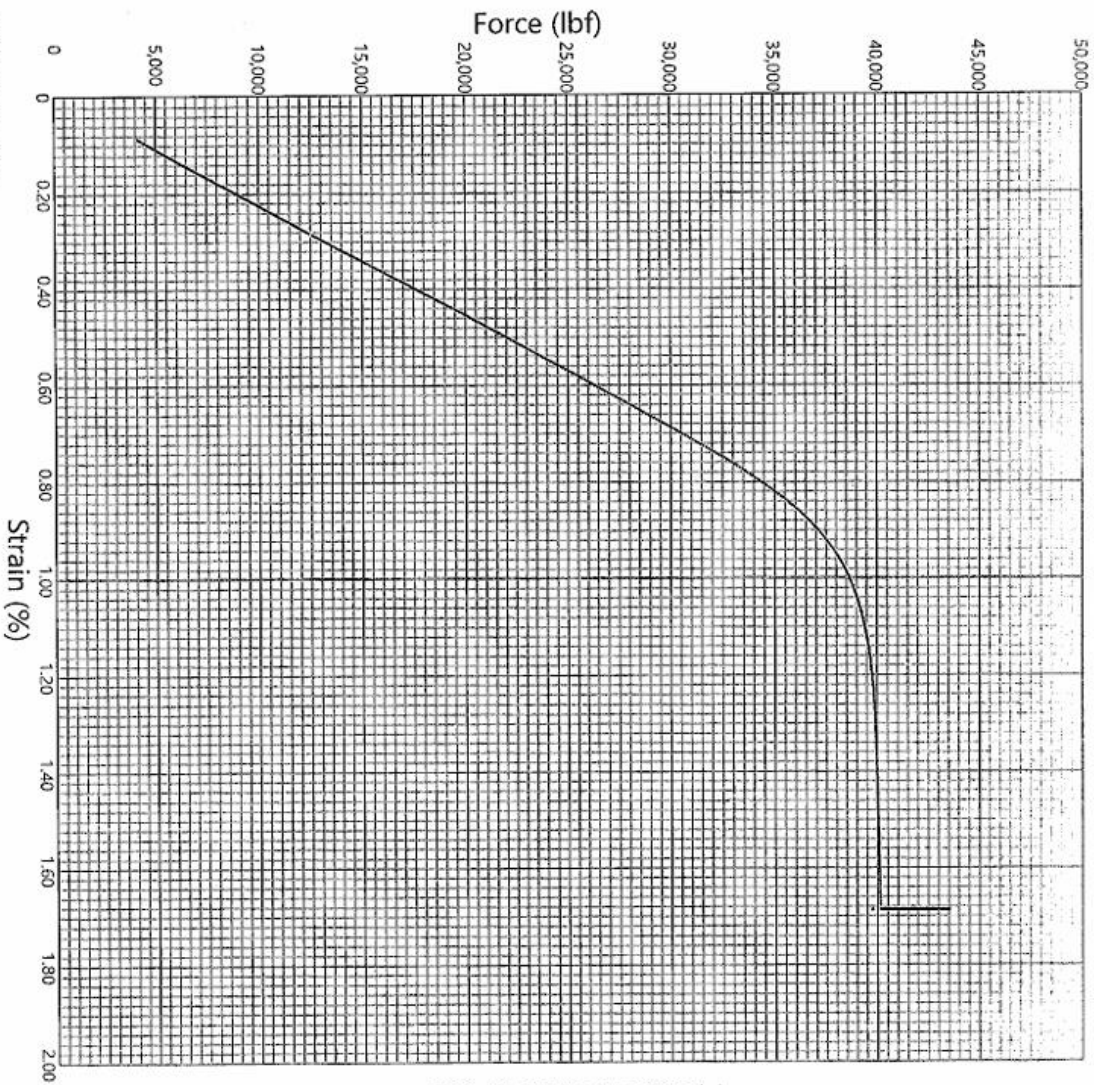
Lot Number	Description	Length	Weight
120137494035	1/2 (12.7mm) 7W 270 LR ASTM A416	11700	6091.0200
120137494037	1/2 (12.7mm) 7W 270 LR ASTM A416	13030	6783.4180
120137494038	1/2 (12.7mm) 7W 270 LR ASTM A416	13030	6783.4180
120137494039	1/2 (12.7mm) 7W 270 LR ASTM A416	13030	6783.4180
120137494040	1/2 (12.7mm) 7W 270 LR ASTM A416	13030	6783.4180
120137494041	1/2 (12.7mm) 7W 270 LR ASTM A416	13030	6783.4180
120137494042	1/2 (12.7mm) 7W 270 LR ASTM A416	13030	6783.4180
Total Number of Packs 7		Totals 89880	46792



This test performed at
11020 Tanner Road
Houston, TX 77041
(800) 791-4108

Test Type: 1/2" 270 TW LOW RELAXATION

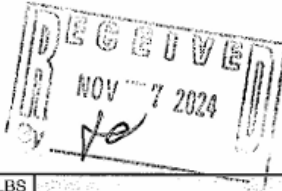
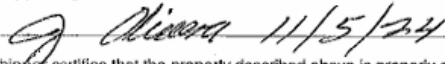
Test Number: 37241028114303
Tested By: J Alvarez
Ultimate Breaking Strength: 43,510 lbf
Ultimate Breaking Strength: 194 kN
Load @ 1% Extension: 38,640 lbf
Load @ 1% Extension: 172 kN
Ultimate Elongation: 6.3 %
Strand Diameter: 0.500 in
Rep. Area: 0.153 in²
Actual Area: 98.7 mm²
Actual Area: 0.1525 in²
Lay Length: 95.39 mm
Avg Modulus of Elasticity: 28.8 Mpsi
Reference: 198,569 MPa



Revised: 10/20/2014
V10.3.1.10 - 33887105 - Insteel Wire Products

0.0041 Inches Break Load (lbf) 10/20/2014 11:45 AM

Appendix A.3 Material Certification of Compliance: 0.6 in. Strands

CUSTOMER COPY						
		INSTEEL WIRE PRODUCTS COMPANY UNIFORM STRAIGHT BILL OF LADING ORIGINAL - NOT NEGOTIABLE			Bill of Lading No. 00403593-10156097 Date: 05-NOV-24 Stop 1 of 1	
SHIP FROM				CARRIER		
Name: INSTEEL WIRE PRODUCTS COMPANY Address: 11020 TANNER ROAD HOUSTON, TX 77041				DMT TRUCKING LLC PO BOX 2487 BIRMINGHAM, AL 35201		
SHIP TO DESTINATION (CONSIGNEE)				FREIGHT PAYMENT METHOD		
Name: ENCON ARIZONA LLC Address: DBA TPAC 3052 S 19TH AVENUE PHOENIX AZ 85009-6926				☒ Prepaid ☐ Customer Truck		
SPECIAL INSTRUCTIONS/COMMENTS						
Chris Holt 602-262-1308 Receiving hours 5:00am - 12:00pm; ck3127Chris Holt 602-262-1308 Receiving hours 5:00am - 12:00pm; AZ DOT , must add binding statement One heat per load; Must have letter of domestic origin w/each load.						
CARGO				NOTE: Wire carriers, if used, remain Insteel's property. To return, please call 1-336-719-9000		
Hazardous Material	Units	Package Type	Sales Order No.	Unit Weight	Weight	Commodity Description, Special Marks, Exceptions
	63210 FT	PACKS	571876	.75296	47595	593-134684 .600 (15.2mm) 7W 270 LR ASTM A416 PO: CH241372 Load Securement PC Strand: Cargo Strapping is the preferred securement device but, If chains are used, chain protectors must be applied to protect the coil packs
						
Total Weight: 47,595 LBS						
RECEIVED, subject exclusively to the Terms and Conditions stated herein to the exclusion of any rates, classifications, or tariffs established or maintained by the Carrier. The Carrier has received from the Shipper, the property described above in actual good order and condition, except as noted, at the location noted in the "SHIP FROM" Box above and will properly and carefully load, handle, carry, keep, care for, and deliver it to the destination noted in the "SHIP TO" Box above, in exchange for certain freight charges, the adequacy of which is hereby acknowledged by the Carrier. Notwithstanding the fact that Shipper may provide recommendations and personnel to assist in loading the Cargo on Carrier's vehicles, Carrier and its agents and employees remain solely responsible for proper arrangement of the Cargo on Carrier's vehicles. It is mutually agreed by and between the Shipper and Carrier that every service to be performed hereunder is subject to the Terms and Conditions hereof. The Carrier hereby certifies that it is familiar with all of those Terms and Conditions and that it irrevocably agrees to them for itself and its assigns.				NOTE QUANTITY & QUALITY EXCEPTIONS AT DESTINATION HERE		
				NOTE: Failure to specify exceptions at destination here does not affect the Shipper's rights against the Carrier.		
				Carrier Signature / Pick Up Date		
Shipper Signature / Date  11/5/24				Customer Signature / Delivery Date		
Shipper certifies that the property described above is properly packaged, marked, and labeled and in proper condition for transportation according to the applicable regulations of the DOT.				Customer acknowledges receipt of the property described above in actual good order and condition, except as noted.		



MATERIAL CERTIFICATION OF COMPLIANCE

11020 Tanner Road
Houston, TX 77041
336-719-9000

ENCON ARIZONA LLC
DBA TPAC
PHOENIX AZ 85009-6926

Bill of Lading: 00403593
Order Number: 571876
PO Number: CH241372

Insteel Wire Products Company hereby certifies that the specimens taken from production lot(s) consisting of one or more of the following Lot/serial numbers were tested in accordance with and met the specification requirements of ASTM A416-18. The attached test report(s) represent the result of such test(s).

.600 (15.2mm) 7W 270 LR ASTM A416

Test Report Number: 37241025104859

Lot/Serial Numbers

120237462123
120237462124
120237462128
120237462135
120237462136
120237462137
120237462141

Heat Number

OT0068945

The products listed in this certification were manufactured and fabricated in the United States of America.

Insteel Wire Products Company hereby certifies that the prestressing strand described above meets or exceeds the minimum bonding requirements as currently accepted in the NASP (North American Strand Producers) pull-out test and the Moustaffa block pull-out test.

All Domestic Prestressing Strand was made from steel rod that was melted, manufactured, and processed completely in the United States of America. The rod was then manufactured into PC Strand in the United States at Insteel Wire Products Company plant in either Sanderson, FL; Houston, TX; or Gallatin, TN. The material meets the "Buy America" requirements of 23 CFR 635.410.

The products listed in this certification were manufactured in the U.S.A. from wire rod which was manufactured in the U.S.A.

Quality Assurance Manager:


Jorge Alvarez

Date: 05-NOV-2024

The individual above has the authority to make this certificate legally binding for Insteel Wire Products Company.



PACKING LIST

Houston, TX

ENCON ARIZONA LLC
DBA TPAC
PHOENIX AZ 85009-6926

Bill of Lading: 00403593
Order Number: 571876
PO Number: CH241372
Date: 05-NOV-24

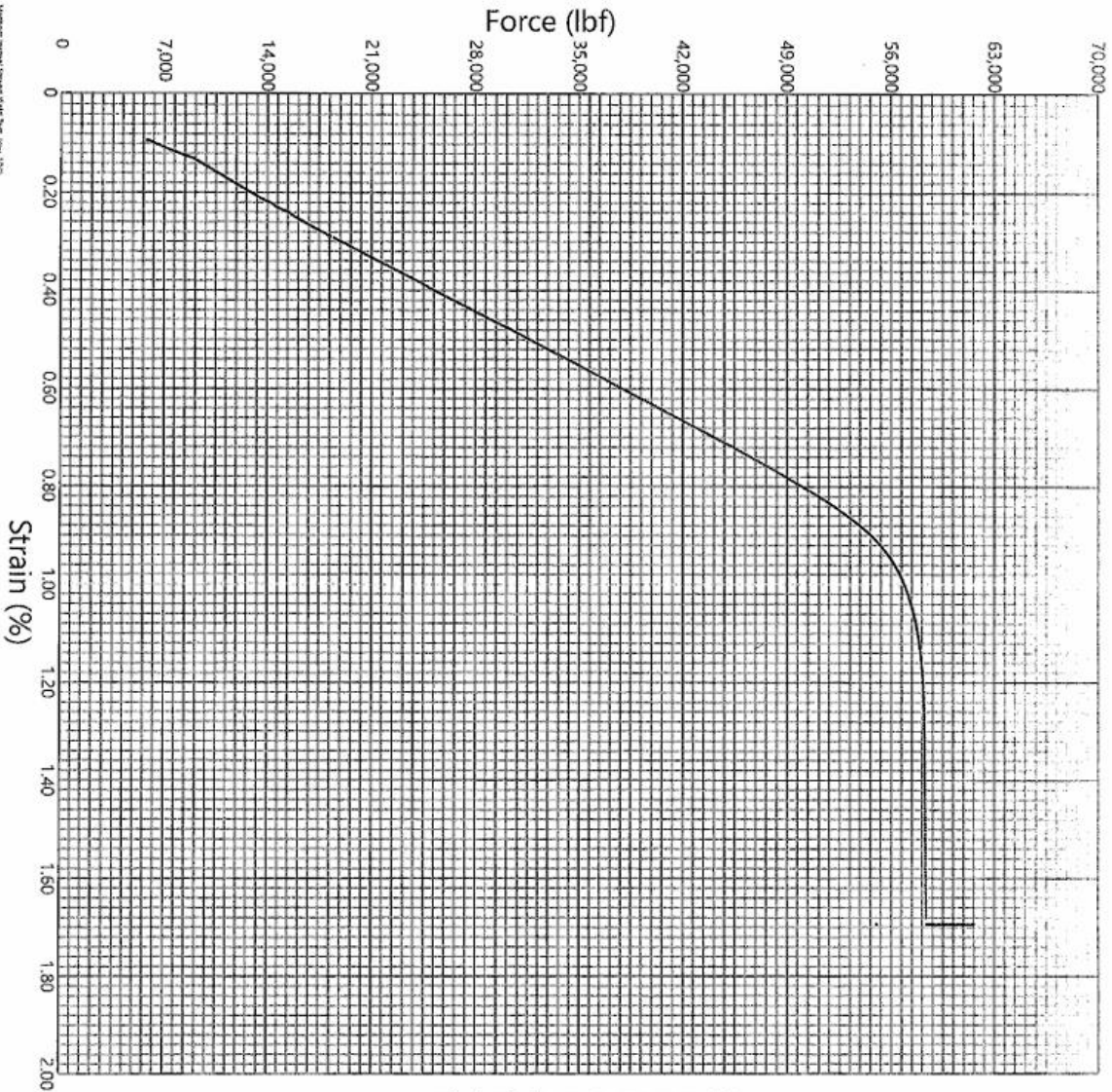
Lot Number	Description	Length	Weight
120237462123	.600 (15.2mm) 7W 270 LR ASTM A416	9030	6799.2288
120237462124	.600 (15.2mm) 7W 270 LR ASTM A416	9030	6799.2288
120237462128	.600 (15.2mm) 7W 270 LR ASTM A416	9030	6799.2288
120237462135	.600 (15.2mm) 7W 270 LR ASTM A416	9030	6799.2288
120237462136	.600 (15.2mm) 7W 270 LR ASTM A416	9030	6799.2288
120237462137	.600 (15.2mm) 7W 270 LR ASTM A416	9030	6799.2288
120237462141	.600 (15.2mm) 7W 270 LR ASTM A416	9030	6799.2288
Total Number of Packs 7		Totals	63210 47595



This test performed at
11020 Tanner Road
Houston, TX 77041
(800) 791-4108

Test Type: .600" 270 TW LOW RELAXATION

Test Number: 37241025104859
Tested By: J Alvarez
Ultimate Breaking Strength: 61,610 lbf
Ultimate Breaking Strength: 274 kN
Load @ 1% Extension: 56,895 lbf
Load @ 1% Extension: 253 kN
Ultimate Elongation: 4.7 %
Strand Diameter: 0.600 in
Rep. Area: 0.217 in²
Rep. Area: 140 mm²
Actual Area: 0.2195 in²
Actual Area: 141.6 mm²
Lay Length: 8.63 in
Avg Modulus of Elasticity: 28.8 Mpsi
Avg Modulus of Elasticity: 198,569 MPa
Reference:



Manufactured Under Patent No. 1,200,000
V103.1.10 - 339317US - Insteel Wire Products

5742103 - 8000000N, Printed 10/25/2024 10:49 AM

Appendix A.4 C-33 Test Data: Aggregates

SAMPLE INFORMATION:

LOCATION: 2024 - 19TH AVE PLANT C-33 TESTING
DESCRIPTION: NO. 57 AGGREGATE
REVIEWED BY: D. JARRELL

MECHANICAL SIEVE ANALYSIS				METHOD
ASTM C 136				
SIEVE SIZE		% PASSING		
US STD	METRIC	RESULTS	SPEC	
2"	50	--		
1.5"	38		100	
1.25"	31.5	100		
1"	25	98	95-100	
3/4"	19	69		
1/2"	12.5	31	25-60	
3/8"	9.5	14		
1/4"	6.4	3		
No. 4	4.8	1	0-10	
No. 8	2.36	1	0-5	
No. 10	2.00	1		
No. 16	1.18	0		
No. 30	0.60	0		
No. 40	0.425	0		
No. 50	0.3	0		
No. 100	0.15	0		
No. 200	0.075	0.0	0-1.0	

COARSE SPECIFIC GRAVITY & ABSORPTION				ASTM C 127
		RESULTS	SPEC	
SPECIFIC GRAVITY, OD		2.558		
SPECIFIC GRAVITY, SSD		2.606		
SPECIFIC GRAVITY, APP		2.687		
% ABSORPTION		1.9%		

UNIT WEIGHT				ASTM C 29
	RODDED	JIGGING	SHOVEL	
UNIT WEIGHT (pcf)	97.2	103.0	92.3	

LA ABRASION			ASTM C 131 B
		RESULTS	SPEC
100 REVOLUTIONS % LOSS		4	
500 REVOLUTIONS % LOSS		22	50 MAX

SODIUM SULFATE SOUNDNESS			ASTM C 88
		RESULTS	SPEC
%LOSS - COARSE AGG		0.3	12 MAX

CLAY LUMPS & FRIABLE PARTICLES			ASTM C 142
		RESULTS	SPEC
% COARSE		0.2	5.0 MAX

LIGHTWEIGHT PARTICLES IN AGGREGATE			ASTM C 123
		RESULTS	SPEC
% OF LIGHTWEIGHT PARTICLES		0.0	0.5 MAX

FRACTURED FACES			ASTM D5821
		RESULTS	SPEC
% FRACTURED - ONE OR MORE		74	--
% FRACTURED - TWO OR MORE		67	--

MATERIALS FINER THAN #200			ASTM C117
		RESULTS	SPEC
% FINER THAN #200		0.2	1.0 MAX

FLAT & ELONGATED PATICLES			ASTM D4791
		RESULTS	SPEC
3/4" SIEVE (%)		3	--
1/2" SIEVE (%)		4	--
3/8" SIEVE (%)		9	--
1/4" SIEVE (%)		11	--
% FLAT & ELONGATED		8	20 MAX

PHX-05351

Ninyo & Moore
 Geotechnical & Environmental Sciences Consultants

C-33 TEST DATA
 CEMEX/C-33 TESTING
 PHOENIX, ARIZONA
 604297002 | 1/24

SAMPLE INFORMATION:

LOCATION: 2024 - 19TH AVE PLANT C-33 TESTING
DESCRIPTION: NO. 7 AGGREGATE
REVIEWED BY: D. JARRELL

MECHANICAL SIEVE ANALYSIS **METHOD**
ASTM C 136

SIEVE SIZE		% PASSING	
US STD	METRIC	RESULTS	SPEC
2"	50	--	
1.5"	38		
1.25"	31.5		
1"	25		
3/4"	19	100	100
1/2"	12.5	94	90-100
3/8"	9.5	48	40-70
1/4"	6.4	21	
No. 4	4.8	9	0-15
No. 8	2.36	1	0-5
No. 10	2.00	1	
No. 16	1.18	1	
No. 30	0.60	0	
No. 40	0.425	0	
No. 50	0.3	0	
No. 100	0.15	0	
No. 200	0.075	0.1	0-1.0

COARSE SPECIFIC GRAVITY & ABSORPTION **ASTM C 127**

	RESULTS	SPEC
SPECIFIC GRAVITY, OD	2.584	
SPECIFIC GRAVITY, SSD	2.622	
SPECIFIC GRAVITY, APP	2.684	
% ABSORPTION	1.4%	

UNIT WEIGHT **ASTM C 29**

	RODDED	JIGGING	SHOVEL
UNIT WEIGHT (pcf)	99.3	100.6	92.6

LA ABRASION **METHOD**
ASTM C 131 C

	RESULTS	SPEC
100 REVOLUTIONS % LOSS	4	
500 REVOLUTIONS % LOSS	20	50 MAX

SODIUM SULFATE SOUNDNESS **ASTM C 88**

	RESULTS	SPEC
%LOSS - COARSE AGG	0.6	12 MAX

CLAY LUMPS & FRIABLE PARTICLES **ASTM C 142**

	RESULTS	SPEC
% COARSE	0.2	5.0 MAX

LIGHTWEIGHT PARTICLES IN AGGREGATE **ASTM C 123**

	RESULTS	SPEC
% OF LIGHTWEIGHT PARTICLES	0.0	0.5 MAX

FRACTURED FACES **ASTM D5821**

	RESULTS	SPEC
% FRACTURED - ONE OR MORE	97	--
% FRACTURED - TWO OR MORE	93	--

MATERIALS FINER THAN #200 **ASTM C117**

	RESULTS	SPEC
% FINER THAN #200	0.3	1.0 MAX

FLAT & ELONGATED PATICLES **ASTM D4791**

	RESULTS	SPEC
3/8" SIEVE (%)	2	--
1/4" SIEVE (%)	9	--
No. 4 SIEVE (%)	14	--
% FLAT & ELONGATED	8	20 MAX

PHX-05352

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

C-33 TEST DATA
CEMEX/C-33 TESTING
PHOENIX, ARIZONA
604297002 | 1/24

SAMPLE INFORMATION:

LOCATION: 2024 - 19TH AVE PLANT C-33 TESTING
DESCRIPTION: NO. 8 AGGREGATE
REVIEWED BY: D. JARRELL

MECHANICAL SIEVE ANALYSIS **METHOD**
ASTM C 136

SIEVE SIZE		% PASSING	
US STD	METRIC	RESULTS	SPEC
2"	50	--	
1.5"	38		
1.25"	31.5		
1"	25		
3/4"	19		
1/2"	12.5	100	100
3/8"	9.5	100	85-100
1/4"	6.4	61	
No. 4	4.8	18	10-30
No. 8	2.36	2	0-10
No. 10	2.00	1	
No. 16	1.18	1	0-5
No. 30	0.60	1	
No. 40	0.425	1	
No. 50	0.3	0	
No. 100	0.15	0	
No. 200	0.075	0.1	0-1.0

COARSE SPECIFIC GRAVITY & ABSORPTION **ASTM C 127**

	RESULTS	SPEC
SPECIFIC GRAVITY, OD	2.524	
SPECIFIC GRAVITY, SSD	2.579	
SPECIFIC GRAVITY, APP	2.670	
% ABSORPTION	2.2%	

UNIT WEIGHT **ASTM C 29**

	RODDED	JIGGING	SHOVEL
UNIT WEIGHT (pcf)	88.2	90.0	83.3

LA ABRASION **METHOD**
ASTM C 131 C

	RESULTS	SPEC
100 REVOLUTIONS % LOSS	6	
500 REVOLUTIONS % LOSS	20	50 MAX

SODIUM SULFATE SOUNDNESS **ASTM C 88**

	RESULTS	SPEC
%LOSS - COARSE AGG	0.4	12 MAX

CLAY LUMPS & FRIABLE PARTICLES **ASTM C 142**

	RESULTS	SPEC
% COARSE	0.3	5.0 MAX

LIGHTWEIGHT PARTICLES IN AGGREGATE **ASTM C 123**

	RESULTS	SPEC
% OF LIGHTWEIGHT PARTICLES	0.0	0.5 MAX

FRACTURED FACES **ASTM D5821**

	RESULTS	SPEC
% FRACTURED - ONE OR MORE	93	--
% FRACTURED - TWO OR MORE	92	--

MATERIALS FINER THAN #200 **ASTM C117**

	RESULTS	SPEC
% FINER THAN #200	0.4	1.0 MAX

FLAT & ELONGATED PATICLES **ASTM D4791**

	RESULTS	SPEC
1/4" SIEVE (%)	6	--
No. 4 SIEVE (%)	13	--
--		
% FLAT & ELONGATED	6	20 MAX

PHX-05353

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

C-33 TEST DATA
CEMEX/C-33 TESTING
PHOENIX, ARIZONA
604297002 | 1/24

SAMPLE INFORMATION:

LOCATION: 2024-19TH AVE PLANT C-33 TESTING
DESCRIPTION: CONCRETE SAND
LAB TECHNICIAN: JB

MECHANICAL SIEVE ANALYSIS		METHOD	
		ASTM C 136	

SIEVE SIZE		% PASSING	
US STD	METRIC	RESULTS	SPEC
2"	50		
1.5"	38		
1.25"	31.5		
1"	25		
3/4"	19		
1/2"	12.5		
3/8"	9.5	100	100
1/4"	6.4	100	
No. 4	4.8	100	95-100
No. 8	2.36	92	80-100
No. 10	2.00	87	
No. 16	1.18	70	50-85
No. 30	0.60	39	25-60
No. 40	0.425	25	
No. 50	0.3	14	5-30
No. 100	0.15	4	0-10
No. 200	0.075	0	0-3.0

FINENESS MODULUS		METHOD	
		ASTM C33	

	RESULTS	SPEC
FINENESS MODULUS	2.8	2.3-3.1

UNIT WEIGHT		METHOD	
		ASTM C 29	

	RODDED	JIGGING	SHOVEL
UNIT WEIGHT (pcf)	106.7	100.9	101.5

ATTERBERG LIMITS		METHOD	
		ASTM D4318	

	RESULTS	SPEC
LIQUID LIMIT (LL) (%)	--	
PLASTIC LIMIT (PL) (%)	--	
PLASTICITY INDEX (PI) (%)	NP	

SODIUM SULFATE SOUNDNESS		METHOD	
		ASTM C 88	

	RESULTS	SPEC
%LOSS - FINE AGG	3.0	10 MAX

CLAY LUMPS & FRIABLE PARTICLES		METHOD	
		ASTM C 142	

	RESULTS	SPEC
% FINE	0.3	3.0 MAX

SAND EQUIVELANT		METHOD	
		AASHTO T176	

	RESULTS	SPEC
SAND EQUIVELANT	88	

LIGHTWEIGHT PARTICLES IN AGGREGATE		METHOD	
		ASTM C 123	

	RESULTS	SPEC
% OF LIGHTWEIGHT PARTICLES	0.2	1.0 MAX

ORGANIC IMPURITIES IN FINE AGGREGATE		METHOD	
		ASTM C40	

	RESULTS	SPEC
ORGANIC PLANT NO.	1	

FINE SPECIFIC GRAVITY & ABSORPTION		METHOD	
		ASTM C 128	

	RESULTS	SPEC
SPECIFIC GRAVITY, OD	2.587	--
SPECIFIC GRAVITY, SSD	2.626	--
SPECIFIC GRAVITY, APP	2.692	--
% ABSORPTION	1.5	--

PHX-05354

Appendix A.5 Manufacturer's Certification of Compliance: Type II/V, Low Alkali, Portland Cement



CALPORTLAND COMPANY
Manufacturers of Arizona Cements – Rillito Cement Plant
11115 N Casa Grande Hwy
PO Box 338
Rillito, AZ 85654-0338
Phone: (520) 682-2221

MANUFACTURER'S CERTIFICATION

We hereby certify that the following **Type II/V, Low Alkali**, Portland cement lots, specified as **"EXTRA"** has been shipped from the United States, CALPORTLAND Rillito Cement Plant, in Rillito, Arizona. All Type II/V cement lots shipped from Rillito meet or exceed the current ASTM C150 specifications for Type II and Type V Low Alkali Cement. Additionally, this cement meets or exceeds the requirements listed in Subsection 1006-2.01 of the Arizona Department of Transportation Specifications, and the requirements of Caltrans Standard Specification Sec. 90 paragraph 2.01.

Individual certifications can be obtained with each load upon request and delivered to your plant sites. These certifications will contain pertinent data including shipping lot number.

The Shipping Lot Numbers for the month of **November 2024** are as follows:

298241x

A handwritten signature in black ink, reading 'John A. Bartolucci', is written over a horizontal line.

John A. Bartolucci

Date Signed: Sunday, December 1, 2024

Quality Control Superintendent



Manufacturer's Certification

Report Date: 12/5/2024

We hereby certify that CalPortland Type II/V EXTRA Cement meets the standard requirements of ASTM C150 and AASHTO M85 specification for Type II and Type V cements. Reported are the average chemical and physical data for the month.

Month: November, 2024

Type II / V EXTRA Cement

Source: Rillito, AZ, USA

Chemical Properties, (ASTM C114)	ASTM C150 and AASHTO M85 Requirements		Analysis	Limestone
	Type II	Type V	Results	Analysis
Silicon dioxide (SiO ₂), %	---	---	20.3	2.8
Aluminum oxide (Al ₂ O ₃), max, %	6.0	---	4.1	0.8
Ferric oxide (Fe ₂ O ₃), max, %	6.0	---	3.2	1.0
Calcium oxide (CaO), %	---	---	62.3	40.8
Magnesium oxide (MgO), max, %	6.0	6.0	3.9	16.1
Sulfur trioxide (SO ₃) ¹ , max, %	3.0	2.3	3.3	0.1
Loss on ignition (LOI), max, %	3.5	3.5	2.4	
Insoluble residue (IR), max, %	1.5	1.5	1.0	Base
Alkalies (Na ₂ O+0.658*K ₂ O), %	---	---	0.32	Cement
Tricalcium silicate (C ₃ S), %	---	---	53	55
Dicalcium silicate (C ₂ S), %	---	---	18	18
Tricalcium aluminate (C ₃ A), max, %	8	5	5	6
Tetracalcium aluminoferrite (C ₄ AF), %	---	---	10	10
C ₄ AF + 2(C ₃ A), max, %	---	25	21	
CO ₂ , %	---	---	1.2	
Limestone addition, max, %	5.0	5.0	2.8	
CaCO ₃ in Limestone, min, %	70	70	96	
Physical Properties				
Air content of mortar, max, volume %, (C185)	12	12	7	
Blaine Fineness, min, m ² /kg, (C204)	260	260	594	
Autoclave expansion, max, %, (C151)	0.80	0.80	0.06	
Compressive Strength, min, (C109)				
3 Day, MPa	10.0	8.0	35.6	
3 Day, psi	1450	1160	5160	
7 Day, MPa	17.0	15.0	42.2	
7 Day, psi	2470	2180	6120	
28 Day (from prior month), MPa	---	21.0	48.1	
28 Day (from prior month), psi	---	3050	6970	
Vicat Setting Time, min-max, minutes, (C191)	45 - 375	45 - 375	102	
Expansion (from prior month), max, %, (C1038)	0.020	0.020	0.007	

Apparatus and methods used in this laboratory have been checked by the Cement and Concrete Reference Laboratory of the National Institute of Standards and Technology. A copy of the report detailing their findings is available upon request. Major oxides are analyzed in accordance with ASTM C114.

Note 1: ASTM C150, Table 1, Note D, It is permissible to exceed the values in the table for SO₃ content, provided it has been demonstrated by Test Method C1038 that the cement with the increased SO₃ will not develop expansion exceeding 0.020% in 14 days.

John Bartolucci

John Bartolucci - Quality Control Superintendent

Appendix A.6 Summary Report for Annual Test of WCS Maricopa Aggregates

Summary Report for Annual Test of Aggregates Standar Specification for Concrete Aggregate (ASTM C33)



PROJECT:	2024 Annual ASTM C 33 Testing, Gila River S & G Maricopa Plant	JOB NO:	65151151
LOCATION:	Sacaton, Arizona	WORKORDER NO:	65151151.0111
MATERIAL:	Concrete Sand	LAB NO:	6115
SAMPLE SOURCE:	Gila River Sand and Gravel, Maricopa Plant, Stockpile	DATE SAMPLED:	10/19/2023

Sieve Analysis of Fine and Coarse Aggregates (ASTM C136/C117)			Sand Equivalent Value for Soils and Fine Aggregate (ASTM D2419)			
Mechanical Analysis						
Fineness Modulus = 2.760		ASTM C33				
Sieve Size	% Passing	Specs	Clay Reading	4.4	4.4	4.5
6in.	100		Sand Reading	4	4	4.1
4in.	100		Sand Equivalent	90.9	90.9	91.1
3in.	100		Sand Eq. Recorded	91	91	92
2in.	100		Sand Eq. Average	92		
1 1/2in.	100		Sand Equivalent	92		
1 1/4in.	100					
1in.	100					
3/4in.	100					
1/2in.	100					
3/8in.	100	100				
1/4in.	100					
#4	99	95-100				
#8	86	80-100				
#10	82					
#16	67	50-85				
#30	44	25-60				
#40	30					
#50	17	5-30				
#100	5	0-10				
#200	2.0	0-3				
Specific Gravity and Absorption of Coarse Aggregate (ASTM C127)			Clay Lumps and Friable Particles in Aggregate (ASTM C142)			
			Fine			
Wgt. of S.S.D aggregate			Percentage of Clay Lumps and Friable Particles			
Wgt. of flask & water			0.4			
Wgt. of oven dry sample in air			ASTM C33 Spec <=3.0%			
Wgt. of flask & water & S.S.D.						
Bulk specific gravity						
Bulk specific gravity (S.S.D)						
Apparent specific gravity						
Percent absorption						
			Liquid Limit, Plastic Limit and Plasticity Index of Soils (ASTM D4318)			
			Liquid Limit	NV	Plasticity Index	NP
			Lightweight Pieces in Aggregate (ASTM C123)			
			Fine			
			Dry Weight of Aggregate (g)		216.4	
			% of Lightweight Pieces (fine)		0.0	
			ASTM C33 Spec <0.5%			
			Amount of Material Finer Than #200 Sieve (ASTM C117)			
			-#200 Wash %			
			0.9			
			ORGANIC IMPURITIES IN FINE AGGREGATE (ASTM C40)			
			Color Match:	Clear	Less than	One
			UNIT WEIGHT AND VOIDS IN AGGREGATE (ASTM C29/C29M)			
			Volume of measure (cu.ft)		0.1000	
			Unit weight (lbs per cu.ft)		104.8	
			Bulk Specific Gravity		2.581	
			Void Content (%)		35	
Soundness of Aggregate by use of Sodium Sulfate (ASTM C88)						
Passing	Retained	Grading on original sample	Weight before testing (g)	Weight after testing (g)	Percent loss	Corrected percent loss
Fine						
3/8 in / 9.5mm	#4	0.9%			4.4%	0
#4	#8	13.6%	100.0	95.6	4.4%	0.6%
#8	#16	18.3%	100.0	97.4	2.6%	0.5%
#16	#30	23.7%	100.0	98.8	1.2%	0.3%
#30	#50	27.6%	100.0	99.4	0.6%	0.2%
Minus #50		17.2%	--	--	--	0.0%
	Total:	100.0%			Total Loss:	2%
ASTM C33 Spec <10%						

REVIEWED BY

Appendix A.7 Pozzolan Test Report: Fly Ash Type F



TPAC
3052 S 19th Ave
Phoenix, AZ 85009-6926

Product: ASTM C618/C1697 Class F, 19th Ave Fly Ash
AASHTO M295

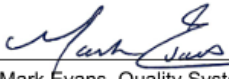
POZZOLAN TEST REPORT

November 2024	Results	Specifications
Chemical Analysis (C311 / C114 / T105 / D4326)		
Silicon Dioxide, SiO ₂	56.2 %	---
Aluminum Oxide, Al ₂ O ₃	20.8 %	---
Ferric Oxide, Fe ₂ O ₃	4.8 %	---
SiO ₂ + Al ₂ O ₃ + Fe ₂ O ₃	81.9 %	50.0 Min
Calcium Oxide, CaO	7.2 %	18.0 Max
Magnesium Oxide, MgO	2.0 %	---
Sulfur Trioxide, SO ₃	0.7 %	5.0 Max
Moisture Content	0.5 %	3.0 Max
Loss on Ignition	1.8 %	6.0 Max
Sodium Oxide, Na ₂ O	1.4 %	---
Potassium Oxide, K ₂ O	1.3 %	---
Total Alkalis	2.2 %	---
Available Alkalis	1.2 %	---
Physical Analysis		
Fineness, amount retained on		
#100 sieve, % (C136) **		
#325 sieve, % (C430)	19	34 Max
variation, points from average	0.0	+/- 5 Max
Density, g/cm ³ (C188)	2.51	---
Variation from average, %	0.2	+/- 5 Max
Strength Activity Index		
with Portland Cement (C311 / C109)		
at 7 days, % of cement control	81	---
at 28 days, % of cement control	87	75 Min
Water Requirement (C311)		
% of cement control	99	105 Max
Soundness, autoclave expansion (C311 / C151)		
or contraction, %	0.01	

** Per Table 2, Note A - only applies to coal ash that is harvested or contains bottom ash

All tests have been made in strict accordance with the current standards of the American Society for Testing and Materials covering the type of material specified. May contain harvested fly ash.




Mark Evans, Quality Systems Manager
03 DEC 2024

PHOENIX CEMENT

Tel: 480-850-5757 • Fax: 480-850-5758 • 8800 E Chaparral Rd • Ste 155 • Scottsdale, AZ 85250

Clarkdale Cement Plant
601 N. Cement Plant Rd
Clarkdale, AZ 86324

Lower Buckeye Terminal
1941 W. Lower Buckeye Rd
Phoenix, AZ 85007

54th Ave. Terminal
5402 W Buchanan St.
Phoenix, AZ 85043

21st Ave. Terminal
1325 N. 21st Ave.
Phoenix, AZ 85009

19th Ave. Terminal
1802 W. Lower Buckeye Rd
Phoenix, AZ 85007

Dobson Storage
9595 E. McKellips Rd.
Scottsdale, AZ 85250

Cholla Fly Ash Plant
4801 Frontage Rd.
Joseph City, AZ 86032

Four Corners Fly Ash Plant
End of County Road 6675
Fruitland, NM 87416

Bonanza Fly Ash Plant
12500 East, 25500 South
Vernal, UT 84078

Huntington Fly Ash Plant
8 Miles West on Highway 31
Huntington, UT 84528

Apache Fly Ash Plant
3537 H Highway 191 South
Cochise, AZ 85606

Coronado Generating Station
Hwy 191, 7 miles North of St. Johns
St. Johns, AZ 85936

Gallup Terminal
900 N 9th St.
Gallup, NM 87301

Fontana Terminal
13600 Napa St.
Fontana, Ca 92335

Bakersfield Terminal
32535 7th Standard Rd.
Bakersfield, CA 93314

Stockton Terminal
1300 N. Gertrude Ave.
Stockton, CA 95215

Tucson Terminal
4120 E Irvington Rd
Tucson, AZ 85714

Appendix B Admixture Data Sheets

Appendix B.1 ADVA CAST 575

TECHNICAL DATA SHEET

ADVA® CAST 575

High Range Water Reducing Admixture

Chryso
Concrete
Solutions

01/03/2025

DESCRIPTION

ADVA® Cast 575 is a high efficiency, low addition rate polycarboxylate-based high-range water reducer designed for the production of a wide range of concrete mixes, from conventional to Self-Consolidating Concrete (SCC). It is designed to impart extreme workability without segregation to the concrete.

ADVA® Cast 575 is supplied as a ready-to-use liquid that weighs approximately 8.9 lbs/gal (1.1 kg/L). ADVA® Cast 575 does not contain intentionally added chlorides.

ADVANTAGES

- Excellent dosage efficiency, moisture control and air control
- Superior air entrainment control
- Enhanced concrete cohesiveness with low viscosity for rapid placement
- Superior finish on cast surfaces
- Enhanced strength development

FIELDS OF APPLICATION

- Formulated to impart improved workability to the concrete and to achieve high early compressive strength as required by the precast industry.

Method of Use

Dosage

- ADVA® Cast 575 is an easy to dispense liquid admixture. Dosage rates can be adjusted to meet a wide spectrum of concrete performance requirements. Addition rates for ADVA® Cast 575 can vary from 2 to 10 fl oz/100 lbs (130 to 650 mL/100 kg) with the type of application, but will typically range from 3 to 6 fl oz/100 lbs (200 to 390 mL/100 kg) of cementitious.
- Should conditions require using more than the recommended addition rate, please consult your representative.
- Mix proportions, cementitious content, aggregate gradations and ambient conditions will affect ADVA® Cast 575 dosage requirements. If materials or conditions require using more than the recommended addition rates, or when developing mix designs for Self-Consolidating Concrete please consult your representative for more information and assistance.

Additional Usage Recommendations

- ADVA® Cast 575 is a plant-added superplasticizer that is formulated to impart improved workability to the concrete and to achieve high early compressive strength as required by the precast industry. ADVA® Cast 575 can be used for the production of Self-Consolidating Concrete in precast/prestressed applications and may be used in conventional concrete production.
- ADVA® Cast 575 may be used in low water-cementitious ratio applications where concrete stability and improved tolerance to concrete material variability are required.
- ADVA® Cast 575 may be used to produce concrete with very low water/cementitious ratios while maintaining normal levels of workability.

Equipment

- A complete line of accurate, automatic dispensing equipment is available.

Complimentary Products

- ADVA® Cast 575 is compatible with most admixtures as long as they are added separately to the concrete mix. However, ADVA® products

The information contained in this technical data sheet is given to the best of our knowledge and the result from extensive testing - which were conducted in order to remain as objective as possible. However, it cannot, in any case, be considered as a warranty involving our liability in case of misuse or any different use of our products, other than those from the "Application" paragraph of this technical data sheet. Some application tests should be carried out before using the product to ensure that the methods of use and conditions of application of the product are satisfactory. Our technical assistance is at the disposal of the users.

P.1/2



TECHNICAL DATA SHEET

ADVA® CAST 575

High Range Water Reducing Admixture

Chryso
Concrete
Solutions

01/03/2025

are not recommended for use in concrete containing naphthalene-based admixtures including DARACEM® 19 and DARACEM®100 and melamine-based admixtures including DARACEM® 65. In general, it is recommended that ADVA® Cast 575 be added to the concrete mix near the end of the batch sequence for optimum performance. Different sequencing may be used if local testing shows better performance. Please see [Technical Bulletin TB-0110, Admixture Dispenser Discharge Line Location and Sequencing for Concrete Batching Operations](#) for further recommendations.

- Pretesting of the concrete mix should be performed before use and as conditions and materials change in order to assure compatibility with other admixtures, and to optimize dosage rates, addition times in the batch sequencing and concrete performance. For concrete that requires air entrainment, the use of an ASTM C260 air-entraining agent (such as DARAVAIR® or DAREX® product lines) is recommended to provide suitable air void parameters for freeze-thaw resistance. Please consult your representative for guidance.

CHARACTERISTICS

Product Nature	Liquid
Color	Blue green
Shelf life	12 months
Specific gravity (25°C) in g/ml	1,079
pH (25°C)	5,20

PRECAUTIONS

- ADVA® Cast 575 will freeze at approximately 32°F (0°C) but will return to full functionality after thawing and thorough mechanical agitation.

SAFETY

Prior to any use, please read carefully the Safety data Sheet.

PACKAGING

- Bulk
- 55 gallon drum
- 275 gallon tote

ADDITIONAL INFORMATION

ADVA® Cast 575 ASTM C494 Type F High-Range Water Reducer Test Data

	US UNITS - CONTROL	US UNITS - ADVA® CAST 575	METRIC - CONTROL	METRIC - ADVA® CAST 575
Cement (g/gal)	517	517	307	307
Coarse aggregate (g/gal)	1944	1944	1153	1153
Fine aggregate (g/gal)	1144	1214	679	720
Water (g/gal)	248	211	143	125
w/cm	0.48	0.41	0.48	0.41
Slump (inches)	3.5	3.25	89	83
Plastic air (%)	5.4	5.5	5.4	5.5
Compressive strength				
1 day (psi) (MPa)	1400	2050	10.1	14.1
7 day (psi) (MPa)	4380	6040	30.2	41.8
28 day (psi) (MPa)	5570	7270	38.4	50.1
Initial set time (hr:min)	4:56	3:57	4:56	3:57
Length change 28 day (%)	-0.027	-0.029	-0.027	-0.029
Freeze-thaw resistance (SDRAC %)	88	91	88	91

The information contained in this technical data sheet is given to the best of our knowledge and the result from extensive testing - which were conducted in order to remain as objective as possible. However, it cannot, in any case, be considered as a warranty involving our liability in case of misuse or any different use of our products, other than those from the "Application" paragraph of this technical data sheet. Some application tests should be carried out before using the product to ensure that the methods of use and conditions of application of the product are satisfactory. Our technical assistance is at the disposal of the users.

P.2/2



Appendix B.2 DARASET 400-1

TECHNICAL DATA SHEET

DARASET® 400

Accelerating Admixture
Non-Chloride

Chryso
Concrete
Solutions

12/13/2024

DESCRIPTION

DARASET® 400 is a non-corrosive, non-chloride set accelerator that offers setting time results and early strength development comparable to calcium chloride, but without the corrosive effects.

Meets or exceeds the requirements of ASTM C494 Type C and can be used at any dosage to meet ACI 318 Guidelines for Chloride Content in Concrete.

ADVANTAGES

- Accelerates setting time
- Increases early compressive and flexural strengths
- Offsets the retarding effects of pozzolans such as slag or fly ash
- Enables cold weather concreting

FIELDS OF APPLICATION

- All Cement Types
- Precast Concrete
- Ready-Mix Concrete
- Concrete Patching
- Very High Early Strength Concrete
- Pre-Stressed Concrete

Method of Use

Dosage

- DARASET® 400 dosage rates can vary with the type of application. The addition rate can range between 10 oz/cwt and 60 oz/cwt (650 mL/100 kg and 3910 mL/100 kg) of cementitious material.
- Optimal addition rates will depend upon specific job conditions, on local materials and on the degree of set acceleration & early strength development required.
- Typical results show that when concrete containing DARASET® 400 is poured at 50°F (10°C), the concrete will set up to 2 hours faster than the reference concrete.
- Addition rates may vary when used in conjunction with other CHRYSO® admixtures.
- Should conditions require using more than the recommended addition rates, please consult your CHRYSO® representative.

Additional Usage Recommendations

- Suitable for use in concrete placed on steel-clad or zinc-coated steel decks where corrosion prevention is crucial.

Implementation

- In general, it is recommended that DARASET® 400 be added to the concrete mix near the end of the batch sequence for optimum performance. Different sequencing may be used if local testing shows better performance.
- Please see [Technical Bulletin TB-0110](#), *Admixture Dispenser Discharge Line Location and Sequencing for Concrete Batching Operations* for further recommendations.
- When used in air entrained concrete, trial mixes must be made to determine the quantity of air-entraining admixture required.
- The concrete producer should account for the water contained in the product. Each gallon of DARASET® 400 added to a concrete mix will contribute 6.3 lbs (0.76 kg/L) of water to that mix.
- Pretesting of the concrete mix should be performed before use and as conditions and materials change in order to assure compatibility with other admixtures, and to optimize dosage rates, addition times in the batch sequencing and concrete performance.

The information contained in this technical data sheet is given to the best of our knowledge and the result from extensive testing - which were conducted in order to remain as objective as possible. However, it cannot, in any case, be considered as a warranty involving our liability in case of misuse or any different use of our products, other than those from the "Application" paragraph of this technical data sheet. Some application tests should be carried out before using the product to ensure that the methods of use and conditions of application of the product are satisfactory. Our technical assistance is at the disposal of the users.

P.1/2



TECHNICAL DATA SHEET

DARASET® 400

Accelerating Admixture
Non-Chloride

Chryso
Concrete
Solutions

12/13/2024

Equipment

- A complete line of accurate, automatic dispensing equipment is available.

Complimentary Products

- DARASET® 400 is compatible with most CHRYSO® admixtures as long as they are added separately to the concrete mix, usually through the water holding tank discharge line.
- For concrete that requires air entrainment, the use of an ASTM C260 air-entraining agent is recommended to provide suitable air void parameters for freeze-thaw resistance.

Performances

- Provides shorter set times and increased early compressive & flexural strengths.

CHARACTERISTICS

Product Nature	Liquid
Color	Light brown
Shelf life	18 months
Cl ⁻ ions content	< 0,100 %
Specific gravity (25°C) in g/ml	1,453
pH (25°C)	9,30

PRECAUTIONS

- Product will begin to freeze at approximately -10°F (-23°C), but will return to full strength after thawing and thorough agitation.
- Do not use pressurized air for agitation.

SAFETY

Prior to any use, please read carefully the Safety data Sheet.

PACKAGING

- Bulk
- 275 gallon tote
- 55 gallon drum

ADDITIONAL CERTIFICATIONS & MARKINGS

- DARASET® 400 is NSF Std. 61 certified when used at a maximum addition rate of 40 fl oz/100 lbs (2600 mL/100 kg) of cementitious material. Certification of compliance will be made available upon request.

The information contained in this technical data sheet is given to the best of our knowledge and the result from extensive testing - which were conducted in order to remain as objective as possible. However, it cannot, in any case, be considered as a warranty involving our liability in case of misuse or any different use of our products, other than those from the "Application" paragraph of this technical data sheet. Some application tests should be carried out before using the product to ensure that the methods of use and conditions of application of the product are satisfactory. Our technical assistance is at the disposal of the users.

P.2/2



Appendix B.3 DARAVAIR 1000

TECHNICAL DATA SHEET

DARAVAIR® 1000

Air entraining admixture

Chryso
Concrete
Solutions

02/18/2025

DESCRIPTION

DARAVAIR® 1000 is a high-grade saponified rosin based air-entraining admixture that provides freeze-thaw resistance, yield control and finishability performance across the full range of concrete mix designs. Chemically similar to vinsol-based products, but with increased purity and supply dependability.

ADVANTAGES

- Produces rapid air build suitable for short mix cycles
- Performs reliably & consistently across a wide spectrum of mix designs
- Improves the durability of concrete to severe exposures

FIELDS OF APPLICATION

- All Cement Types
- Precast Concrete
- Post Tensioned & Prestressed Concrete
- Ready-Mix Concrete
- Concrete Exposed to Freeze-Thaw Cycles

Method of Use

Dosage

- DARAVAIR® 1000 dosage rates can vary with the type of application. The addition rate can range between 0.5 oz/cwt and 3 oz/cwt (30 mL/100 kg and 200 mL/100 kg) of cementitious material.
- Optimal addition rates will depend on temperature, cement, sand gradation, and the use of extra fine materials such as fly ash and microsilica.
- Dosage rates may vary when used in conjunction with other CHRYSO® admixtures. The air-entraining capacity of DARAVAIR® 1000 is usually increased when other concrete admixtures are contained in the concrete, particularly water-reducing admixtures and water-reducing retarders. This may allow up to ⅓ reduction in the amount of product required.
- Should conditions require using more than the recommended addition rates, please consult your CHRYSO® representative.

Additional Usage Recommendations

- Formulated to perform across the entire spectrum of production mixes, it generates specification quality, freeze-thaw resistant air systems in concrete.

Implementation

- In general, it is recommended that DARAVAIR® 1000 be added early in the batching sequence for optimum performance, preferably by "dribbling" on the sand.
- Product should not be added directly to heated water.
- Different sequencing may be used if local testing shows better performance.
- Please see [Technical Bulletin TB-0110](#), *Admixture Dispenser Discharge Line Location and Sequencing for Concrete Batching Operations* for further recommendations.
- Pretesting of the concrete mix should be performed before use and as conditions and materials change in order to assure compatibility with other admixtures, and to optimize dosage rates, addition times in the batch sequencing, and concrete performance.

The information contained in this technical data sheet is given to the best of our knowledge and the result from extensive testing - which were conducted in order to remain as objective as possible. However, it cannot, in any case, be considered as a warranty involving our liability in case of misuse or any different use of our products, other than those from the "Application" paragraph of this technical data sheet. Some application tests should be carried out before using the product to ensure that the methods of use and conditions of application of the product are satisfactory. Our technical assistance is at the disposal of the users.

P.1/2



TECHNICAL DATA SHEET

DARAVAIR® 1000

Air entraining admixture

Chryso
Concrete
Solutions

02/18/2025

Equipment

- A complete line of accurate, automatic dispensing equipment is available.

Complimentary Products

- DARAVAIR® 1000 is compatible with most CHRYSO® admixtures as long as they are added separately to the concrete mix.

Performances

- Incorporates air into the concrete by the mechanics of mixing and stabilizing millions of discrete semi-microscopic bubbles.
- Promotes the mobility, or plasticity and workability of the concrete through air bubbles that act much like flexible ball bearings.
- Enables a reduction in mixing water with no loss of slump
- Aids placeability while minimizing bleeding, plastic shrinkage and segregation.
- Increases the volume of the concrete making it necessary to adjust the mix proportions to maintain the cement factor and yield.
- Produces impart resistance to the action of frost and de-icing salts as well as sulfate, sea and alkaline waters.

CHARACTERISTICS

Product Nature	Liquid
Color	Brown
Shelf life	12 months
Cl ⁻ Ions content	< 0,100 %
Specific gravity (25°C) in g/ml	1,013
pH (25°C)	10,40

PRECAUTIONS

- Product will begin to freeze at approximately -30 °F (-1 °C), but will return to full capabilities after thawing and thorough agitation.
- Do not use pressurized air for agitation.

SAFETY

Prior to any use, please read carefully the Safety data Sheet.

PACKAGING

- Bulk
- 1000L Tote (275 gallons)
- 210 L (55 Gallons) Drum

The information contained in this technical data sheet is given to the best of our knowledge and the result from extensive testing - which were conducted in order to remain as objective as possible. However, it cannot, in any case, be considered as a warranty involving our liability in case of misuse or any different use of our products, other than those from the "Application" paragraph of this technical data sheet. Some application tests should be carried out before using the product to ensure that the methods of use and conditions of application of the product are satisfactory. Our technical assistance is at the disposal of the users.

P.2/2

 **chryso**
SAINT-GOBAIN

Appendix B.4 RECOVER

TECHNICAL DATA SHEET

RECOVER®

Set retarding admixture

Chryso
Concrete
Solutions

12/17/2024

DESCRIPTION

RECOVER® is a ready-to-use aqueous solution of chemical compounds specifically designed to stabilize the hydration of Portland cement concretes.

Meets or exceeds the requirements of ASTM C494 Type B & D

ADVANTAGES

- Eliminates the need to discharge wash water from the mixer
- Prevents the waste of unused concrete
- Provides predictable extended set times
- Enables long hauls to remote sites

FIELDS OF APPLICATION

- All Cement Types
- Ready-Mix Concrete
- Precast Concrete
- Hot Weather Concreting
- Mass Concrete
- HPC & UHPC Concrete

Method of Use

Dosage

- RECOVER® addition rates can vary with the type of application. The addition rate can range between 6 fl. oz & 128 fl. oz (180 mL & 3800 mL) per treatment.
- Typical dosage rates are:
 - Returned or Lefover Concrete: 3 to 128 fl. oz/cwt (195 to 8350 mL/100 kg)
 - Set Time Extensions (+4 hours): 5 to 50 fl. oz/cwt (325 to 3260 mL/100 kg)
 - ASTM Type B or D Retarder: 2 to 6 fl. oz/cwt (130 to 390 mL/100 kg)
- Optimal addition rates will depend on the specific materials involved, mixer type and stabilization period.
- Dosage rates may vary when used in conjunction with other CHRYSO® admixtures.
- Should conditions require using more than the recommended addition rates, please consult your CHRYSO® representative.

Additional Usage Recommendations

- Designed to stabilize mixer wash water and returned or leftover concrete for extended periods, allowing for use of the materials when specified or allowed.
- Suitable for use where controlled extended set of concrete is needed. It is the concrete user's responsibility to determine if leftover, returned, or extended-set concrete is specified or allowed.
- Ideal for wash water applications, eliminating the need to discharge wash water from the mixer. This allows the wash water to be used as mix water in the next batch of concrete produced and prevents the residual plastic concrete from hardening.
- Used to prevent plastic concrete from reaching initial set for returned or leftover concrete. This allows the concrete to be stored in a plastic state and then used when specified or allowed. The use of this concrete may require the addition of freshly batched concrete and/or an accelerator.
- Recommended in situations where a controlled set time extension is required, such as extended hauls, large continuous pours, or pre-batching of concrete for later use.

The information contained in this technical data sheet is given to the best of our knowledge and the result from extensive testing - which were conducted in order to remain as objective as possible. However, it cannot, in any case, be considered as a warranty involving our liability in case of misuse or any different use of our products, other than those from the "Application" paragraph of this technical data sheet. Some application tests should be carried out before using the product to ensure that the methods of use and conditions of application of the product are satisfactory. Our technical assistance is at the disposal of the users.

P.1/2

 **chryso**
SAINT-GOBAIN

TECHNICAL DATA SHEET

RECOVER®

Set retarding admixture

Chryso
Concrete
Solutions

12/17/2024

Implementation

- In general, it is recommended that RECOVER® be added to the concrete mix near the end of the batch sequence for optimum performance. Different sequencing may be used if local testing shows better performance.
- Please see [Technical Bulletin TB-0110](#), *Admixture Dispenser Discharge Line Location and Sequencing for Concrete Batching Operations* for further recommendations.
- Pretesting of the concrete mix should be performed before use and as conditions and materials change in order to assure compatibility with other admixtures, and to optimize dosage rates, addition times in the batch sequencing and concrete performance.

Equipment

- A complete line of accurate, automatic dispensing equipment is available.
- *Reach 360TM System*, an innovative spray wand technology that simplifies wash water procedures.

Complimentary Products

- RECOVER® is compatible with most CHRYSO® admixtures as long as they are added separately to the concrete mix, usually through the water holding tank discharge line.
- For concrete that requires air entrainment, the use of an ASTM C260 air-entraining agent is recommended to provide suitable air void parameters for freeze-thaw resistance.

Performances

- Stabilizes the hydration process of Portland cement preventing it from reaching initial set. This stabilization is not permanent and is controlled by dosage rate.
- Provides stabilization of up to 96 hours is possible depending on dosage rate.
- Coats the interior of the mixer with treated wash water. The water is used as mix water in the next batch of concrete produced, which then scours the unhardened material from the interior of the mixer.
- Maintains the plasticity of returned or leftover concrete for the desired storage duration. The concrete resumes normal hydration when the dosage effects subside or when activated by fresh concrete or an accelerator, resulting in concrete with normal plastic and hardened properties.

CHARACTERISTICS

Product Nature	Liquid
Color	Blue green
Shelf life	9 months
Cl ⁻ Ions content	< 0,100 %
Specific gravity (25°C) in g/ml	1,116
pH (25°C)	6,80

PRECAUTIONS

- Product will begin to freeze at approximately 32 °F (0 °C), but will return to full capabilities after thawing and thorough agitation.
- Do not use pressurized air for agitation.

SAFETY

Prior to any use, please read carefully the Safety data Sheet.

PACKAGING

- 55 gallon drum
- 275 gallon tote
- Bulk

The information contained in this technical data sheet is given to the best of our knowledge and the result from extensive testing - which were conducted in order to remain as objective as possible. However, it cannot, in any case, be considered as a warranty involving our liability in case of misuse or any different use of our products, other than those from the "Application" paragraph of this technical data sheet. Some application tests should be carried out before using the product to ensure that the methods of use and conditions of application of the product are satisfactory. Our technical assistance is at the disposal of the users.

P.2/2

 **chryso**
SAINT-GOBAIN

TECHNICAL DATA SHEET

V-MAR® 3

Viscosity Modifying Admixture

Chryso
Concrete
Solutions

01/10/2025

DESCRIPTION

V-MAR® 3 is a high-efficiency, viscosity-modifying admixture designed to enhance the rheology of concrete, enabling its use in a wide variety of applications.

It enhances thixotropic properties, enabling the concrete to maintain its shape under stress and restore its viscosity when the stress is released.

ADVANTAGES

- Improves productivity
- Minimizes wear & tear on forms
- Enhances surface appearance for a superior finish
- Ensures minimal impact on air entrainment
- Reduces pump pressure
- Supports efficient slipform paving

FIELDS OF APPLICATION

- All Cement Types
- Precast Concrete
- Post Tensioned & Prestressed Concrete
- Ready-Mix Concrete
- Paving Concrete
- Underwater & Antiwashout Concrete Applications

Method of Use

Dosage

- V-MAR® 3 dosage rates can vary with the type of application. Typical addition rates range between 8 to 100 fl oz/yd³ (309 to 3868 mL/m³) of concrete.
- Dosage requirements are based on water content in the mix. As water content increases, dosage requirement will increase.
- Optimal addition rates will depend on mix design, cementitious content, aggregate gradations and SCC application.
- Dosage rates may vary when used in conjunction with other CHRYSO® admixtures.
- Should conditions require using more than the recommended addition rates, please consult your CHRYSO® representative.

Implementation

- In general, it is recommended that V-MAR® 3 be added to the concrete mix after the dry materials and most of the water for optimum performance. Different sequencing may be used if local testing shows better performance.
- Pretesting of the concrete mix should be performed before use and as conditions and materials change in order to assure compatibility with other admixtures, and to optimize dosage rates, addition times in the batch sequencing and concrete performance.

Equipment

- A complete line of accurate, automatic dispensing equipment is available.

Complimentary Products

- V-MAR® 3 is compatible with most CHRYSO® admixtures as long as they are added separately to the concrete mix.
- V-MAR® 3 is recommended for use in conjunction with [CHRYSO® Superplasticizers](#) and in combination of [CHRYSO® Air-Entraining Agents](#).

Performances

- Modifies concrete rheological properties for improved workability.

The information contained in this technical data sheet is given to the best of our knowledge and the result from extensive testing - which were conducted in order to remain as objective as possible. However, it cannot, in any case, be considered as a warranty involving our liability in case of misuse or any different use of our products, other than those from the "Application" paragraph of this technical data sheet. Some application tests should be carried out before using the product to ensure that the methods of use and conditions of application of the product are satisfactory. Our technical assistance is at the disposal of the users.

P.1/2



TECHNICAL DATA SHEET

V-MAR® 3

Viscosity Modifying Admixture

Chryso
Concrete
Solutions

01/10/2025

- Enhances finishing in flatwork applications.
- Improves workability in low/no-slump concrete.
- Facilitates better workability and finishability when using harsh aggregates.
- Simplifies placement and pumping, regardless of cement type or aggregate gradation.
- Accommodates fluctuating moisture content.
- Prevents segregation and reduces bleeding, maintaining cohesiveness in high-flow mixes.
- Ensures consistent production even under harsh conditions like high winds or low humidity.
- Eliminates the need for vibration by enabling self-leveling and self-consolidation in high-flow applications.

CHARACTERISTICS

Product Nature	Liquid
Color	Colourless to light yellow
Shelf life	12 months
Cl ⁻ ions content	< 0,100 %
pH (25°C)	4,40

PRECAUTIONS

- Product will begin to freeze at approximately 28°F (-2°C), but will return to full capabilities after thawing and thorough agitation.
- Do not use pressurized air for agitation.

SAFETY

Prior to any use, please read carefully the Safety data Sheet.

PACKAGING

- Bulk
- 275 gallon tote
- 55 gallon drum

The information contained in this technical data sheet is given to the best of our knowledge and the result from extensive testing - which were conducted in order to remain as objective as possible. However, it cannot, in any case, be considered as a warranty involving our liability in case of misuse or any different use of our products, other than those from the "Application" paragraph of this technical data sheet. Some application tests should be carried out before using the product to ensure that the methods of use and conditions of application of the product are satisfactory. Our technical assistance is at the disposal of the users.

P.2/2

 **chryso**
SAINT-GOBAIN

Appendix B.6 V-MAR F100

TECHNICAL DATA SHEET

V-MAR® F100

Viscosity Modifying Admixture

Chryso
Concrete
Solutions

12/20/2024

DESCRIPTION

V-MAR® F100 is a high-performance, rheology-modifying admixture designed to enhance the lubricity of concrete, enabling increased productivity and superior surface texture.

It improves workability, allowing concrete to flow more smoothly during placement while achieving a high-quality finish with a consistent and refined surface.

ADVANTAGES

- Enhances concrete rheological properties for improved workability
- Produces cohesive concrete mixes without stickiness
- Facilitates efficient concrete extrusion
- Improves concrete surface appearance
- Accelerates concrete discharge rates

FIELDS OF APPLICATION

- All Cement Types
- Precast Concrete
- Post Tensioned & Prestressed Concrete
- Concrete Pipe
- Concrete Extrusion
- Concrete Paving
- Slip Formed Concrete
- Roller-Compacted Concrete

Method of Use

Dosage

- V-MAR® F100 dosage rates can vary with the type of application. Typical addition rates range between 3 to 12 fl oz/cwt (195–780 mL/100 kg) of cementitious material.
- Optimal addition rates will depend on mix design, cementitious content, aggregate gradations and application.
- Dosage rates may vary when used in conjunction with other CHRYSO® admixtures.
- Should conditions require using more than the recommended addition rates, please consult your CHRYSO® representative.

Implementation

- In general, it is recommended that V-MAR® F100 be added early in the batching sequence for optimum performance.
- Different sequencing may be used if local testing shows better performance.
- Please see [Technical Bulletin TB-0110](#), *Admixture Dispenser Discharge Line Location and Sequencing for Concrete Batching Operations* for further recommendations.
- Pretesting of the concrete mix should be performed before use and as conditions and materials change in order to assure compatibility with other admixtures, and to optimize dosage rates, addition times in the batch sequencing, and concrete performance.

Equipment

- A complete line of accurate, automatic dispensing equipment is available.

Complimentary Products

- V-MAR® F100 is compatible with most CHRYSO® admixtures as long as they are added separately to the concrete mix.
- For concrete that requires air entrainment, the use of an ASTM C260 air-entraining agent is recommended to provide suitable air void parameters for freeze-thaw resistance.

The information contained in this technical data sheet is given to the best of our knowledge and the result from extensive testing - which were conducted in order to remain as objective as possible. However, it cannot, in any case, be considered as a warranty involving our liability in case of misuse or any different use of our products, other than those from the "Application" paragraph of this technical data sheet. Some application tests should be carried out before using the product to ensure that the methods of use and conditions of application of the product are satisfactory. Our technical assistance is at the disposal of the users.

P.1/2



TECHNICAL DATA SHEET

V-MAR® F100

Viscosity Modifying Admixture

Chryso
Concrete
Solutions

12/20/2024

Performances

- Enhances productivity with higher throughput.
- Enables concrete to flow more easily and quickly through machinery.
- Improves paste consistency for better creaminess and finishability.
- Promotes concrete consolidation with reduced vibration effort.
- Increases water tolerance, making concrete less sensitive to typical moisture variations during manufacturing.
- Supports the use of angular aggregates and manufactured sands in concrete mixes.
- Delivers finishes with significantly fewer surface defects.
- Reduces cement requirements for surface closure, lowering overall material costs.

CHARACTERISTICS

Product Nature	Liquid
Color	Brown
Shelf life	12 months
Cl ⁻ Ions content	< 0,100 %
Specific gravity (25°C) in g/ml	1,008
pH (25°C)	5,30

PRECAUTIONS

- Product will begin to freeze at approximately 28°F (-2°C), but will return to full functionality after thawing and thorough mechanical agitation.
- Do not use pressurized air for agitation.

SAFETY

Prior to any use, please read carefully the Safety data Sheet.

PACKAGING

- Bulk
- 275 gallon tote
- 55 gallon drum

The information contained in this technical data sheet is given to the best of our knowledge and the result from extensive testing - which were conducted in order to remain as objective as possible. However, it cannot, in any case, be considered as a warranty involving our liability in case of misuse or any different use of our products, other than those from the "Application" paragraph of this technical data sheet. Some application tests should be carried out before using the product to ensure that the methods of use and conditions of application of the product are satisfactory. Our technical assistance is at the disposal of the users.

P.2/2



Appendix C Design Considerations

Process	Evaluation of...
Cross section properties	centroids, moment of inertia, and weight
Free-body, shear, and moment diagrams	applied loads, shear capacity, and moment capacity to inform calculation of cracking and failure loads.
Losses	short-term losses (elastic shortening), and long-term losses (creep, shrinkage, and steel relaxation)
Flexural analysis	nominal moment in order to ensure that the steel yields before the concrete crushes (to ensure a safer method of failure)
Transfer and development lengths	the required length needed to anchor the strand and fully develop the transfer of its compressive force.
Stresses	stresses at transfer and test, compared to allowable stress limits
Prediction of failure load	When cracking moment exceeds applied moment, leading to cracks forming in the concrete
Prediction of cracking and failure loads	When the ultimate moment exceeds applied moment, leading to the beam's failure
Shear analysis	Whether shear capacity exceeds shear demand (forcing the beam to fail in flexure)
Calculation of deflection	Prediction of the beam's maximum deflection when the maximum loading is applied.
Cost	Evaluation of cost per the PCI Big Beam 2024-2025 rules [2].

Appendix D Design Calculations

Appendix D.1 Mathcad



PCI Big Beam 2024-2025
Mathcad Calculations

CROSS SECTION PROPERTIES

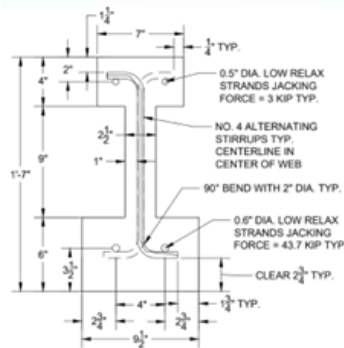


Figure 1: cross section design from shop drawings

$$\begin{aligned}
 L_{tot} &:= 19 \text{ ft} && \text{beam length} \\
 L &:= 18 \text{ ft} && x := 0 \text{ ft}, 0.1 \text{ ft} \dots L \text{ span length} \\
 t_{tf} &:= 3.5 \text{ in} && \text{thickness of top flange} \\
 t_{bf} &:= 6 \text{ in} && \text{thickness of bottom flange} \\
 h_w &:= 9 \text{ in} && \text{height of web} \\
 b_{tf} &:= 9 \text{ in} && \text{width of top flange} \\
 b_{bf} &:= 9.5 \text{ in} && \text{width of bottom flange} \\
 b_w &:= 2.5 \text{ in} && \text{width of web} \\
 h &:= t_{tf} + t_{bf} + h_w = 18.5 \text{ in} && \text{beam height} \\
 L_{p, xs} &:= 2 \cdot (t_{tf} + t_{bf} + h_w) + b_{tf} + b_{bf} + (b_{tf} - b_w) + (b_{bf} - b_w) = 69 \text{ in} && \text{perimeter of cross section}
 \end{aligned}$$

LOADING

$$P_{tot} := 34.9 \text{ kip}$$

total applied actuator load

Predictions

Cracking Load: 22.8 kips
Breaking Load: 34.9 kips

$$P := 0.5 P_{tot} = 17.5 \text{ kip}$$

half of actuator load to each point load

Test Results

Cracking Load: 22.7 kip
Breaking Load: 38.7 kip

MATERIAL PROPERTIES

$$\begin{aligned}
 \rho &:= 124.1 \text{ pcf} \\
 E_{ps} &:= 28500 \text{ ksi} \\
 E_s &:= 29000 \text{ ksi} \\
 f_{pu} &:= 270 \text{ ksi}
 \end{aligned}$$

concrete density (normalweight)
prestressing strand modulus of elasticity
steel reinforcement modulus of elasticity
strength of prestressing strands

Concrete Properties

$$\begin{aligned}
 f'_{ci, req} &:= 5000 \text{ psi} \\
 f'_{ci} &:= 5077.5 \text{ psi} \\
 f'_{c, req} &:= 8000 \text{ psi} \\
 f'_c &:= 7260 \text{ psi} \\
 d_{agr} &:= 0.5 \text{ in}
 \end{aligned}$$

Section updated based on cylinder test data
required strength of concrete to cut strands
initial concrete strength (when strands cut)
required strength of concrete to test
strength of concrete (based on ASTM C78)
diameter of aggregate

$$\begin{aligned}
 E_{ci} &:= 33 \cdot (\rho \div \text{pcf})^{1.5} \cdot \sqrt{f'_{ci} \cdot \text{psi}} = 3251 \text{ ksi} \\
 E_c &:= 33 \cdot (\rho \div \text{pcf})^{1.5} \cdot \sqrt{f'_c \cdot \text{psi}} = 3887 \text{ ksi}
 \end{aligned}$$

initial concrete modulus of elasticity
concrete modulus of elasticity

$$\begin{aligned}
 \lambda &:= 0.75 \\
 RH &:= 75
 \end{aligned}$$

Lightweight factor = 1 normalweight, 0.75 lightweight
relative humidity, (%)

STRAND & REINFORCEMENT

Prestressing Strands (7-wire) (bottom)

$$\begin{aligned}
 d_{ps} &:= 0.6 \text{ in} \\
 A_{ps1} &:= 0.217 \text{ in}^2 \\
 y_{ps1} &:= 3.5 \text{ in} \\
 y_{ps2} &:= 3.5 \text{ in} \\
 y_{ps3} &:= 0 \text{ in} \\
 n_{ps} &:= 2 \\
 A_{ps} &:= A_{ps1} \cdot n_{ps} = 0.434 \text{ in}^2 \\
 w_{ps, ind} &:= 0.737 \text{ plf}
 \end{aligned}$$

diameter
nominal area
height of prestressing strand 1, from bottom
height of prestressing strand 2, from bottom
height of prestressing strand 3, from bottom
number prestressing strands
total area of prestressing strands

Steel Reinforcement

$d_r := 0 \text{ in}$	diameter	
$A_{r1} := 0 \text{ in}^2$	nominal area	
$y_{r1} := 0 \text{ in}$	height of steel reinforcement strand 1, from bottom	
$y_{r2} := 0 \text{ in}$	height of steel reinforcement strand 2, from bottom	
$n_r := 0$	number of reinforcement bars	
$A_r := A_{r1} \cdot n_r = 0 \text{ in}^2$	total area of reinforcement	
$w_{r.ind} := 0 \text{ plf}$	weight of reinforcement bar	
$y_{sbar} := \frac{(A_{ps1} \cdot y_{ps1}) + (A_{ps1} \cdot y_{ps2}) + (A_{ps1} \cdot y_{ps3}) + (A_{r1} \cdot y_{r1}) + (A_{r1} \cdot y_{r2})}{A_{ps} + A_r} = 3.5 \text{ in}$	centroid of prestressed strands	
$d_p := h - y_{sbar} = 15 \text{ in}$	height to center of bars	
$w_{ps} := w_{ps.ind} \cdot n_{ps} = 1.474 \text{ plf}$	nominal weight of prestressing strands	
$w_r := w_{r.ind} \cdot n_r = 0 \text{ plf}$	nominal weight of reinforcing bars	

Compression Prestressing strands (top, non functional)

$d'_{ps} := 0.5 \text{ in}$	diameter
$A'_{ps1} := 0.153 \text{ in}^2$	nominal area
$n'_{ps} := 2$	number (2 inch vertical spacing)
$w'_{ps} := w_{ps.ind} \cdot n'_{ps} = 1.474 \text{ plf}$	normal weight

Areas of steel reinforcement and prestressing strands

$A_{ps} = 0.434 \text{ in}^2$	area of prestressing strands (bottom)
$A'_{ps} := A'_{ps1} \cdot n'_{ps} = 0.306 \text{ in}^2$	area of prestressing strands (top)

SHEAR REINFORCEMENT

$no_{legs} := 1$	number of legs
$A_{stirrup} := 0.2 \text{ in}^2$	area of stirrup (No. 4)
$A_v := A_{stirrup} \cdot no_{legs} = 0.2 \text{ in}^2$	shear area of steel
$d_A := 0.5 \text{ in}$	diameter of stirrup (No. 4)
$s := 7 \text{ in}$	spacing of stirrups
$f_y := 60 \text{ ksi}$	strength of shear reinforcement
$L_{stirrup} := 19.75 \text{ in}$	length of stirrups
$n_{stirrup} := 26$	amount of stirrups
$w_{stirrup} := 0.668 \frac{\text{lb}}{\text{ft}}$	unit weight of stirrups

Spacing

$Spacing := \frac{(b_{bf} - (d_{ps} \cdot n_{ps})) - (no_{legs} \cdot d_A) - \left(\frac{5}{8} \text{ in} \cdot 2\right)}{(2)} = 3.3 \text{ in}$		
$S_{min1} := \max\left(d_{ps}, \frac{5}{8} \text{ in}\right) = 0.63 \text{ in}$	clear cover (Table 20.5.1.3.3, ACI 318-19)	
$S_{min2} := \max\left(2 \text{ in}, \frac{4}{3} (d_{agr} + d_A)\right) = 2 \text{ in}$	minimum spacing (25.2.4, ACI 318-19)	
$check := \text{if}(Spacing \geq \max(S_{min1}, S_{min2}), \text{"OK"}, \text{"Does Not Meet"}) = \text{"OK"}$		Note: for constructability, spacing 2 in. increments center to center

SECTION PROPERTIES - CENTROIDS & INTERTIA

Top Flange

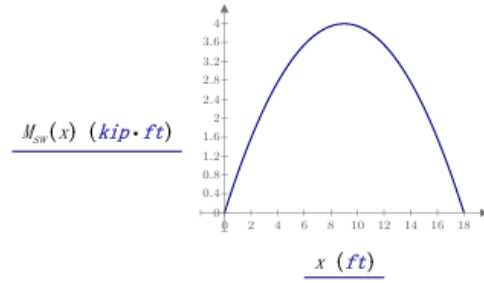
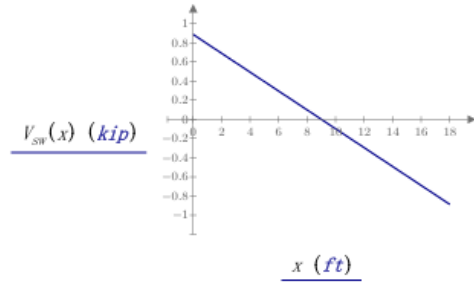
$A_{tf} := t_{tf} \cdot b_{tf} = 31.5 \text{ in}^2$	area of top flange
---	--------------------

Web	$y_{tf} := \frac{t_{tf}}{2} + h_w + t_{bf} = 16.75 \text{ in}$	centroid of top flange
	$A_w := b_w \cdot h_w = 22.5 \text{ in}^2$	area of web
	$y_w := \frac{h_w}{2} + t_{bf} = 10.5 \text{ in}$	centroid of web
Bottom Flange	$A_{bf} := t_{bf} \cdot b_{bf} = 57 \text{ in}^2$	area of bottom flange
	$y_{bf} := \frac{t_{bf}}{2} = 3 \text{ in}$	centroid of bottom flange
Beam	$y_{barbot} := \frac{(A_{tf} \cdot y_{tf}) + (A_w \cdot y_w) + (A_{bf} \cdot y_{bf})}{A_{tf} + A_w + A_{bf}} = 8.422 \text{ in}$	centroid of beam, from bottom
	$y_{bartop} := h - y_{barbot} = 10.078 \text{ in}$	centroid of beam, from top
	$A_g := A_{tf} + A_w + A_{bf} = 111 \text{ in}^2$	gross area of concrete
	$V_g := A_g \cdot L = 0.51 \text{ yd}^3$	gross volume of concrete, CY
	$e := d_p - y_{bartop} = 4.922 \text{ in}$	eccentricity
Moment of Inertia	$I_{tf} := \frac{1}{12} b_{tf} \cdot t_{tf}^3 + A_{tf} \cdot (y_{tf} - y_{barbot})^2 = 2216.701 \text{ in}^4$	inertia top flange
	$I_w := \frac{1}{12} b_w \cdot (h - t_{tf} - t_{bf})^3 + A_w \cdot (y_w - y_{barbot})^2 = 249.004 \text{ in}^4$	inertia web
	$I_{bf} := \frac{1}{12} b_{bf} \cdot t_{bf}^3 + A_{bf} \cdot (y_{bf} - y_{barbot})^2 = 1846.875 \text{ in}^4$	inertia bottom flange
	$I_g := I_{tf} + I_w + I_{bf} = 4312.58 \text{ in}^4$	total inertia
	$EI := E_c \cdot I_g = 116416.51 \text{ ft}^2 \cdot \text{kip}$	EI check

APPLIED LOADS, SHEAR, AND MOMENT

Selfweight

$w_{SWC} := A_g \cdot \rho = 95.7 \text{ plf}$	concrete selfweight, distributed load
$w_{SW} := w_{SWC} + w'_{PS} + w_{PS} = 98.6 \text{ plf}$	total self weight, distributed load
$w_{SWT, P} := w_{SW} \cdot L = 1775 \text{ lbf}$	weight, for shipping & handling
$check := \text{if}(w_{SWT, P} < 2000 \text{ lbf}, "OK", "Make Lighter") = "OK"$	
$M_{SW}(x) := \frac{w_{SW} \cdot x}{2} \cdot (L - x)$	selfweight moment
$V_{SW}(x) := w_{SW} \cdot (0.5 \cdot L - x)$	selfweight shear



Live Load

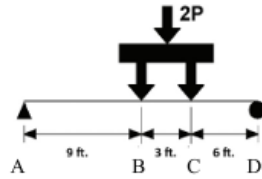


Figure 2: Loading Diagram i

$$AB := 9 \text{ ft} \quad CD := 6 \text{ ft} \quad BC := L - AB - CD = 3 \text{ ft}$$

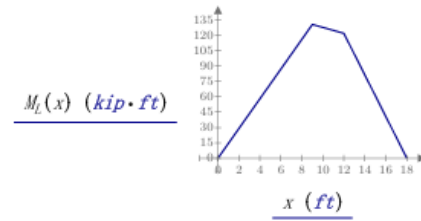
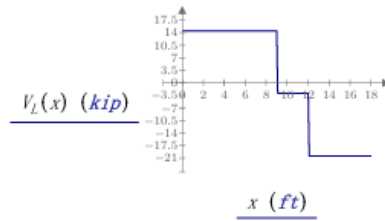
$$L_{ab} := AB = 9 \text{ ft} \quad L_{ac} := AB + BC = 12 \text{ ft} \quad L_{ad} := L = 18 \text{ ft}$$

$$R_A := P \div L \cdot (L - AB + CD) = 14.54 \text{ kip}$$

$$R_D := P \div L \cdot (L - CD + AB) = 20.36 \text{ kip}$$

$$V_L(x) := \text{if}(x \leq L_{ab}, R_A, \text{if}(L_{ab} < x \leq L_{ac}, P \div L \cdot (CD - AB), -R_D))$$

$$M_L(x) := \text{if}(x \leq L_{ab}, R_A \cdot x, \text{if}(L_{ab} < x < L_{ac}, R_A \cdot x - P \cdot (x - AB), R_D \cdot CD - R_D \cdot (x - L_{ac})))$$



Total Loads

$$V_{service}(x) := V_{sw}(x) + V_L(x)$$

total unfactored service shear

$$M_{service}(x) := M_{sw}(x) + M_L(x)$$

total unfactored service moment

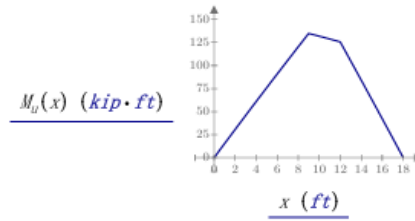
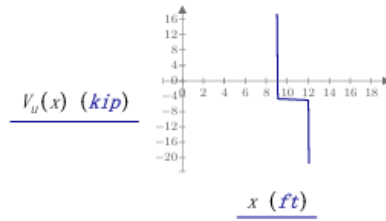
$$V_u(x) := 1.2 \cdot V_{sw}(x) + 1.6 \cdot V_L(x)$$

total factored service shear

(load factors = 1.0 for accurate lab testing)

$$M_u(x) := M_{sw}(x) + M_L(x)$$

total factored service moment



LOSSES

$$f_j := 0.75 \cdot f_{pu} = 202.5 \text{ ksi}$$

jacking stress

Elastic Shortening (ES)

$$P_j := f_j \cdot A_{ps} = 87.9 \text{ kip}$$

jacking force

$$P_{j, \text{perstrand}} := \frac{P_j}{n_{ps}} = 43.9 \text{ kip}$$

Jacking force per strand

$$M_{sw, mid} := \frac{w_{sw} \cdot L^2}{8} = 47.924 \text{ kip} \cdot \text{in}$$

max moment of beam (selfweight)

$$k_{ES} := 1.0$$

kes constant - pretensioned members

$$k_{cir} := 0.9$$

keir constant - pretensioned members

$$f_{cir} := k_{cir} \cdot \left(\frac{P_j}{A_g} + \frac{P_j \cdot e^2}{I_g} \right) - \frac{M_{sw, mid} \cdot e}{I_g} = 1.1 \text{ ksi}$$

strand stress at CGS

$$ES := \frac{E_{ps}}{E_{ci}} \cdot k_{ES} \cdot f_{cir} = 9.7 \text{ ksi}$$

elastic shortening

Creep (CR)

$$k_{cr} := \text{if } (\lambda < 1, 1.6, 2) = 1.6$$

creep strain amplifier

$$CR := k_{cr} \cdot \frac{E_{ps}}{E_c} \cdot (f_{cir}) = 12.9 \text{ ksi}$$

creep

Shrinkage (SH)

$$V_{div, S} := A_g \div L_{p, XS} = 1.609 \text{ in}$$

$$k_{sh} := 1.0$$

shrinkage constant

$$SH := \left((8.2 \cdot 10^{-6}) \cdot k_{sh} \cdot E_{ps} \cdot \frac{1}{ft} (1 \text{ ft} - (0.06 \cdot V_{div, S})) (100 - Rf) \right) = 5.8 \text{ ksi}$$

Steel relaxation (RE)

$$k_{RE} := 5 \text{ ksi}$$

[PT 5.8.1]

$$J := 0.04$$

[PT 5.8.1]

$$C := 1.0$$

[PT 5.8.2]

$$ju_{ps} := (f_j - ES) \div f_{pu} = 0.714$$

$$C_{ps} := \text{if } \left(ju_{ps} \geq 0.54, \frac{ju_{ps}}{0.21} \cdot \left(\frac{ju_{ps}}{0.9} - 0.55 \right), \frac{ju_{ps}}{4.25} \right) = 0.828 \text{ bottom strands}$$

$$RE := (k_{RE} - J \cdot (SH + CR + ES)) \cdot C_{ps} = 3.2 \text{ ksi}$$

relaxation

STRESS AND FORCE AFTER LOSSES

$$L_{shl} := ES = 9.7 \text{ ksi}$$

short term losses

$$L_{int} := CR + SH + RE = 21.9 \text{ ksi}$$

long term losses

$$TL := L_{shl} + L_{int} = 31.6 \text{ ksi}$$

total losses

$$f_{pi} := f_j - ES = 192.8 \text{ ksi}$$

initial stress after ES

$$P_i := A_{ps} \cdot f_{pi} = 83.7 \text{ kip}$$

prestress force after ES at transfer

$$f_{se} := f_j - CR - SH - RE = 180.6 \text{ ksi}$$

final stress after all losses

$$P_e := f_{se} \cdot A_{ps} = 78.4 \text{ kip}$$

prestress force after ES at transfer

FLEXURAL CAPACITY

Code Equations

$$check := \text{if}(f_{se} \geq 0.5 f_{pu}, \text{"OK"}, \text{"Condition Not Met"}) = \text{"OK"}$$

$$\rho_p := \frac{A_{ps}}{b_{tf} \cdot d_p} = 0.003$$

$$\gamma_p := 0.28$$

gamma factor for prestressing

$$\beta_1 := \max\left(0.65, \min\left(0.85, 0.85 - 0.05 \cdot \left(\frac{(f'_c - 4000 \text{ psi})}{1000 \text{ psi}}\right)\right)\right) = 0.687$$

beta strength factor

$$f_{ps} := f_{pu} \cdot \left(1 - \frac{\gamma_p}{\beta_1} \cdot \left(\rho_p \cdot \frac{f_{pu}}{f'_c}\right)\right) = 256.843 \text{ ksi}$$

flexural strength

$$a := \frac{A_{ps} \cdot f_{ps}}{0.85 \cdot f'_c \cdot b_{tf}} = 2.007 \text{ in}$$

depth of Whitney stress block

$$c := \frac{a}{\beta_1} = 2.921 \text{ in}$$

depth to neutral axis

$$c := 3.031 \text{ in}$$

refined guess at c

Refine with Strain Compatibility

$$\epsilon_1 := \frac{f_{se}}{E_{ps}} = 6.3 \cdot 10^{-3}$$

strain due to Pe alone

$$\epsilon_2 := \frac{P_e}{A_g \cdot E_c} \cdot \left(1 + \frac{e^2 \cdot A_g}{I_g}\right) = 2.9 \cdot 10^{-4}$$

increase in steel strain to decompress concrete at the steel

$$\epsilon_{cu} := 0.003$$

ultimate strain in concrete

$$\epsilon_3 := \epsilon_{cu} \cdot \left(\frac{d_p - c}{c}\right) = 1.2 \cdot 10^{-2}$$

steel strain to failure, concrete crushing

$$\epsilon_{ps} := \epsilon_1 + \epsilon_2 + \epsilon_3 = 1.8 \cdot 10^{-2}$$

total steel strain at failure

$$f_{ps} := \text{if} \left(\epsilon_{ps} \leq 0.0085, 28800 \text{ ksi} \cdot \epsilon_{ps}, 270 \text{ ksi} - \frac{0.04}{\epsilon_{ps} - 0.007} \cdot \text{ksi} \right) = 266.5 \text{ ksi}$$

$$c := \frac{A_{ps} \cdot f_{ps}}{0.85 \cdot f'_c \cdot \beta_1 \cdot b_{tf}} = 3.031 \text{ in} \quad \text{depth of neutral axis}$$

$$a := \frac{A_{ps} \cdot f_{ps}}{0.85 \cdot f'_c \cdot b_{tf}} = 2.083 \text{ in}$$

$$\text{check} := \text{if} (a < t_{tf}, \text{"OK"}, \text{"Condition Not Met"}) = \text{"OK"}$$

$$M_n := \text{if} \left(a > t_{tf}, \left(0.85 \cdot f'_c \cdot t_{tf} \cdot (b_{bf} - b_w) \cdot \left(\frac{a}{2} - \frac{t_{tf}}{2} \right) \right) + A_{ps} \cdot f_{ps} \cdot \left(d_p - \frac{a}{2} \right), A_{ps} \cdot f_{ps} \cdot \left(d_p - \frac{a}{2} \right) \right)$$

$$M_n = 134.5 \text{ kip} \cdot \text{ft} \quad \text{nominal moment}$$

$$\phi_{flexure} := 1.0$$

use 1.0 to calculate lab capacity

$$\phi M_n := \phi_{flexure} \cdot M_n = 134.5 \text{ kip} \cdot \text{ft} \quad \text{factored nominal moment}$$

TRANSFER AND DEVELOPMENT LENGTH

$$l_t := f_{se} \div (3 \text{ ksi}) \cdot d_{ps} = 36.1 \text{ in}$$

$$l_t = 3.01 \text{ ft}$$

transfer length

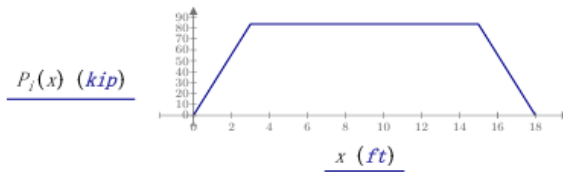
$$l_d := l_t + (f_{ps} - f_{se}) \div (1 \text{ ksi}) \cdot d_{ps} = 87.7 \text{ in}$$

$$l_d = 7.31 \text{ ft}$$

development length

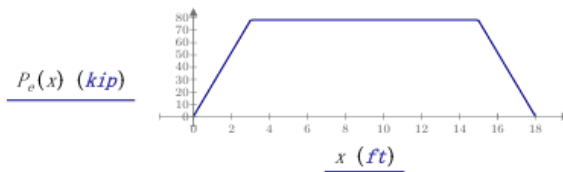
Force at Transfer

$$P_t(x) := \text{if} \left(x \leq l_t, \frac{x}{l_t} \cdot P_t, \text{if} \left(l_t < x \leq L - l_t, P_t, P_t - \frac{P_t}{l_t} \cdot (x - (L - l_t)) \right) \right)$$



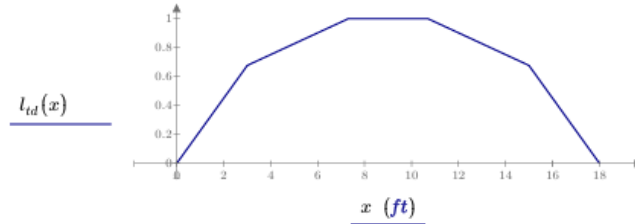
Force at Service

$$P_e(x) := \text{if} \left(x \leq l_t, \frac{x}{l_t} \cdot P_e, \text{if} \left(l_t < x \leq L - l_t, P_e, P_e - \frac{P_e}{l_t} \cdot (x - (L - l_t)) \right) \right)$$



Transfer & Development Length Factor

$$l_{dt}(x) := \text{if} \left(x < l_t, \frac{x}{l_t} \cdot \frac{f_{su}}{f_{pu}}, \text{if} \left(l_t \leq x \leq l_d, \frac{x - l_t}{l_d - l_t} \cdot \left(1 - \frac{f_{su}}{f_{pu}} \right) + \frac{f_{su}}{f_{pu}}, \text{if} \left(l_d < x \leq L - l_d, 1, \text{if} \left(L - l_d < x \leq L - l_t, 1 - \frac{x - (L - l_d)}{l_d - l_t} \cdot \left(1 - \frac{f_{su}}{f_{pu}} \right) \cdot \frac{f_{su}}{f_{pu}} - \frac{x - (L - l_t)}{l_t} \cdot \frac{f_{su}}{f_{pu}} \right) \right) \right) \right)$$



ALLOWABLE STRESS VS. LIMITS

STRESSES AT TRANSFER

Stress Limits

$$\sigma_{c, end} := -0.7 \cdot f'_{ci} = -3554.3 \text{ psi}$$

allowable compressive stress at end

$$\sigma_{c, mid} := -0.6 \cdot f'_{ci} = -3046.5 \text{ psi}$$

allowable compressive stress at middle

$$\sigma_{tc, PCI}(x) := \text{if} \left(x < 0.25 \cdot L, -0.7 \cdot f'_{ci}, \text{if} \left(0.25 \cdot L < x < 0.75 \cdot L, -0.6 \cdot f'_{ci}, -0.7 \cdot f'_{ci} \right) \right)$$

$$\sigma_{t, end} := 6 \cdot \sqrt{f'_{ci}} \cdot \sqrt{\text{psi}} = 428 \text{ psi}$$

allowable tensile stress at end

$$\sigma_{t, mid} := 3 \cdot \sqrt{f'_{ci}} \cdot \sqrt{\text{psi}} = 214 \text{ psi}$$

allowable tensile stress at middle

$$\sigma_{tt, PCI}(x) := \text{if} \left(x < 0.25 \cdot L, 6 \cdot \sqrt{f'_{ci} \cdot \text{psi}}, \text{if} \left(0.25 \cdot L < x < 0.75 \cdot L, 3 \cdot \sqrt{f'_{ci} \cdot \text{psi}}, 6 \cdot \sqrt{f'_{ci} \cdot \text{psi}} \right) \right)$$

Applied Stress

$$\sigma_{tt}(x) := -\frac{P_i(x)}{A_g} + \frac{P_i(x) \cdot e \cdot y_{barbot}}{I_g} - \frac{M_{sw}(x) \cdot y_{barbot}}{I_g}$$

applied stress at top

$$\sigma_{tb}(x) := -\frac{P_i(x)}{A_g} - \frac{P_i(x) \cdot e \cdot y_{barbot}}{I_g} + \frac{M_{sw}(x) \cdot y_{barbot}}{I_g}$$

applied stress at bottom

Stress Checks

$$\sigma_{tt}(7.4 \text{ ft}) = 100.2 \text{ psi}$$

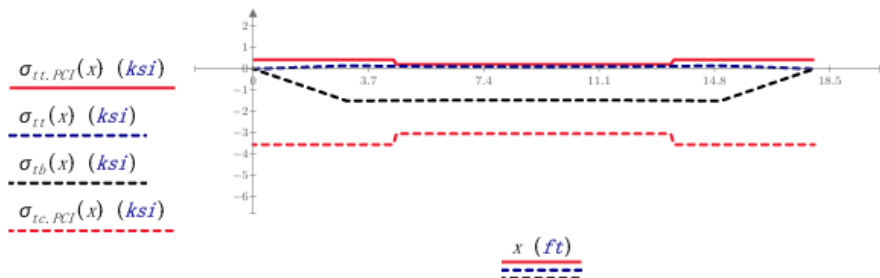
$$\sigma_{tt, PCI}(7.4 \text{ ft}) = 213.8 \text{ psi}$$

$$\sigma_{tt}(11.1 \text{ ft}) = 102.8 \text{ psi}$$

$$\sigma_{tt, PCI}(11.1 \text{ ft}) = 213.8 \text{ psi}$$

$$\sigma_{tb}(7.4 \text{ ft}) = -1467.9 \text{ psi}$$

$$\sigma_{tc, PCI}(7.4 \text{ ft}) = -3046.5 \text{ psi}$$



All stresses due to applied loads are less than the allowable stress limits.

STRESSES AT SERVICE

Stress Limits

$$\sigma_{sc, PCI} := -0.6 \cdot f'_c = -4356 \text{ psi}$$

allowable compressive stress

$$\sigma_{st, PCI} := 7.5 \cdot \sqrt{f'_c} \cdot \sqrt{\text{psi}} = 639 \text{ psi}$$

allowable tensile stress

Applied Stress

$$\sigma_{st}(x) := -\frac{P_e(x)}{A_g} + \frac{P_e(x) \cdot e \cdot y_{barbot}}{I_g} - \frac{M_{sw}(x) \cdot y_{barbot}}{I_g} - \frac{M_L(x) \cdot y_{barbot}}{I_g}$$

applied stress at top

$$\sigma_{sb}(x) := -\frac{P_e(x)}{A_g} - \frac{P_e(x) \cdot e \cdot y_{barbot}}{I_g} + \frac{M_{sw}(x) \cdot y_{barbot}}{I_g} + \frac{M_L(x) \cdot y_{barbot}}{I_g}$$

applied stress at bottom

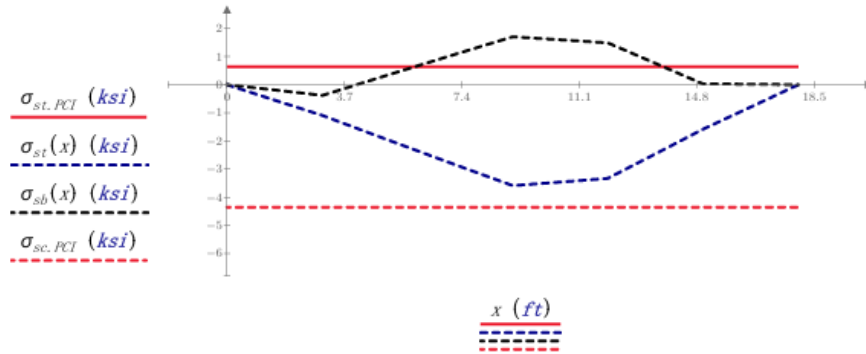
Stress Checks

$$\sigma_{sb}(7.4 \text{ ft}) = 1153.1 \text{ psi}$$

$$\sigma_{sb}(11.1 \text{ ft}) = 1553.1 \text{ psi}$$

$$\sigma_{sc, PCI} = -4356 \text{ psi}$$

$$\sigma_{st, PCI} = 639 \text{ psi}$$



All stresses due to applied loads are not less than the allowable stress limits.

CRACKING MOMENT

$$f_r := 7.5 \cdot \sqrt{f'_c} \cdot \sqrt{\text{psi}} = 0.639 \text{ ksi}$$

modulus of rupture

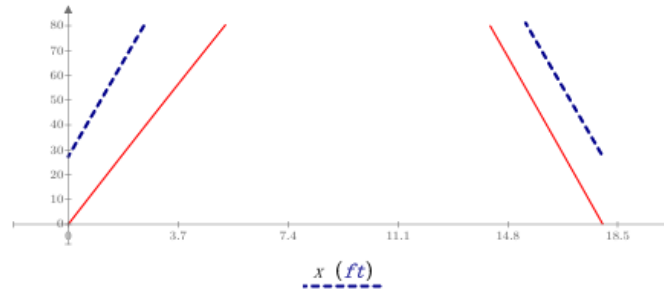
Updated based on cylinder
compression results (ASTM C39)

cracking moment

$$M_{cr}(x) := \left(f_r + \frac{P_e(x)}{A_g} + \frac{P_e(x) \cdot e \cdot y_{barbot}}{I_g} \right) \cdot \frac{I_g}{y_{barbot}}$$

$$M_{cr}(x) \text{ (kip} \cdot \text{ft)}$$

$$M_{service}(x) \text{ (kip} \cdot \text{ft)}$$



$$check := \text{if} (M_{service}(AB) > M_{cr}(AB), "Crack", "Not Crack") = "Crack"$$

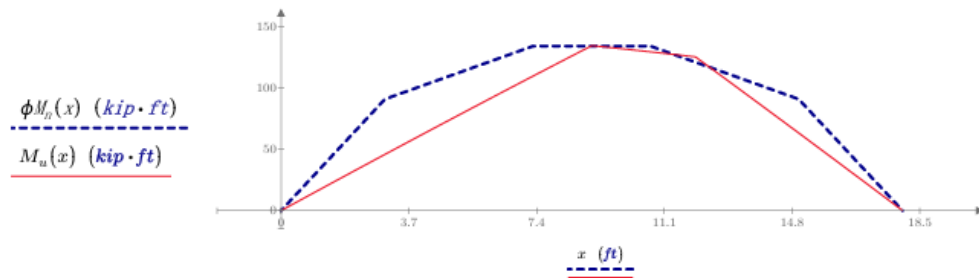
$$M_{service}(AB) = 134.9 \text{ kip} \cdot \text{ft} \quad M_{cr}(AB) = 89.5 \text{ kip} \cdot \text{ft}$$

$$M_{ratio} := M_{service}(AB) \div M_{cr}(AB) = 1.51$$

NOMINAL MOMENT CAPACITY VS. DEMAND

Modified Flexural Capacity

$$\phi M_n(x) := \phi_{flexure} \cdot M_n \cdot I_{td}(x)$$



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

$$M_u(AB) = 134.9 \text{ kip} \cdot \text{ft}$$

$$\phi M_n(AB) = 134.5 \text{ kip} \cdot \text{ft}$$

$$M_u(AB) \div \phi M_n(AB) = 1.00$$

SHEAR CAPACITY

$$\phi_{shear} := 1.0$$

resistance factor for shear

$$L_{t, shear} := 50 \cdot d_{ps} = 2.5 \text{ ft}$$

[A22. 5. 7. I]

Checks to use simple method

$$x_{crit} := \frac{h}{2} = 9.25 \text{ in}$$

$$check := \text{if} (A_{ps} \cdot f_{se} > 0.4 A_{ps} \cdot f_{pu}, "OK to use Simple Method", "Recheck") = "OK to use Simple Method"$$

$$A_v = 0.2 \text{ in}^2$$

area of stirrups

$$V_{cf}(x) := \left(0.6 \cdot \lambda \cdot \sqrt{f'_c \cdot psi} + 700 \text{ psi} \cdot \min \left(\frac{|V_u(x)| \cdot d_p}{|M_u(x)|}, 1 \right) \right) \cdot b_w \cdot \max(d_p, 0.8 \cdot h)$$

concrete shear strength

$$V_{c, min} := 2 \cdot \lambda \cdot \sqrt{f'_c \cdot psi} \cdot b_w \cdot d_p = 4.8 \text{ kip}$$

min concrete contribution

$$V_{c, max} := 5 \cdot \lambda \cdot \sqrt{f'_c \cdot psi} \cdot b_w \cdot d_p = 12 \text{ kip}$$

max concrete contribution

$$V_c(x) := \max(\min(V_{c, max}, V_{cf}(x)), V_{c, min})$$

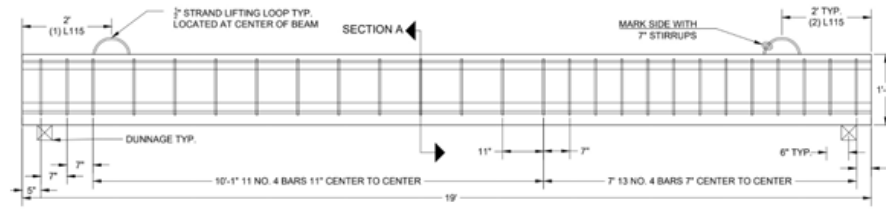
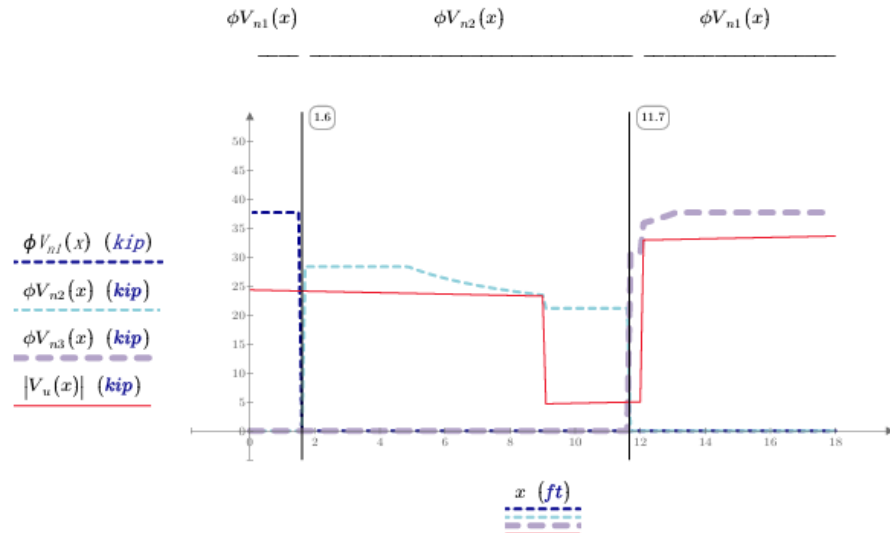


Figure 3: Stirrup Design from shop drawings

$$\begin{aligned}
 & s_1 := 7 \text{ in} & s_2 := 11 \text{ in} & s_3 := 7 \text{ in} & \text{spacing} \\
 & V_{s1} := \frac{A_v \cdot f_y \cdot d_p}{s_1} = 25.714 \text{ kip} & V_{s2} := \frac{A_v \cdot f_y \cdot d_p}{s_2} = 16.364 \text{ kip} & V_{s3} := \frac{A_v \cdot f_y \cdot d_p}{s_3} = 25.714 \text{ kip} & \text{steel shear strength} \\
 & s_{mar1} := \text{if} \left(V_{s1} > 4 \cdot \lambda \cdot \sqrt{f'_c \cdot \text{psi}} \cdot b_w \cdot d_p, \min(0.375 \cdot h, 12 \text{ in}), \min(0.75 \cdot h, 24 \text{ in}) \right) = 6.9 \text{ in} & \text{max stirrup spacing} \\
 & s_{mar2} := \text{if} \left(V_{s2} > 4 \cdot \lambda \cdot \sqrt{f'_c \cdot \text{psi}} \cdot b_w \cdot d_p, \min(0.375 \cdot h, 12 \text{ in}), \min(0.75 \cdot h, 24 \text{ in}) \right) = 6.9 \text{ in} \\
 & s_{mar3} := \text{if} \left(V_{s3} > 4 \cdot \lambda \cdot \sqrt{f'_c \cdot \text{psi}} \cdot b_w \cdot d_p, \min(0.375 \cdot h, 12 \text{ in}), \min(0.75 \cdot h, 24 \text{ in}) \right) = 6.9 \text{ in} \\
 & A_{v,min} := \min \left(\frac{A_{ps} \cdot f_{pu} \cdot s}{80 \cdot f_y \cdot d_p} \cdot \sqrt{\frac{d_p}{b_w}}, \max \left(0.75 \cdot \sqrt{f'_c \cdot \text{psi}} \cdot \frac{b_w \cdot s}{f_y}, 50 \text{ psi} \cdot \frac{b_w \cdot s}{f_y} \right) \right) = 0.019 \text{ in}^2 & \text{min stirrup area} \\
 & \phi V_{n1}(x) := \text{if} \left(x < 1.6 \text{ ft}, \phi_{shear} \cdot (V_c(x) + V_{s1}), 0 \right) & \text{Limits for plotting readability} \\
 & \phi V_{n2}(x) := \text{if} \left(1.6 \text{ ft} < x < 11.7 \text{ ft}, \phi_{shear} \cdot (V_c(x) + V_{s2}), 0 \right) \\
 & \phi V_{n3}(x) := \text{if} \left(x > 11.7 \text{ ft}, \phi_{shear} \cdot (V_c(x) + V_{s3}), 0 \right) \\
 & (V_u(x)) & \text{factored shear capacity}
 \end{aligned}$$



DEFLECTION BY SUPERPOSITION METHOD

$$\Delta_{cam} := \frac{((A_{ps} \cdot f_{pi}) \cdot L_{tot}^2 \cdot e)}{8 \cdot E_{ci} \cdot I_g} = 0.191 \text{ in} \quad \text{deflection due to camber}$$

$$\Delta_{sw} := \frac{-(5 \cdot W_{swt, p} \cdot L^4)}{384 \cdot E_c \cdot I_g} \div 1 \text{ ft} = -0.25 \text{ in} \quad \text{deflection due to selfweight}$$

$$\Delta_{LL,1} := \frac{-P \cdot CD^2 \cdot AB^2}{3 \cdot EI \cdot L} = -0.097 \text{ in} \quad \text{deflection due to point load 6' from end}$$

$$\Delta_{LL,2} := \frac{-P \cdot L^3}{48 \cdot EI} = -0.2 \text{ in} \quad \text{deflection due to point load at midspan}$$

$$check := \text{if} \left(\Delta_{LL,1} + \Delta_{LL,2} < \frac{L}{180}, \text{"Condition Met"}, \text{"Decrease Deflection"} \right) = \text{"Condition Met"}$$

$$\Delta_f := \Delta_{cam} + \Delta_{sw} + \Delta_{LL,1} + \Delta_{LL,2} = -0.375 \text{ in} \quad \text{total deflection}$$

DEFLECTION BY VIRTUAL WORK METHOD

COST

Concrete

$$f'_c = 7.26 \text{ ksi}$$

strength of concrete, at 28 days

$$C_c := \left(20 + \left(\frac{10 \cdot \text{in}^2}{\text{kip}} \cdot f'_c \right) \right) = 92.6$$

cost of concrete, \$

Formwork

$$L_{p,ss} = 5.8 \text{ ft}$$

$$C_{fw} := (L_{p,ss} - b_{lf}) \cdot (L) \cdot \frac{1.25}{\text{ft}^2} = 112.5$$

cost of formwork, \$

Prestressing Reinforcement

$$d_{ps} = 0.6 \text{ in}$$

diameter of bottom prestressing strands

$$C_{ps} := \frac{0.33}{\text{ft}} \cdot L \cdot (n_{ps}) = 11.9$$

cost of bottom prestressing strands, \$

$$d'_{ps} = 0.5 \text{ in}$$

diameter of top prestressing strands

$$C'_{ps} := \frac{0.30}{\text{ft}} \cdot L \cdot (n'_{ps}) = 10.8$$

cost of top prestressing strands, \$

Shear Reinforcement

$$L_{stirrup} = 19.8 \text{ in}$$

length of stirrups

$$n_{stirrup} = 26$$

amount of stirrups

$$w_{stirrup} = 0.7 \frac{\text{lb}}{\text{ft}}$$

unit weight of stirrups

$$C_{stirrup} := w_{stirrup} \cdot L_{stirrup} \cdot n_{stirrup} \cdot \frac{0.45}{\text{lb}} = 12.9$$

cost of stirrups, \$

Total Cost

$$C_t := C_c + C_{fw} + C_{ps} + C'_{ps} + C_{stirrup} = 240.6$$

total cost, \$

The following unit cost shall be used to determine the beam cost. Concrete cost is based on actual strength, not design strength.

Material	Cost	Notes/Instructions
Concrete Cost (yd ³):	\$145/cubic yard (9ksi min) < \$20 + \$10 (concrete strength ksi) < \$200	Round concrete strength down to nearest ksi
Ultra-High-Performance Concrete	\$400/yd ³	
Prestressing Strand:		Use estimated lengths used in the beam
1/4 in. diameter	\$0.27/ft	
1/2 in. diameter	\$0.30/ft	
3/4 in. special	\$0.33/ft	
0.6 in. diameter	\$0.42/ft	
0.7 in. diameter	\$0.55/ft	
Steel:		Use estimated lengths and nominal unit weights in this calculation as provided in the PCI Design Handbook
A615/A706	\$0.45/lb	
Welded Wire (deformed or smooth; for shear)	\$0.60/lb	
Epoxy Coated	\$0.50/lb	
A1035	\$0.70/lb	
Plate Steel	\$0.55/lb	
Forming	\$1.25/ft ² of formwork (include all contact surfaces)	

- There is no need to include cost of steel fabrication, concrete fabrication, curing, inserts, etc. Concrete cost is based on actual strength.
- The beam weight shall be estimated by using the measured unit weight of the concrete or by actually weighing the beam. If the beam weight is estimated, it is estimated based on the gross concrete cross section only, ignoring reinforcement, bearing plates, etc. * Special circumstances or special materials not addressed in these rules must be reviewed by the chair of the committee and/or PCI cost.

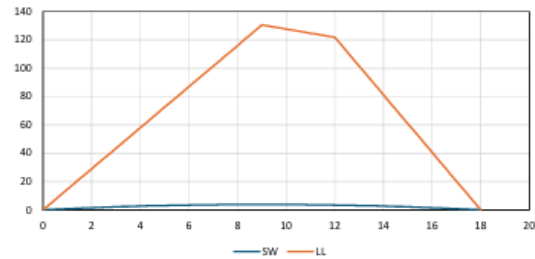
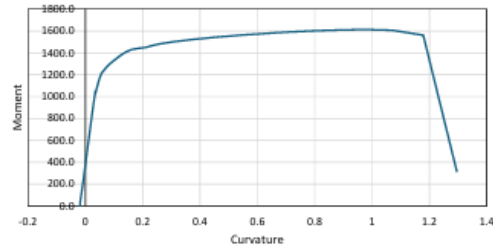
Appendix D.2 Deflection and Curvature through Virtual Work Method

DEFLECTION CALCULATIONS:
Curvature and Moment Plot through Double integration

Curvature (rad/10 ³ in.)	Curvature (rad)	M (k-in.)	M (k-ft)
-0.019	-0.000019	0.0	0.0
-0.018	-0.000018	34.0	2.8
-0.007	-0.000007	238.1	19.8
0.003	0.000003	442.2	36.8
0.014	0.000014	646.2	53.9
0.024	0.000024	850.2	70.9
0.035	0.000035	1054.0	87.8
0.035	0.000035	1026.3	85.5
0.037	0.000037	1045.1	87.1
0.046	0.000046	1141.9	95.2
0.056	0.000056	1210.3	100.9
0.067	0.000067	1246.7	103.9
0.077	0.000077	1276.6	106.4
0.088	0.000088	1303.0	108.6
0.098	0.000098	1327.0	110.6
0.109	0.000109	1349.1	112.4
0.12	0.00012	1370.4	114.2
0.132	0.000132	1392.4	116.0
0.145	0.000145	1413.6	117.8
0.159	0.000159	1429.5	119.1
0.175	0.000175	1437.6	119.8
0.193	0.000193	1443.8	120.3
0.212	0.000212	1451.1	120.9
0.233	0.000233	1466.9	122.2
0.256	0.000256	1480.3	123.4
0.282	0.000282	1491.9	124.3
0.31	0.00031	1502.5	125.2
0.341	0.000341	1512.6	126.0
0.375	0.000375	1522.3	126.9
0.413	0.000413	1532.1	127.7
0.454	0.000454	1542.6	128.5
0.499	0.000499	1552.6	129.4
0.549	0.000549	1562.9	130.2
0.604	0.000604	1573.2	131.1
0.665	0.000665	1583.3	131.9
0.678	0.000678	1585.4	132.1
0.689	0.000689	1587.1	132.3
0.697	0.000697	1588.4	132.4
0.704	0.000704	1589.4	132.5
0.705	0.000705	1589.6	132.5
0.709	0.000709	1590.2	132.5
0.731	0.000731	1593.4	132.8
0.804	0.000804	1602.5	133.5
0.885	0.000885	1609.9	134.2
0.973	0.000973	1612.9	134.4
1.07	0.00107	1606.2	133.8
1.178	0.001178	1561.0	130.1
1.295	0.001295	316.1	26.3

Loading	
ws _w =	0.0956 klf
L =	18 ft
AB =	9 ft
BC =	3 ft
CD =	6 ft
P _L =	34.8 k
0.5P _L =	17.4 k
R _a =	14.5 k
R _d =	20.3 k

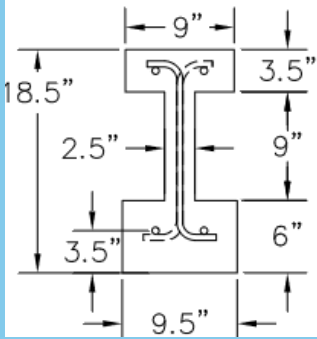
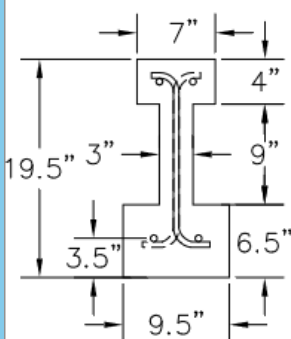
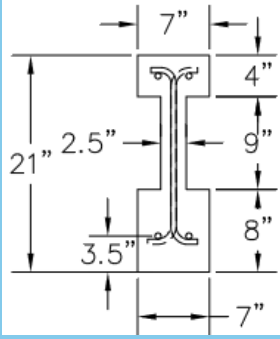
Camber	
A _{ps}	0.434 in. ²
f _{pi}	192.8 ksi
L	228 in.
e	4.716 in.
E _{ci}	3226 ksi
I _g	4189 in. ⁴

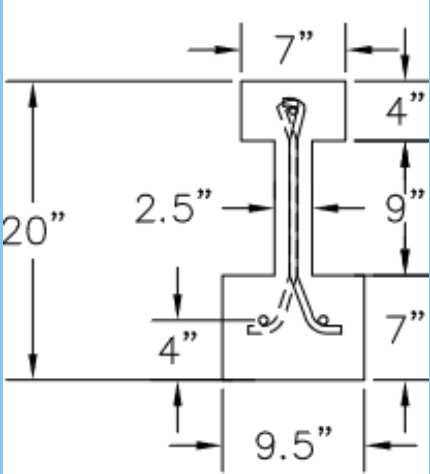
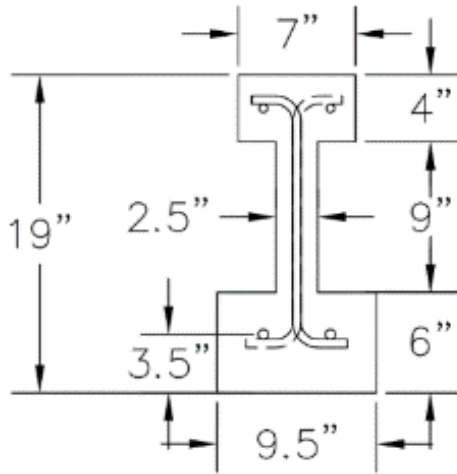


DEFLECTION CALCULATIONS:
Curvature and Moment Plot through Double integration

x	Msw	ML	dx	Virtual m(x)	Real M(x)	Curvature M(x)/EI	m(x)·M(x)/EI·dx	
ft	k·ft	k·ft	in.	in.	k·in.	1/in.		
0	0.00	0.00	0	0.0	0.0	-0.000019	0.00000	Camber = -0.190
0.25	0.21	3.63	3	1.5	46.0	-0.000017	-0.00008	Col Sum = 1.41
0.5	0.42	7.25	6	3.0	92.0	-0.000015	-0.00013	
0.75	0.62	10.88	9	4.5	137.9	-0.000012	-0.00017	
1	0.81	14.50	12	6.0	183.8	-0.000010	-0.00018	
1.25	1.00	18.13	15	7.5	229.5	-0.000007	-0.00017	
1.5	1.18	21.75	18	9.0	275.2	-0.000005	-0.00014	
1.75	1.36	25.38	21	10.5	320.8	-0.000003	-0.00009	
2	1.53	29.00	24	12.0	366.4	-0.000001	-0.00003	
2.25	1.69	32.63	27	13.5	411.8	0.000002	0.00006	
2.5	1.85	36.25	30	15.0	457.2	0.000004	0.00017	
2.75	2.00	39.88	33	16.5	502.6	0.000006	0.00031	
3	2.15	43.50	36	18.0	547.8	0.000009	0.00047	
3.25	2.29	47.13	39	19.5	593.0	0.000011	0.00065	
3.5	2.43	50.75	42	21.0	638.1	0.000014	0.00085	
3.75	2.55	54.38	45	22.5	683.2	0.000016	0.00107	
4	2.68	58.00	48	24.0	728.1	0.000018	0.00130	
4.25	2.79	61.63	51	25.5	773.0	0.000020	0.00155	
4.5	2.90	65.25	54	27.0	817.8	0.000022	0.00182	
4.75	3.01	68.88	57	28.5	862.6	0.000025	0.00211	
5	3.11	72.50	60	30.0	907.3	0.000027	0.00244	
5.25	3.20	76.13	63	31.5	951.9	0.000029	0.00279	
5.5	3.29	79.75	66	33.0	996.4	0.000032	0.00316	
5.75	3.37	83.38	69	34.5	1040.9	0.000034	0.00355	
6	3.44	87.00	72	36.0	1085.3	0.000041	0.00440	
6.25	3.51	90.63	75	37.5	1129.6	0.000045	0.00505	
6.5	3.57	94.25	78	39.0	1173.9	0.000051	0.00593	
6.75	3.63	97.88	81	40.5	1218.1	0.000058	0.00709	
7	3.68	101.50	84	42.0	1262.2	0.000072	0.00909	
7.25	3.73	105.13	87	43.5	1306.2	0.000089	0.01166	
7.5	3.76	108.75	90	45.0	1350.2	0.000110	0.01479	
7.75	3.80	112.38	93	46.5	1394.1	0.000133	0.01856	
8	3.82	116.00	96	48.0	1437.9	0.000176	0.02531	
8.25	3.84	119.63	99	49.5	1481.6	0.000259	0.03847	
8.5	3.86	123.25	102	51.0	1525.3	0.000387	0.05915	
8.75	3.87	126.88	105	52.5	1568.9	0.000581	0.09154	
9	3.87	130.50	108	54.0	1612.5	0.000960	0.15548	
9.25	3.87	129.78	111	52.5	1603.7	0.000817	0.12875	
9.5	3.86	129.05	114	51.0	1594.9	0.000743	0.11373	
9.75	3.84	128.33	117	49.5	1586.0	0.000682	0.10128	
10	3.82	127.60	120	48.0	1577.1	0.000627	0.09035	
10.25	3.80	126.88	123	46.5	1568.1	0.000577	0.08044	
10.5	3.76	126.15	126	45.0	1559.0	0.000530	0.07154	
10.75	3.73	125.43	129	43.5	1549.8	0.000486	0.06348	
11	3.68	124.70	132	42.0	1540.6	0.000446	0.05622	
11.25	3.63	123.98	135	40.5	1531.3	0.000410	0.04976	
11.5	3.57	123.25	138	39.0	1521.9	0.000373	0.04370	
11.75	3.51	122.53	141	37.5	1512.4	0.000341	0.03832	
12	3.44	121.80	144	36.0	1502.9	0.000311	0.03360	
12.25	3.37	116.73	147	34.5	1441.1	0.000185	0.01916	
12.5	3.29	111.65	150	33.0	1379.2	0.000125	0.01236	
12.75	3.20	106.58	153	31.5	1317.3	0.000094	0.00888	
13	3.11	101.50	156	30.0	1255.3	0.000070	0.00629	
13.25	3.01	96.43	159	28.5	1193.2	0.000053	0.00457	
13.5	2.90	91.35	162	27.0	1131.0	0.000045	0.00364	
13.75	2.79	86.28	165	25.5	1068.8	0.000039	0.00300	
14	2.68	81.20	168	24.0	1006.5	0.000032	0.00234	
14.25	2.55	76.13	171	22.5	944.2	0.000029	0.00196	
14.5	2.43	71.05	174	21.0	881.7	0.000026	0.00162	
14.75	2.29	65.98	177	19.5	819.2	0.000022	0.00132	
15	2.15	60.90	180	18.0	756.6	0.000019	0.00105	
15.25	2.00	55.83	183	16.5	694.0	0.000016	0.00081	
15.5	1.85	50.75	186	15.0	631.2	0.000013	0.00059	
15.75	1.69	45.68	189	13.5	568.4	0.000010	0.00040	
16	1.53	40.60	192	12.0	505.6	0.000006	0.00023	
16.25	1.36	35.53	195	10.5	442.6	0.000003	0.00010	
16.5	1.18	30.45	198	9.0	379.6	0.000000	0.00000	
16.75	1.00	25.38	201	7.5	316.5	-0.000003	-0.00007	
17	0.81	20.30	204	6.0	253.4	-0.000006	-0.00011	
17.25	0.62	15.23	207	4.5	190.1	-0.000010	-0.00013	
17.5	0.42	10.15	210	3.0	126.8	-0.000013	-0.00012	
17.75	0.21	5.08	213	1.5	63.4	-0.000016	-0.00007	
18	0.00	0.00	216	0.0	0.0	-0.000019	0.00000	

Appendix E Alternate Designs

	Design 1	Design 2	Design 3
Design			
Change	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
Result	Weight low Deflection high	High weight; Increased deflection	Low deflection Decreased weight

	Design 4	Design 5
Design		
Change	One strand at top to hold stirrup, higher deflection and failure load	Bottom flange reduced
Result	Clear cover excessive, high weight, stirrup design not constructable	Clear cover reduced; Decreased weight

Appendix F Performance Multiplier Scoring

Multiplier Scoring			
First Crack		Break	
Kip	Score	Kip	Score
20	0.95	32	0.95
21	0.96	33	0.97
22	0.98	34	1
23	1	35	1.03
24	1.02	36	1.05
25	1.03	37	1.03
26	1.05	38	1
27	1.03	39	0.97
28	1.02	40	0.95
29	1		
30	0.98		
31	0.96		

Appendix G Decision Matrix

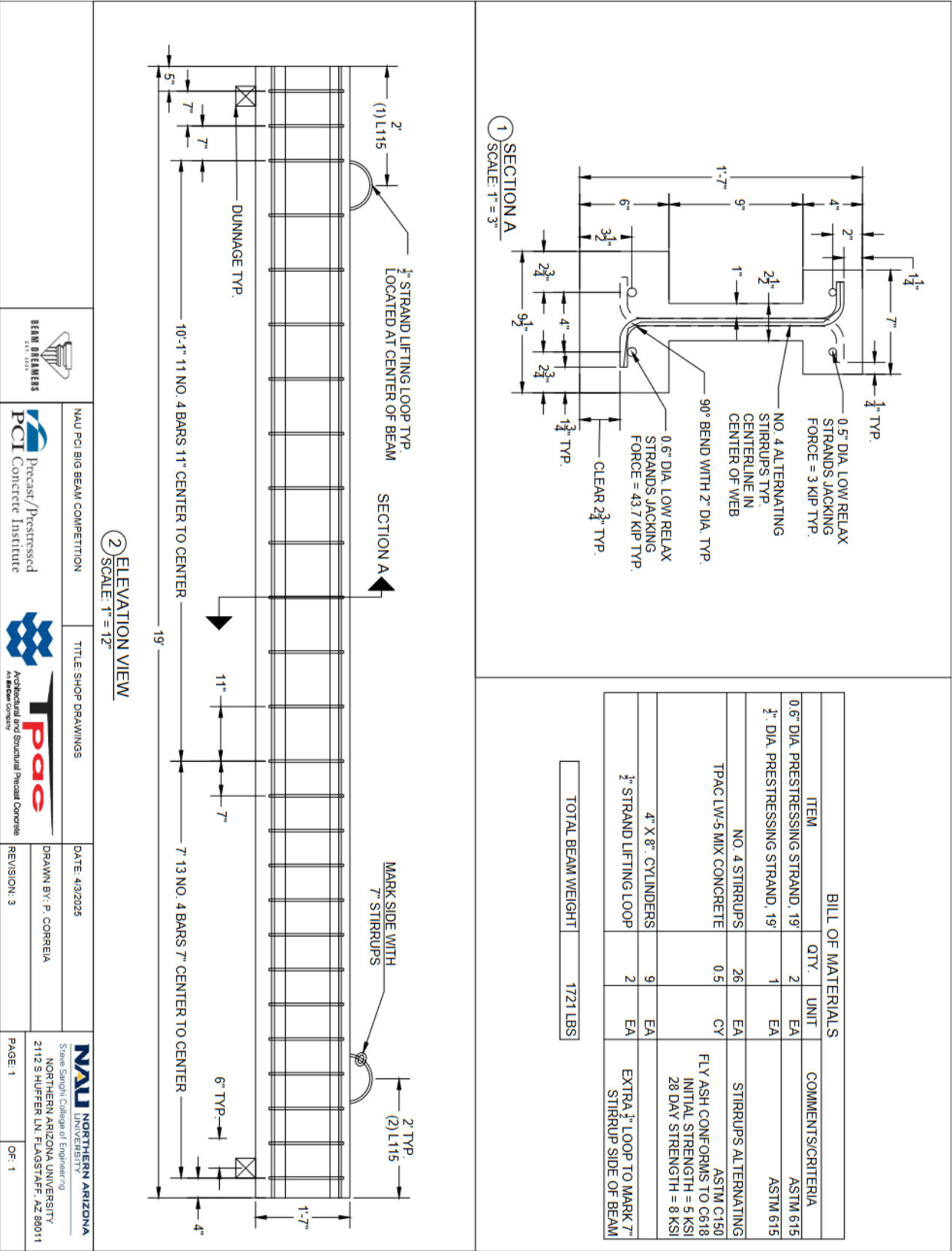
The design numbers correspond with the designs shown in Appendix E above. Design 5 is the final design, and the cross section is shown in Appendix H below. All weight, deflection, cost, first cracking, and breaking values are based on the MathCAD calculations in Appendix D.

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	0.50	1.35
3	1721	1	0.099	0	234.4	0.50	1.50
4	1690	0	0.124	1	232.5	1	2
5	1721	1	0.117	0.72	234.4	0.50	2.22

Performance multipliers were used to account for the constraints on the first crack being between 20 kips and 32 kips, and the beam breaking between 32 kips and 40 kips. The scoring of the multipliers is shown above in Appendix F.

Design	Performance Multiplier					Adjusted Score (max: 3.31) =A*B*C
	Initial Score A	Theoretical Values (kips)		Multiplier (between 0.95-1.05)		
		First Crack	Break	First Crack B	Break C	
1	1.30	23.25	34.9	1	1	1.3
2	1.35	23.85	36.75	1	1.05	1.42
3	1.50	23.65	35.89	1	1.03	1.55
4	2	23.85	36.55	1.02	1.05	2.14
5	2.22	23.03	35.35	1	1.03	2.28

Appendix H Shop Drawings



Appendix I Test Cylinder Analysis of Concrete Mixture
I.1 Raw Cylinder Test Data LW-5

Cylinder Test by Mix Design

Date cast	Product	Mix Design	Pre-set	FHR	Max Temp	Air Temp	Conc Temp	UNIT WEIGHT	Slump	Air%	Time Sample	Age @ Release	PSI @ Release	Req PSI @ Rel.	PSI @ 7 Days	PSI @ 14 Days	PSI @ 28 Days	Req 28Day
3/23/2020	BIG BEAM REJECT	LW-5				68	78	125	25.50	4.40	10.15	44.75	4750	5000			8020	8000
3/31/2020	BIG BEAM	LW-5				66	69	125	27.00	6.00	8.56	3.00	6365	5000			8220	8000
9/16/2020	24" DOUBLE TEES AIR DRY WEIGHT: 117.3 PCF	LW-5				87	84	122.8	30.25	7.50	8.05	11.50	4830	3700			9363	6000
9/18/2020	24" DOUBLE TEES AIR DRY WEIGHT: 117.2 PCF	LW-5				88	82	123.1	30.00	7.20	8.40	3.00	6220	3700			9050	6000
9/21/2020	24" DOUBLE TEES AIR DRY WEIGHT: 122.5 PCF	LW-5				88	87	126.6	28.00	4.10	9.05	11.00	5640	3700			8406	6000
9/23/2020	24" DOUBLE TEES AIR DRY WEIGHT: 118.1 PCF	LW-5				88	85	125.6	29.00	5.80	8.56	15.50	5240	3700			8990	6000
9/25/2020	24" DOUBLE TEES AIR DRY WEIGHT: 119.9 PCF	LW-5				88	86	126.7	28.50	7.00	8.58	3.00	6930	3700			9183	6000
9/29/2020	24" DOUBLE TEES AIR DRY WEIGHT: 118.4 PCF	LW-5				93	86	125.4	29.00	7.80	10.05	15.00	5460	3700			8963	6000
10/5/2020	24" DOUBLE TEES AIR DRY WEIGHT: 120.6 PCF	LW-5				87	89	126.7	30.00	8.00	9.30	12.00	4920	3700			8466	6000
10/6/2020	24" DOUBLE TEES AIR DRY WEIGHT: 120.1 PCF	LW-5				80	83	126.1	29.75	7.40	8.40	12.00	5040	3700			10186	6000
10/7/2020	24" DOUBLE TEES AIR DRY WEIGHT: 116.0 PCF	LW-5				85	81	123.1	28.50	9.00	8.30	12.50	5220	3700			8683	6000

Date cast	Product	Mix Design	Pre-set	FHR	Max Temp	Air Temp	Conc Temp	UNIT WEIGHT	Slump	Air%	Time Sample	Age @ Release	PSI @ Release	Req PSI @ Rel.	PSI @ 7 Days	PSI @ 14 Days	PSI @ 28 Days	Req 28Day
10/8/2020	24" DOUBLE TEES AIR DRY WEIGHT: 117.6 PCF	LW-5				90	91	123.8	27.00	8.20	8.45	14.00	5700	3700			7866	6000
10/9/2020	24" DOUBLE TEES AIR DRY WEIGHT: 121.3 PCF	LW-5				80	87	127.3	29.00	8.00	8.15	3.00	7690	3700			9937	6000
10/12/2020	24" DOUBLE TEES AIR DRY WEIGHT: 121.2 PCF	LW-5				80	79	129	25.75	9.20	9.45	14.00	6000	3700			7906	6000
2/25/2021	5 1/2" FLOOR SLABS	LW-5				53	66	125.7	27.00	5.70	7.23	17.00	4505	3500			8796	6000
3/2/2021	FLAT SLABS	LW-5				64	67	123.1	30.00	5.10	9.22	16.00	4655	3500			9183	6000
3/4/2021	FLOOR SLABS	LW-5				57	69	125.8	28.00	4.90	8.37	17.00	4815	3500			9076	6000
3/8/2021	FLOOR SLABS	LW-5				73	77	125.1	29.25	6.00	9.25	14.50	4605	3500			9136	6000
3/10/2021	FLOOR SLABS	LW-5				60	74	126.4	30.00	5.90	9.45	14.00	4328	3500			9150	6000
3/15/2021	FLOOR SLABS	LW-5				63	69	124	30.00	7.70	10.58	14.00	5370	3500			8803	6000
3/15/2021	BIG BEAM	LW-5				63	69	123.8	30.00	7.70	10.58	14.00	5370	5000			8803	8000
3/17/2021	FLOOR SLABS	LW-5				52	63	124.4	30.00	6.20	7.59	17.50	4160	3500			8187	6000
3/19/2021	FLAT SLABS	LW-5				67	73	127.5	28.25	3.00	8.55	2.00	37815	3500			9196	6000
3/23/2021	FLAT SLABS	LW-5				64	71	124.7	30.00	8.40	10.08	15.00	4370	3500			8983	6000

Date cast	Product	Mix Design	Pre-set	FHR	Max Temp	Air Temp	Conc Temp	UNIT WEIGHT	Slump	Air%	Time Sample	Age @ Release	PSI @ Release	Req PSI @ Rel.	PSI @ 7 Days	PSI @ 14 Days	PSI @ 28 Days	Req 28Day
3/25/2021	FLAT SLABS	LW-5				50	64	128	30.00	6.30	6.35	17.50	5430	3500			11046	6000
3/29/2021	FLAT SLABS	LW-5				70	74	127.5	28.00	6.10	8.29	17.00	4555	3500			9738	6000
3/30/2021	FLAT SLABS	LW-5				70	70	124.8	25.00	6.30	7.59	18.00	4750	3500			8956	6000
3/31/2021	FLAT SLABS	LW-5				68	78	129.6	27.50	6.00	9.07	16.00	5430	3500			10933	6000
4/2/2021	FLAT SLABS	LW-5				69	76	128	24.00	5.70	5.30	2.00	7310	3500			10153	6000
4/6/2021	FLAT SLABS	LW-5				69	75	127.8	27.00	5.60	6.00	19.00	5900	3500			9858	6000
4/21/2021	FLAT SLABS	LW-5				72	73	121.5	25.00	8.00	7.29	14.00	4560	3500			8596	6000
4/21/2021	NAU BIG BEAM 170-1	LW-5				72	73	119.7	25.00	8.00	7.29	2.00	5450	5000			8596	8000
3/28/2022	BEAM 126.0 PCF	LW-5				68	74	126	27.75	3.50	8.37	37.75	6750	5000			10113	8000

Appendix J Fabrication Reports

J.1 TPAC Test Cylinder Report

TPAC

An Encon Company
Quality Control Dept.
(602) 262-1324

Concrete Test Report

Job Name: PCI BIG BEAM CONTEST

TPAC Job Number 8185.C

Contractor: NAU

Report Date: 4/8/2025

Address:

Date cast	Product	Mix Design	Pre-set	Initial UW	Final UW	Air Temp.	Conc. Temp.	Slump/Spread	% Air	Time Sample	Age @ Release	PSI @ Release	Req. PSI @ Rel.	PSI @ 7 Days	PSI @ 14 Days	PSI @ 28 Days	Req. PSI @ 28 Days
4/4/2025	BEAM	LW-5		118.2		69	67	27.50	7.25	9.18	3.00 DAY	5077.5	5000				8000

J.2 Inspection Report

Prestressed Girders- Prepour/Postpour Inspection Report

By: T. CHAPMAN ADOT Yes ☐ No ☐ Job # 8185-L Girder Type "I" Bed # 170-1 Weather Alone
 (R) Before Casting
 Cast Date: 4/4/25 Friday TPAC Postpour Date: 4/8/25
 Seq. # Marks # 1 Job Name: NAU BIG BEAM

	Girder #1	Girder #2	Girder #3	Girder #4
Rebar	4000			
	0001			
	B A B A B A B A			
Sizes and Shapes	✓			
Widths & Lengths	✓			
Depths & Thickness	✓			
Ends Square/Dags	✓			
Sleeves-blockouts-Openings	✓			
Side Forms leveled and lined	✓			
Headers/slopes/skews	✓			
Sidewalls clean, remove buildup	✓			
Oil wiped to a semi dry finish	✓			
Header Condition Checked	✓			
Soffit Condition Checked	✓			
Side Form Walls Clamped Down	✓			
Strand-Rebar-Mesh	✓			
Strand Identified (Manufacturer)	✓			
Strand Height/Pattern	✓			
Tower setup/position	✓			
Rollers Lubed	✓			
Depression Points	✓			
Tensioning checked	✓			
Rebar checked and cleaned	✓			
End Mesh Added ?	✓			
Plates-Lift Hooks-Inserts	✓			
Proper No., Location and size	✓			
Plates square and flat	✓			
Safety sleeves location	✓			
Blidwell Pipes location	✓			
Weld clip/ Hanger layout	✓			
Insert Locations	✓			
Lifeline installation checked	✓			
Surface & Appearance	✓			
Chipping, Cracking, spalling	N/A	N/A	N/A	N/A
Form Leaks-Vibration	N/A	N/A	N/A	N/A
Edges & Corners	N/A	N/A	N/A	N/A
Strand Projection- Marked and Checked	N/A	N/A	N/A	N/A
Form Finish-Exterior ADOT	N/A	N/A	N/A	N/A
Top Finish per schedule	N/A	N/A	N/A	N/A
Curing-Steam/Water-Covered	N/A	N/A	N/A	N/A
Daily Housekeeping				

Remarks & Corrections Required
 Length & width +1/4"
 Double lifter unsecured
 verify not touching
 forms after concrete
 placement.
 Patch / Rebar
 small Chipping @ edges

Manager Signoff: Bed Foreman _____ Date: _____

Superintendent _____ Date: _____

J.3 Tensioning Record

NAU Big Beam

JOSE



TPAC TENSIONING PROGRAM

Date: 4/3/2025 Time: 5:00:21 AM

Job Number / Name: 30-8185.C / NAU BIG BEAM 2025
 Plant Location: Phoenix
 Bed: 170 #1
 Pump Number: TP20, TP22, TP23
 Default Strand Type: 0.6
 Initial Pull in Pounds: 3000
 Number of Strands: 4
 Bed Number: 2
 Remarks: 4 - 0.6" 270K LOLAX & (2) 1/2" Strands @ 3.k

Big Beam
170 #1

Bed Data: Length = 2168 inches, Shortening = 0.375 inches.
 Pump Data: Zero load reading = 3.9304574431 pounds, Slope = 0.060737864
 Strand Data: Area = 0.22 inches², Modulus of elasticity = 28,800,000
 Pull Data: Default final pull = 43,700 pounds, Maximum pull = 43,700 pounds.
 Slippage Data: Live end slippage = 0.5 inch, Dead end slippage = 0.125 inch.
 Splice Chuck: Splice chuck is not being used.

Beginning Strand #	Ending Strand #	Elongation Reduction	Number of Pieces	Strand Type	Final Pull	Bed
1	2			0.6	43,700	170
3	4			1/2	3,000	170



PHOENIX TENSIONING RECORD

DAY: Friday DATE: 4-4-25 TIME: 2:10 AM
 CAST: #1 INSPECTOR: Alex TENSIONED BY: F. Lujan

JOB ID: 30-8185.C / NAU BIG BEAM 2025

BED: 170

BED ID: 1A

PUMP: TP20, TP22, TP23 JACK: 23, 26

.6 pump #22 Jack #23
 .5 pump #01 Jack #23

REMARKS: 4 - 0.6" 270K LOLAX & (2) 1/2" Strands @ 3.k

NOTE: ALL STRANDS TO RECEIVE INITIAL 3000 POUNDS TENSION BEFORE MEASUREMENTS

STRAND			ELONGATION				GAUGE			
STR NO.	STR SIZE	PACK NUMBER	FINAL ELONGATION MEASUREMENT	DESIRED ELONG	ELONGATION TOLERANCE (IN.)		FINAL GAUGE READ.	REQD GAUGE READ.	GAUGE TOLERANCE	
					LOW	HIGH			LOW	HIGH
.6	1	0.6	120237 462135	14 3/8	14 1/8	14 3/4	2600 42400	2750	2680	2820
.6	2	0.6	120237 462135	14 1/4	14 1/8	14 3/4	2600 42400	2750	2680	2820
.5	3	1/2	120137 494037	1/2	0 1/2	0 1/2	250	250	240	250
.5	4	1/2	120137 494037	1/2	0 1/2	0 1/2	250	250	240	250

TPAC

MULTIPLE STRAND STRESSING / ELONGATION REPORT

JOB ID: 30-8185.C / NAU BIG BEAM 2025 PLANT: PHOENIX
 BED: 170 BED ID: 2
 PUMP: TP20, TP22, TP23 JACK: 23, 26
 REMARKS: 4 - 0.6" 270K LOLAX & (2) 1/2" Strands @ 3.k
 NOTES: All strands to receive initial 3000 pounds tension before measurements.

Stressed By: F Lujan Date: 3-4-29

INITIAL

CHECKLIST

- | | | |
|---------------------|------|--|
| <u>FL</u> | 1). | Check strand vises for proper seating and extension. |
| <u>FL</u> | 2). | Strand extends at least 2" beyond the strand vise cap. |
| <u>FL</u> | 3). | Hoses, rams, and pump oil level are in good condition and are ready for use. |
| <u>FL</u> | 4). | Stress to initial tension as required. |
| <u>FL</u> | 5). | Blow the all clear siren to clear the bed. |
| <u>FL</u> | 6). | Line is cleared, final stressing may proceed. |
| <u>FL</u> | 7). | Three people maximum in the stressing area. |
| <u>FL</u> | 8). | Final pressure/elongation is reached. |
| <u>FL</u> | 9). | Release the pump pressure. |
| <u>FL</u> | 10). | Wait 30 seconds after pressure is released, sound the siren for crew return. |
| <u>Doc. Control</u> | 11). | Record Elongation to the nearest 1/8". |
| _____ | 12). | Route Completed Checklist to QC Department by end of shift. |
| <u>Log</u> _____ | 13). | _____ |
| <u>File</u> _____ | 14). | _____ |
| <u>X-File</u> _____ | 15). | _____ |
| Comments / Other: | | _____ |
| | | _____ |