2018 – 2019 PCI BIG BEAM

THE B.E.A.M. TEAM

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THANK YOU TO OUR SPONSORS

Figure 1 Western Tech. Logo

Figure 3 Utilite Logo

Figure 4 PCI Logo

Figure 5 Border Logo

Figure 2 Cemex Logo

Figure 6 Tpac Logo

THE 2018 – 2019 PCI BIG BEAM COMPETITION INTRODUCTION

1. Design Accuracy
2. Lowest Cost
3. Lowest Weight
4. Largest Measured Deflection
5. Most Accurate Predictions
6. Report Quality
7. Practicality, Innovation, and Conformance

[1] All competition guidelines stated by PCI Organization

MILESTONES

- Concrete Mix Design
- Cross Section Design / Reinforcement Layout
- Decision Matrix
- Final Beam Selection
- Procurement / Fabrication
- Transportation
- Beam Testing / Structural Analysis

MIX DESIGN

Table 1: Mix Design Properties

Property	Requested	Actual
Unit Weight	144 lb/ft^3	145 lb/ft^3
3-Day Compressive Strength	6,000 psi	8,260 psi
28-Day Compression Strength	8,000	9,770

Figure 7 Broken Cylinder [2]

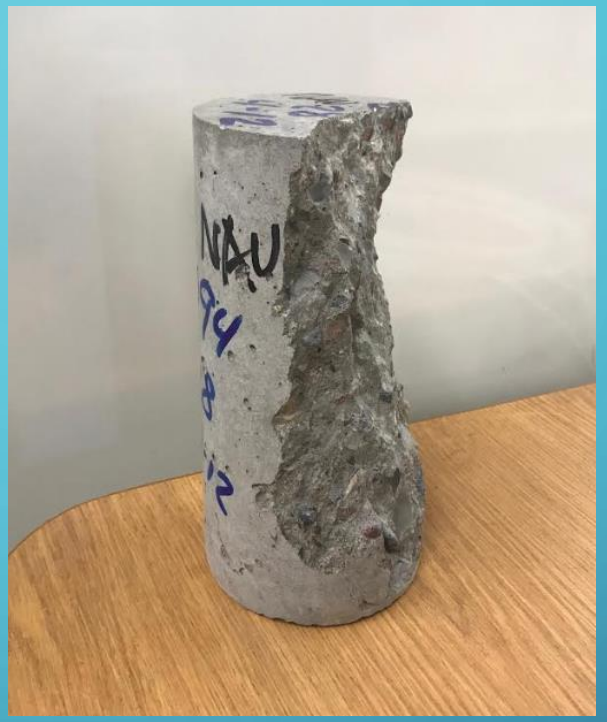


Figure 8 Broken Cylinder [2]

Figure 9 Crocket Breaking Cylinder [6]

CROSS SECTION DESIGN/REINFORCEMENT LAYOUT

$$M_{cr} = S_{bc}\left[\frac{P}{A} + \frac{Pe}{S_b} + f_r\right] - M_{nc}\left(\frac{S_{bc}}{S_b} - 1\right)$$

Eq. 1 Cracking Moment [3]

$$M_n = A_{ps} f_{ps}\left(d_p - \frac{a}{2}\right) + A_s f_y\left(d - \frac{a}{2}\right) + A'_s f'_s\left(\frac{a}{2} - d'\right)$$

Eq. 2 Nominal Capacity [3]

$$f_r = 7.5\lambda\sqrt{f'_c}$$

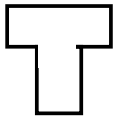
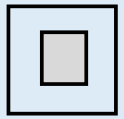
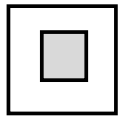
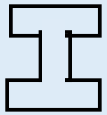
Eq. 3 Rupturing Stress [3]

M_{CR} = Cracking moment
S_b = Section modulus
P = Prestress force
A = Cross section area
e = Eccentricity
f_r = Rupturing stress

M_n = Nominal capacity
A_{PS} = Area of prestress
A_S = Area of tension Steel
A'_S = Area of compression Steel
d_P = Depth of prestressing
d = Depth of tension steel
d' = Depth of compressive steel
f_y = Yield stress of steel
f_{PS} = Nominal stress of restress strands
a = Depth of compressive stress block

DECISION MATRIX

Table 2: Cross Section Decision Matrix

Section	Shape	Weight (lb)	Gross Area (in^2)	Cost	Formwork
Shallow T-Beam		3960	198	$284.33	Difficult
T-Beam		2640	132	$262.66	Difficult
LW Hollow Box		1940	114	$257.13	Moderate
NW Hollow Box		1960	98	$204.03	Moderate
I-Beam		3400	177	$328.24	Difficult

FINAL BEAM SELECTION

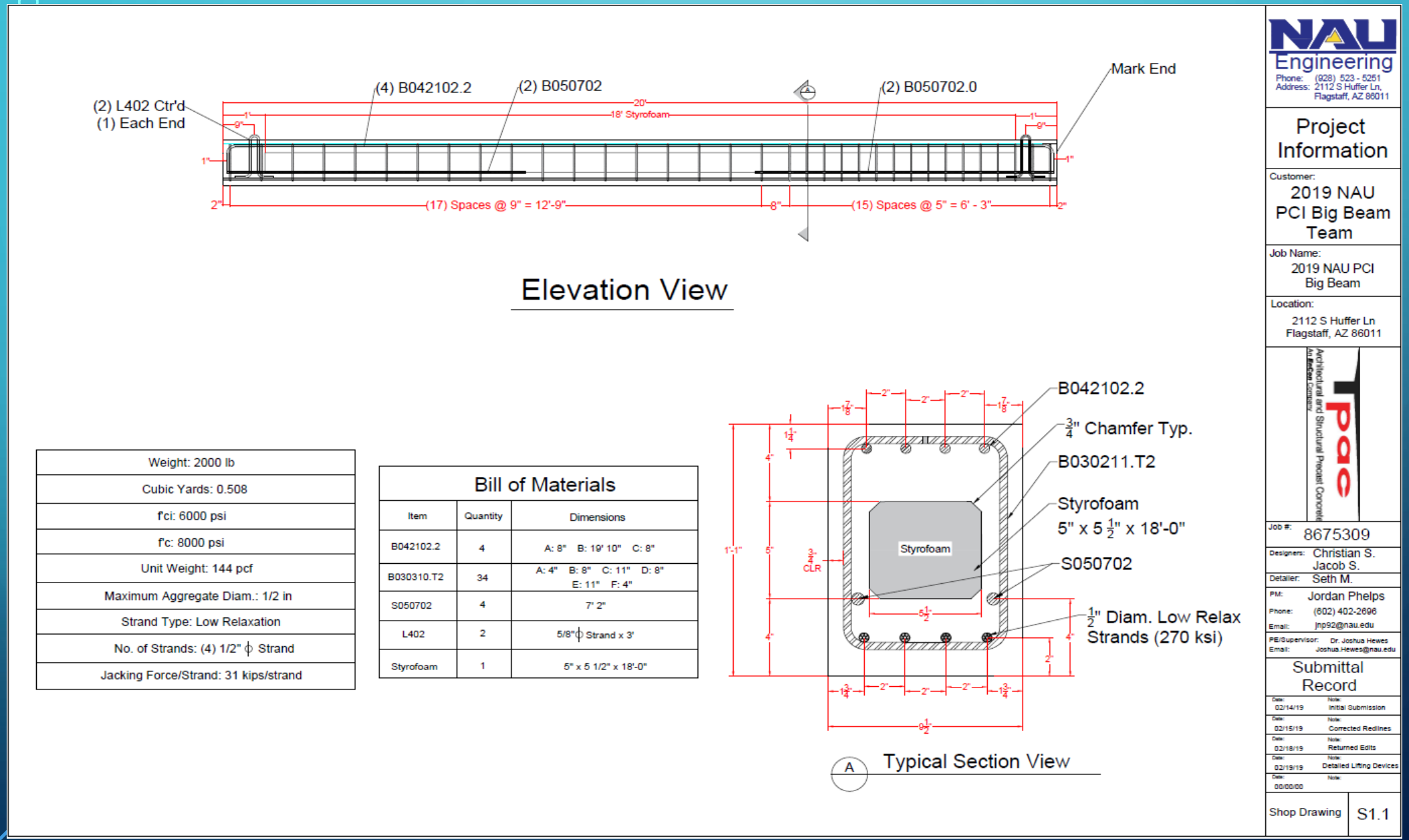


Figure 7: Final Shop Drawings

PROCUREMENT / FABRICATION

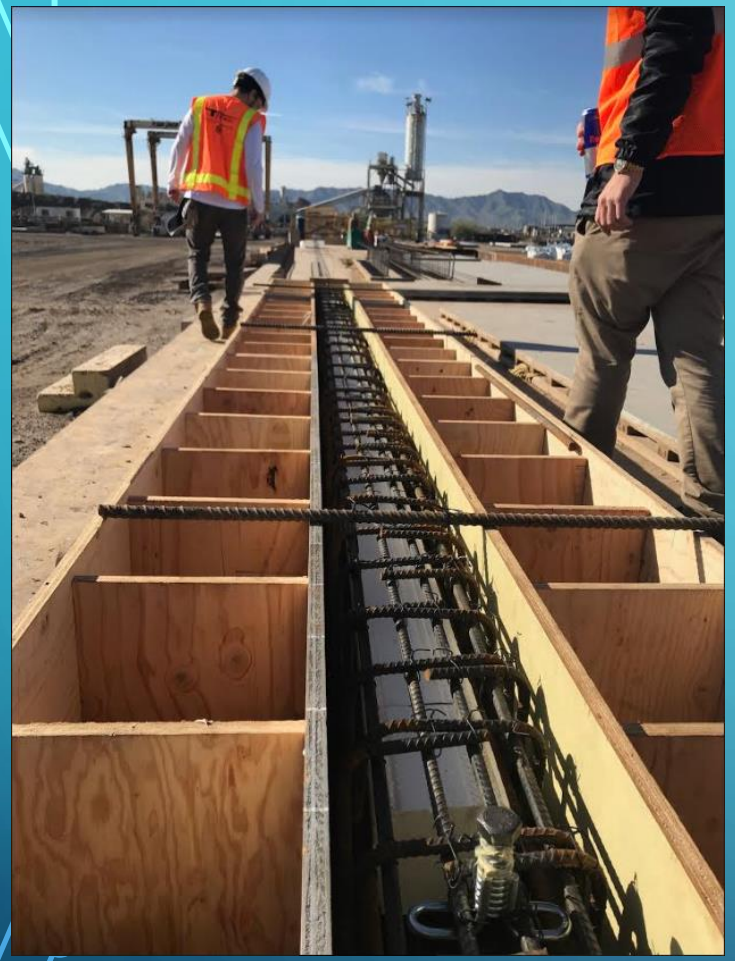


Figure 10 Formwork [2]

Figure 11 Screeding of Concrete [2]

Figure 12 Final Cast [2]

TRANSPORTATION

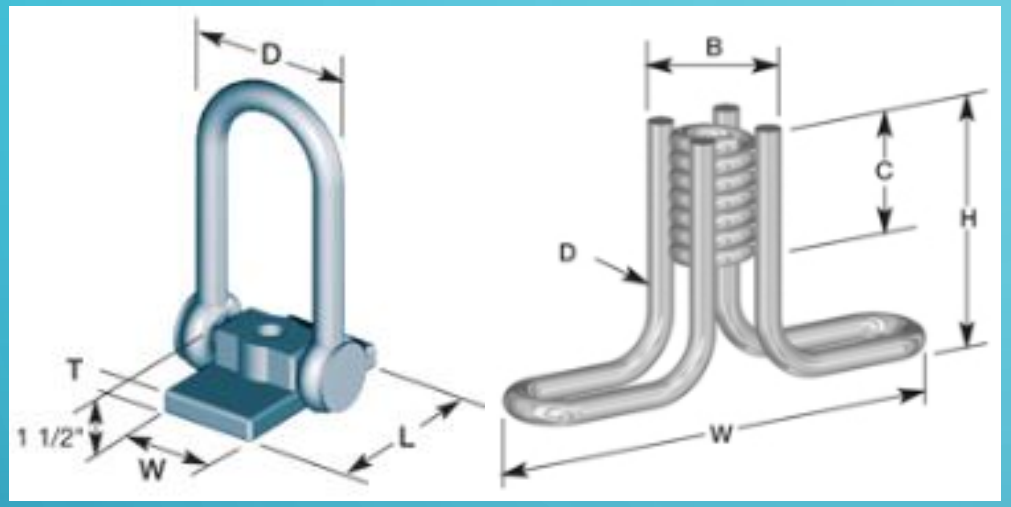


Figure 13 CX-28 Coil Wingnut & LP-11 Swivel Lifting Plate [4]

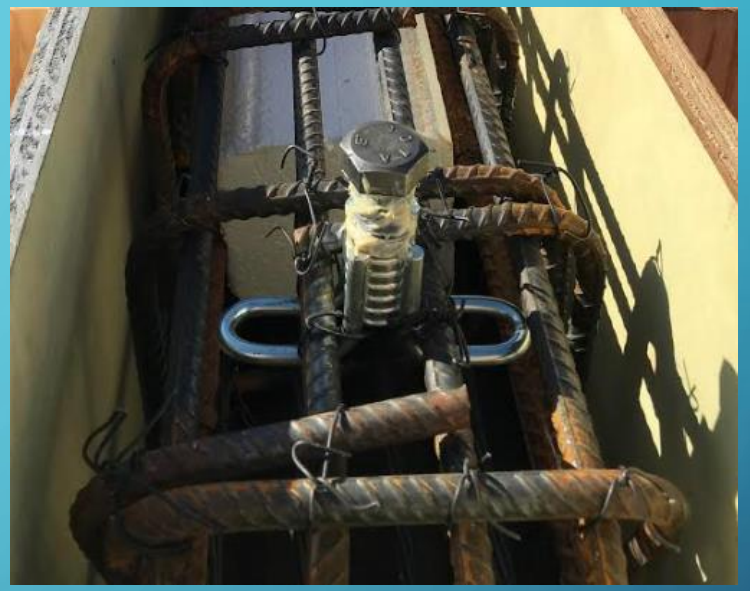


Figure 14 Formwork [2]

Figure 15 Resting Beam [2]

RESPONSE 2000

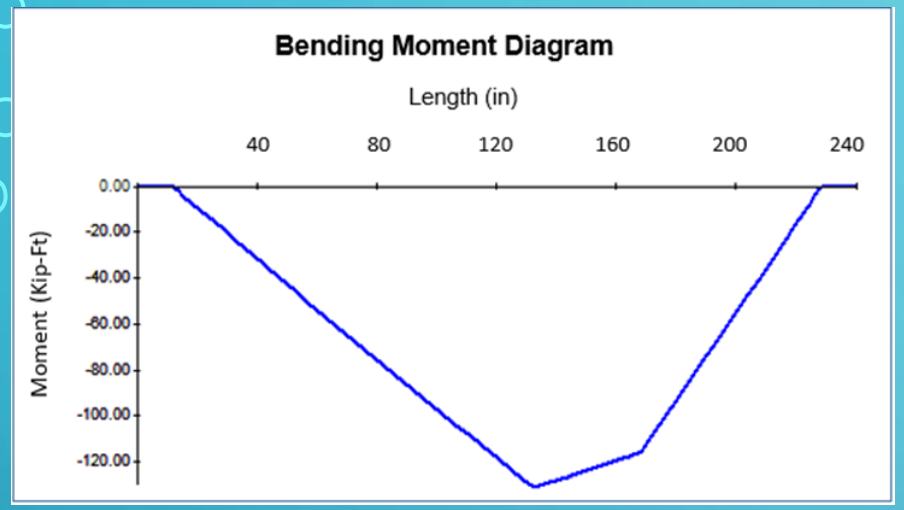


Figure 16 Response 2000 Bending Moment Diagram [5]

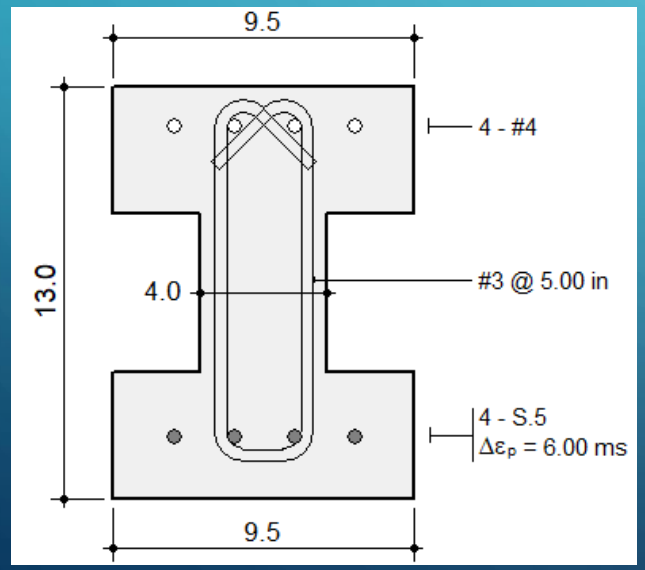


Figure 19 Response 2000 Modeled Cross-Section [5]

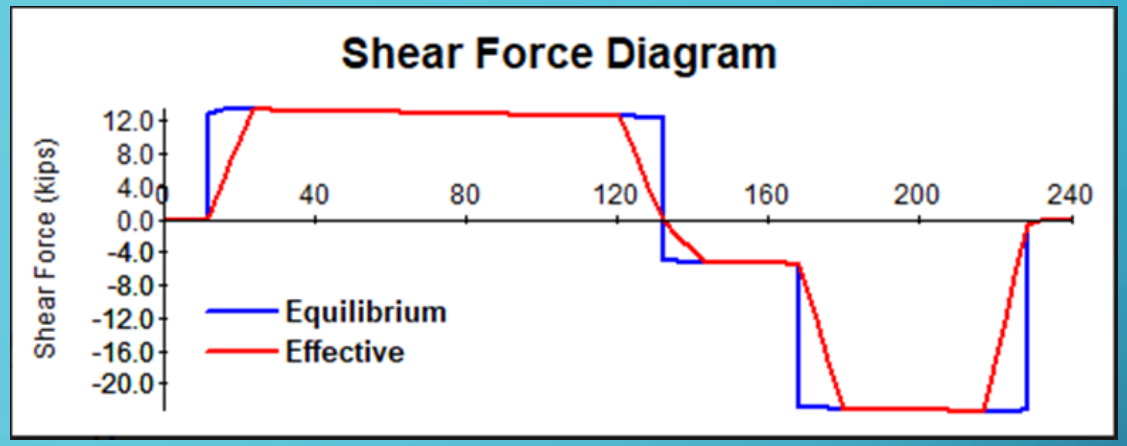


Figure 17 Response 2000 Shear Force Diagram [5]

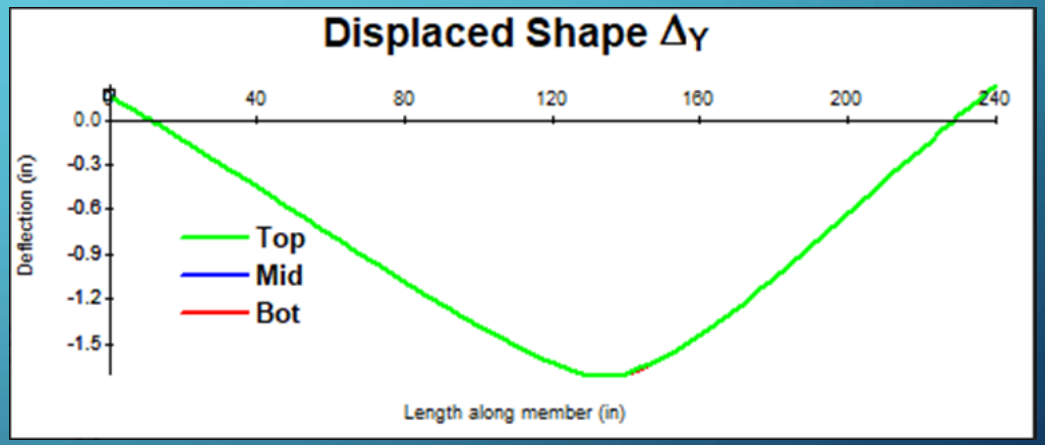


Figure 18 Response 2000 Graphical Deflection [5]

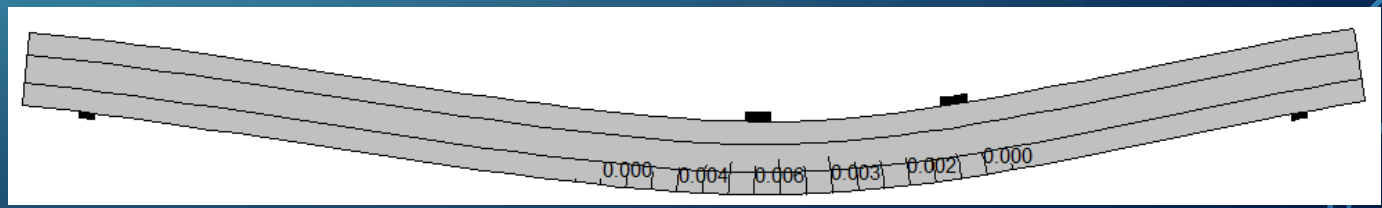


Figure 20 Response 2000 Modeled Curvature [5]

BEAM PRE-TESTING

Table 3 Predicted Results

Category	Predicted
Cracking Load (kips)	21.2
Failure Load (kips)	36.4
Deflection (in)	2

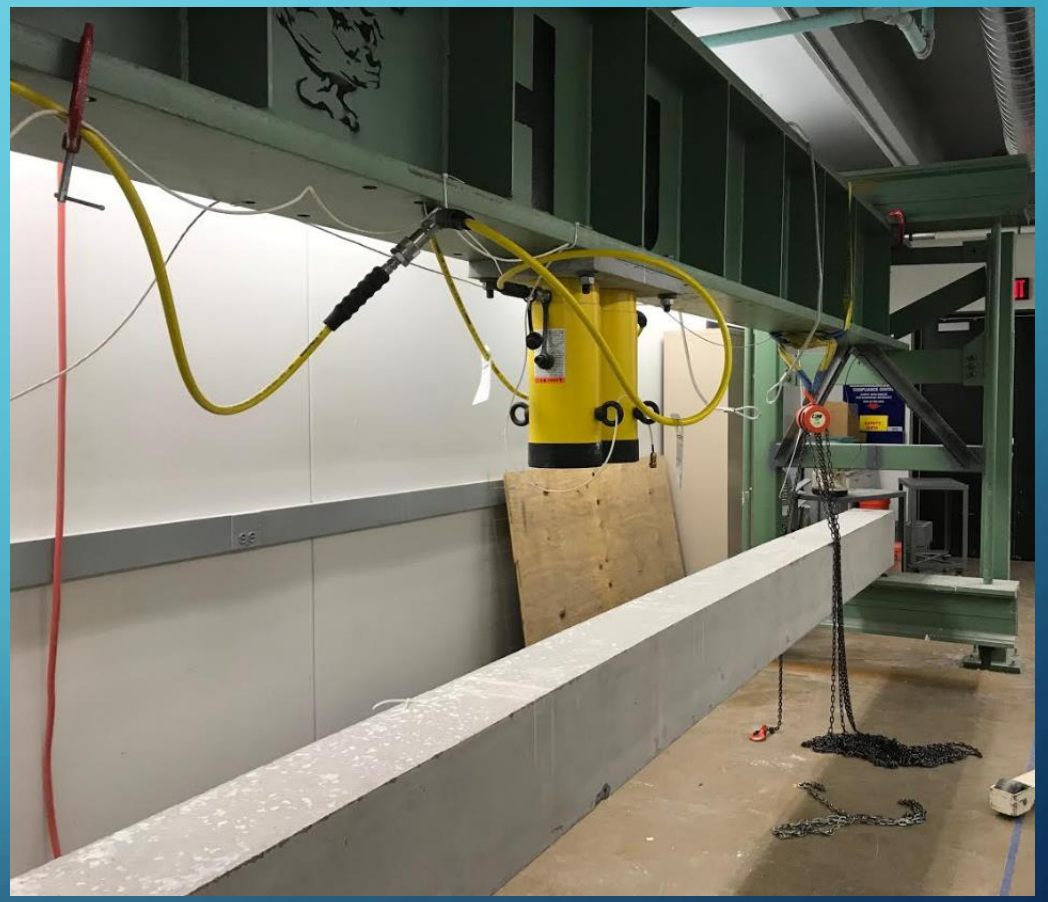


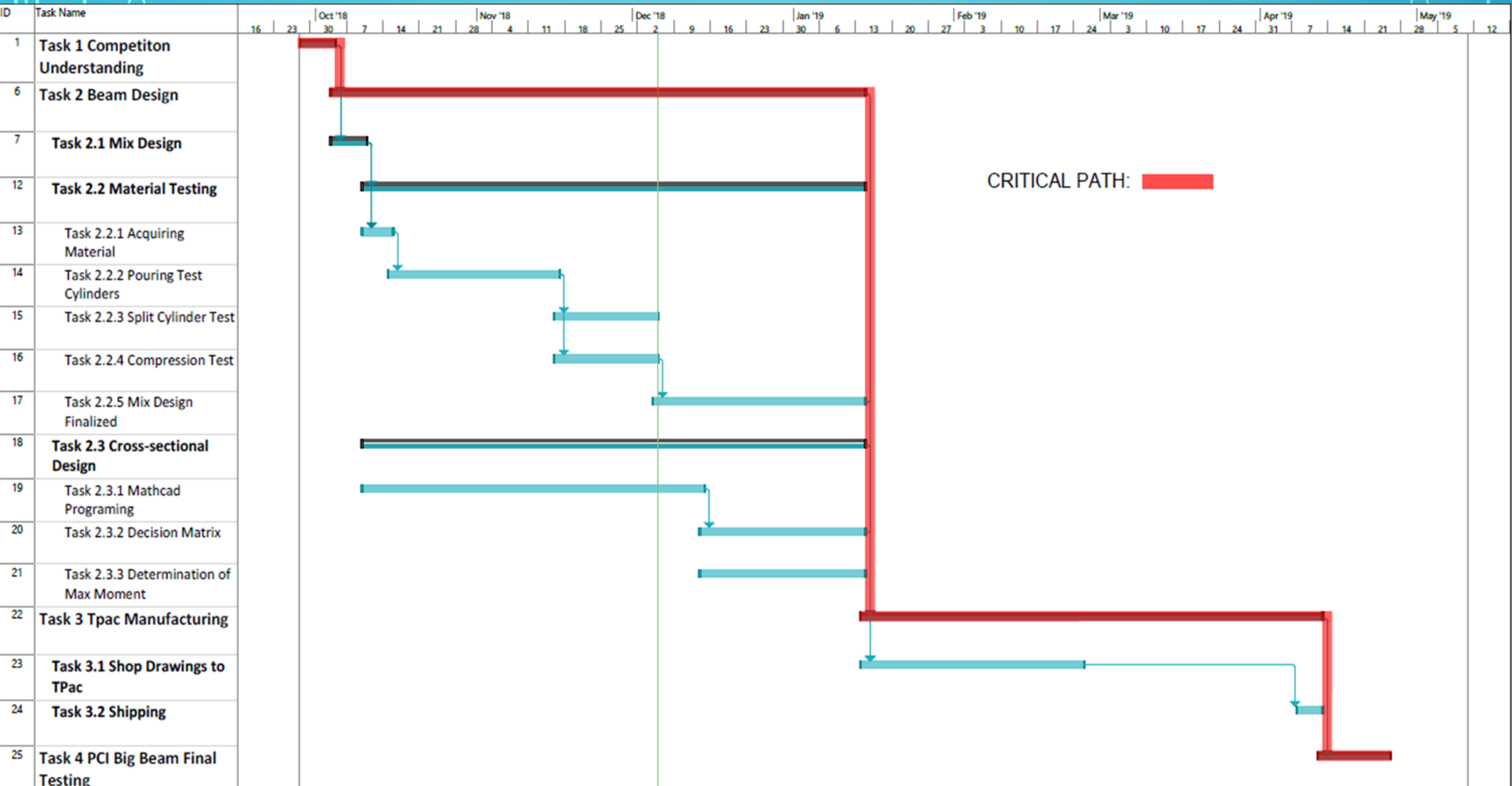
Figure 21 Current State of Beam Setup [2]

BEAM POST-TESTING

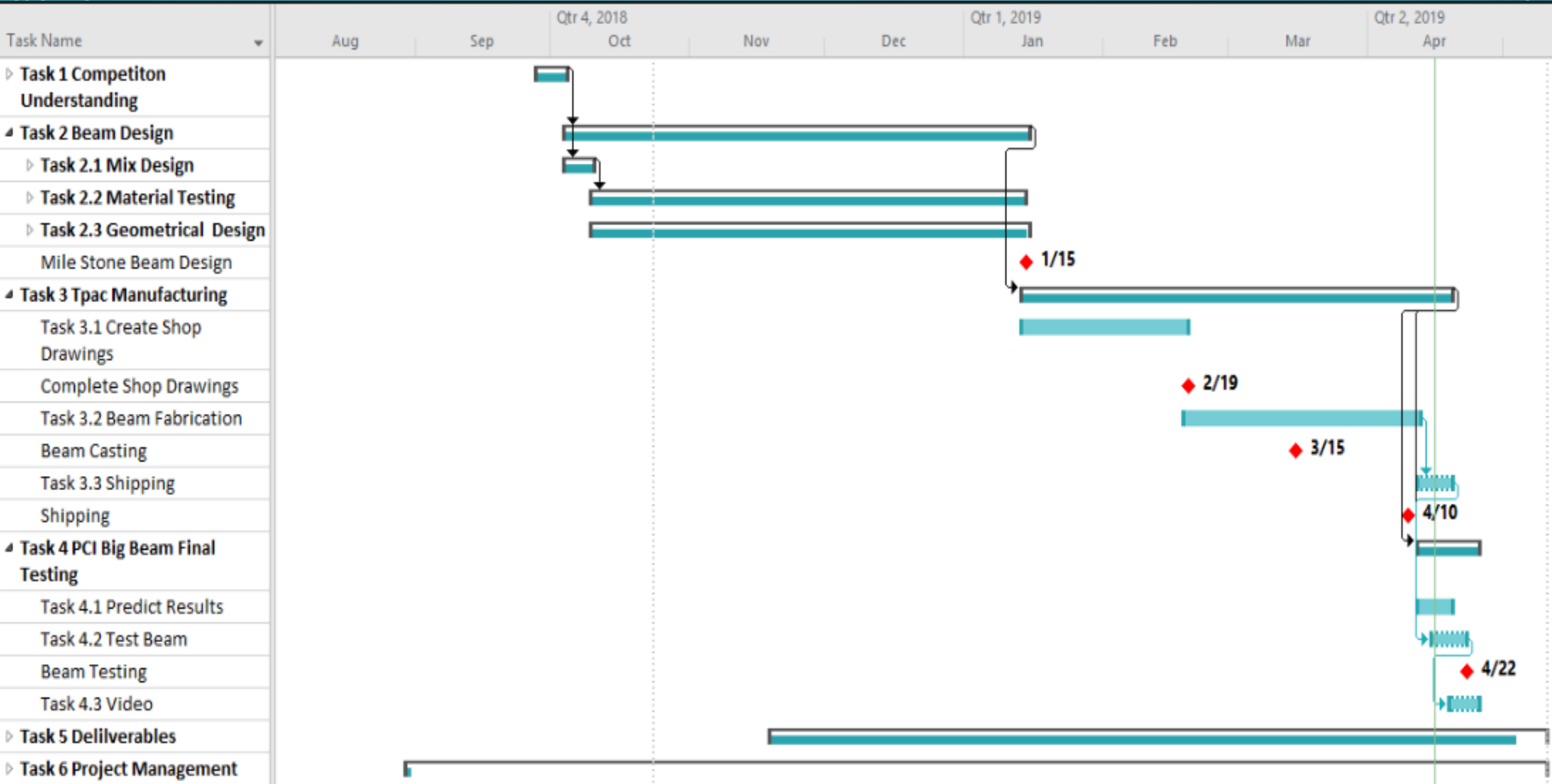
Table 4 Testing Results

Category	Predicted	Test Results	% Difference
Cracking Load (kips)	21.2	NA	NA
Failure Load (kips)	36.4	NA	NA
Deflection (in)	2	NA	NA

INITIAL SCHEDULE



UPDATED SCHEDULE



PROPOSED PROJECT HOURS

Table 5 Proposed Project Hours

Task	Senior Engineer	Structural Engineer	Lab Technician	EIT	Task Hours
Task 1 – Competition Understanding	8	8	8	8	32
Task 2 – Beam Design	80	100	25	25	230
Task 3 – Tpac Manufacturing	10	25	10	30	75
Task 4 – Final Beam Testing	10	10	10	10	40
Task 5 – Deliverables	25	25	20	35	105
Task 6 – Project Management	35	35	30	30	130
Project Hours	**168**	**203**	**103**	**138**	**612**

UPDATED HOURS

Table 6 Updated Project Hours

Task	Senior Engineer	Structural Engineer	Lab Technician	EIT	Task Hours
Task 1 – Competition Understanding	5	5	5	5	20
Task 2 – Beam Design	120	140	80	72	412
Task 3 – Tpac Manufacturing	10	6	4	28	48
Task 4 – Final Beam Testing	2	2	2	2	8
Task 5 – Deliverables	32	15	15	74	136
Task 6 – Project Management	20	20	20	25	85
Project Hours	**189**	**188**	**126**	**206**	**709**

PROPOSED PROJECT COST

Table 7 Cost of Engineering Services

Personnel	Hours	Rate ($/hour)	Cost
Senior Engineer	168	126	$ 21,086
Structural Engineer	203	101	$ 20510
Lab Technician	103	57	$ 5,903
EIT	138	52	$7,180
		Total	**$ 54,679**

Proposed Project Cost = $ 57,357

Table 8 Travel Cost

Location	$/mile	Miles	Travel Cost
Cemex	$ 0.55	20	$ 11
Tpac	$ 0.55	300	$ 165
Western Tech	$ 0.55	10	$ 6
		Total	**$ 182**

Table 9 Subcontracting Cost

Item	$/Test	# of Test	Total Cost
Compression Test	104	12	$ 1248
Split Cylinder Test	104	12	$ 1248
		Total	**$ 2496**

UPDATED PROJECT COST

Table 10 Cost of Engineering Services

Personnel	Hours	Rate ($/hour)	Cost ($)
Senior Engineer	189	126	$ 23,721
Structural Engineer	188	101	$ 18,995
Lab Technician	126	57	$ 7,221
EIT	206	52	$ 10,718
		Total	**$ 60,655**

Table 11 Travel Cost

Location	$/mile	Miles	Travel Cost
Cemex	$ 0.55	20	$ 11
Tpac	$ 0.55	300	$ 165
Western Tech	$ 0.55	10	$ 6
		Total	**$ 182**

UPDATED PROJECT COST CONT.

Table 12 Beam Testing Cost

Item	Total Cost
Plaster of Paris	$ 5
Load Cell	$ 350
Sensor Pots	$ 300
Fiber Optic Cables	$ 75
DAQ Software	$ 100
Compression Test	$ 936
Total	**$ 1,766**

Total Project Cost = $ 62,603

LEARNING OUTCOMES

1. Take advantage of the first semester.
2. Know time frame required by Tpac.
3. Better communication with Tpac.

Figure 22 Team Photo [2]

REFERENCES

[1] "Precast/Prestress Concrete Institute," PCI, 2019. [Online].

[2] J. Phelps, Photo Taken, Flagstaff, 2018.

[3] PCI Design Handbook, Chicago, 2004.

[4] "Tpac: Providing Engineered Concrete Solutions," Tpac, 2019. [Online].

[5] E. Bentz, "Response 2000," University of Toronto, 2010. [Online].

[6] J. Phelps, Photo Taken, Flagstaff, 2018.

[6] ACI Committee, ACI 318-14 Building Code Requirements, 2014.

[7] "The Civil Engineering Daily," [Online].

[8] R. Crouch, "PCI Big Beam Competition 2017-2018", 2018.