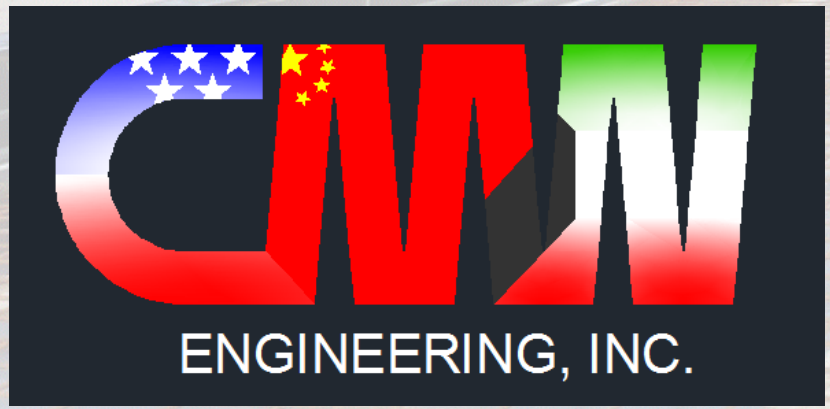
PCI Big Beam Contest



CMW Engineering, Inc.
Wael Alqattan
Chad Dietrich
Mengxi Du

Purpose

- Effectively design a prestressed/reinforced concrete beam
- Meet parameters set by PCI Contest Committee
- Coordinate with PCI Producer Member
- Beam will be tested, analyzed and judged

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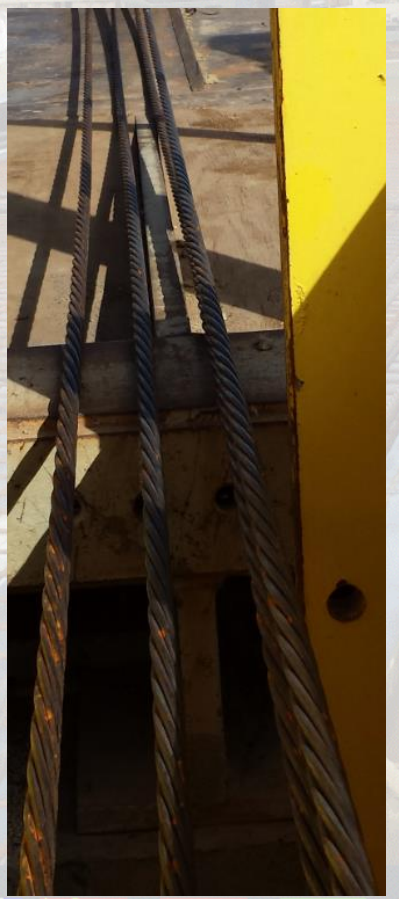
Prestressed Background

- Precast has innovated the structural industry
- Prestressed concrete is the process of prestressing concrete with strands
  - Allows for a higher ultimate capacity as well as a higher deflection



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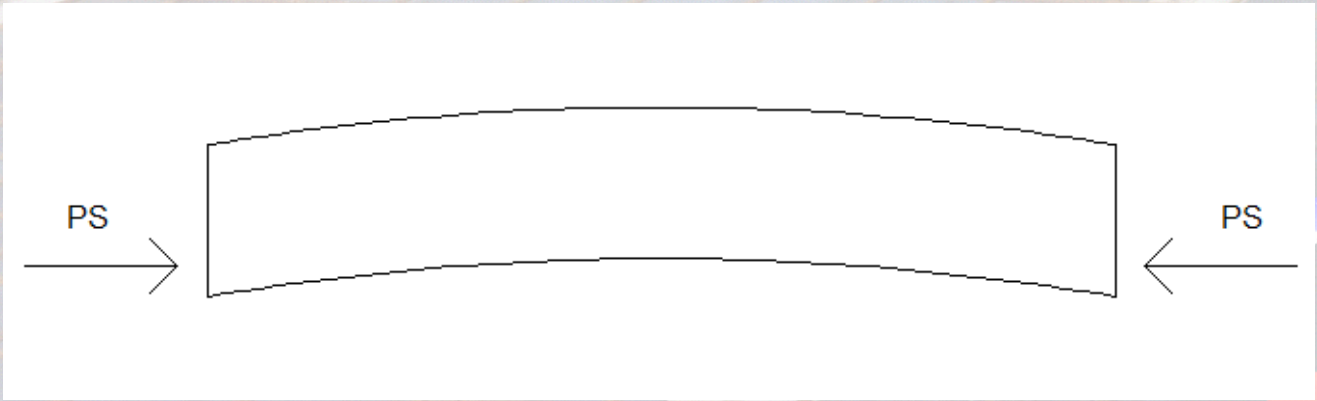

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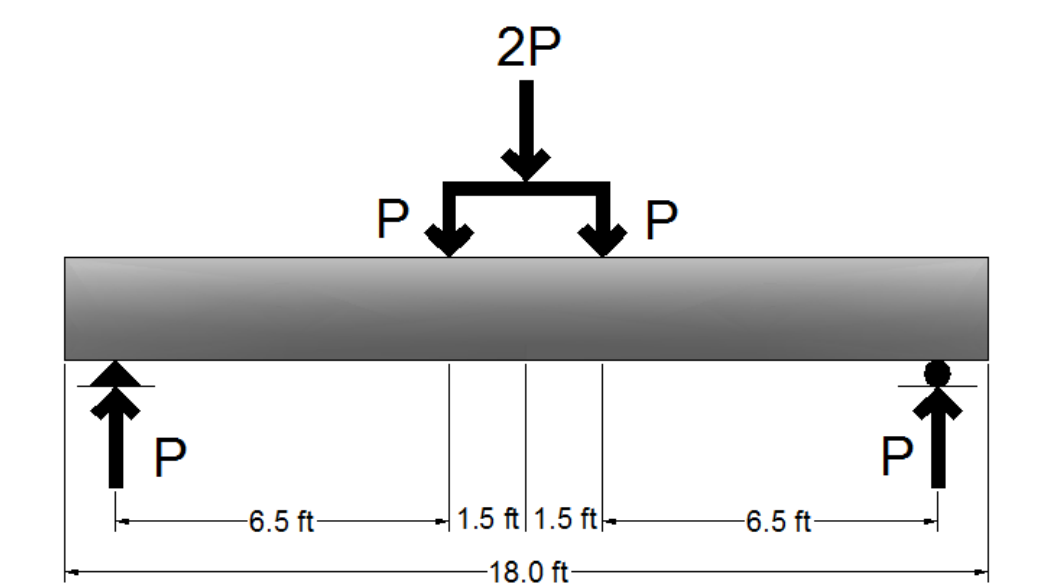
Contest Parameters/Existing Conditions

- 18 ft long, prestressed, precast beam that is simply supported over 16 ft
- Design for
  - Cracking above service load (22 kips)
  - Fail above factored load (35.2 kips) and below peak load (42 kips)
- Judging Criteria
- Few Constraints



Technical Objectives

- Design of Prestressed Beam
  - Design, analysis, testing, results and report
- Research Existing Projects
- Acquire additional knowledge outside of the undergraduate curriculum

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Challenges

- Rules and Parameters given by PCI
- Communication with Client
- Testing accuracy
- Deadlines set forth by PCI Big Beam Competition

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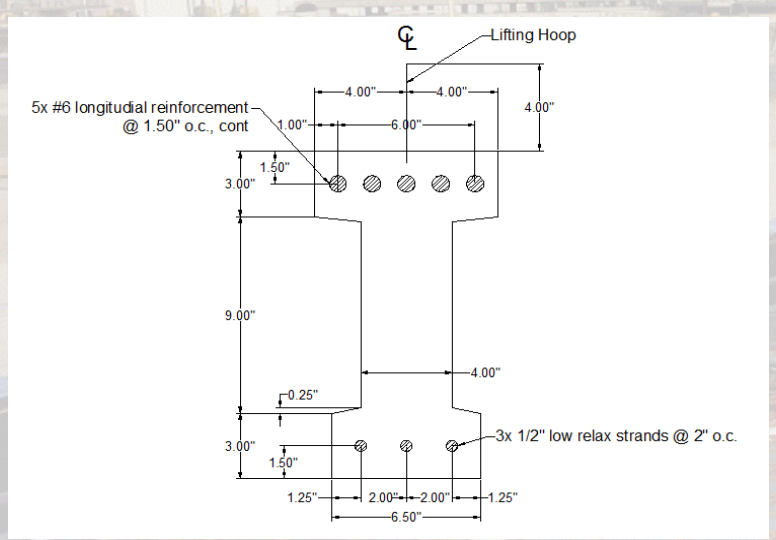
Preliminary Analysis

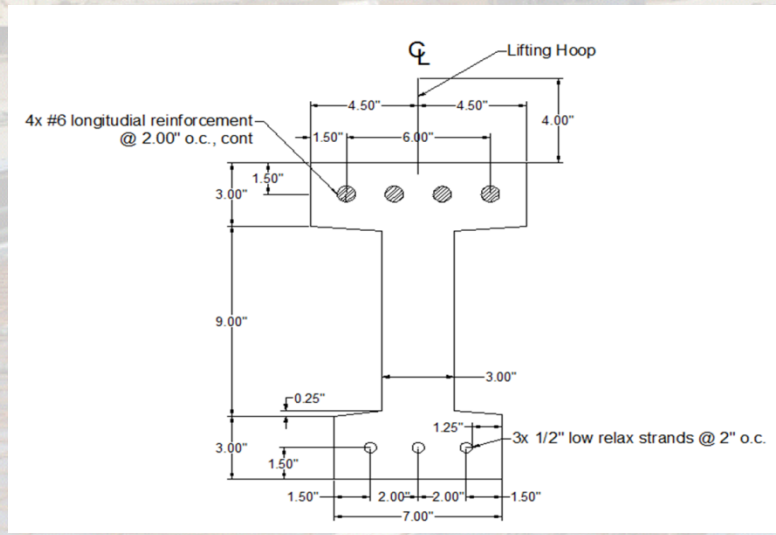
- Microsoft Excel was utilized
  - Made interactive
  - Concrete properties and dimensions inputted
  - Received cracking moment, ultimate moment and deflection
- Given the moments structural analysis was used to determine the loads
- Response 2000 was utilized to determine accuracy of spreadsheet

Alternatives

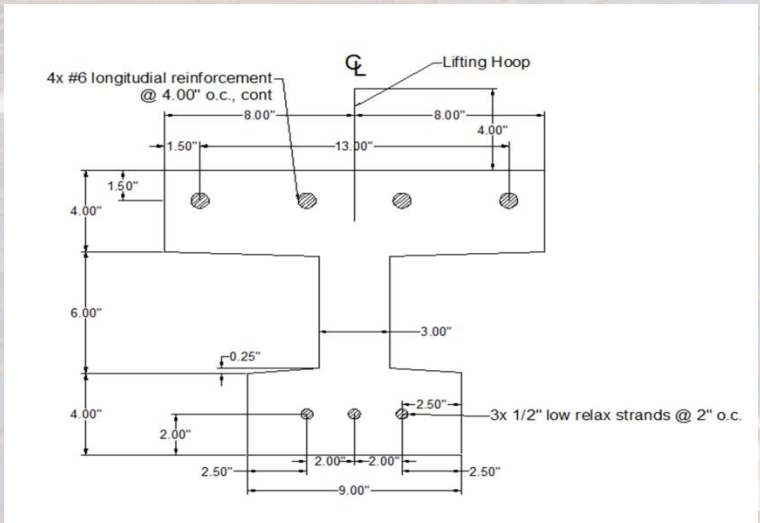
Alternative 1



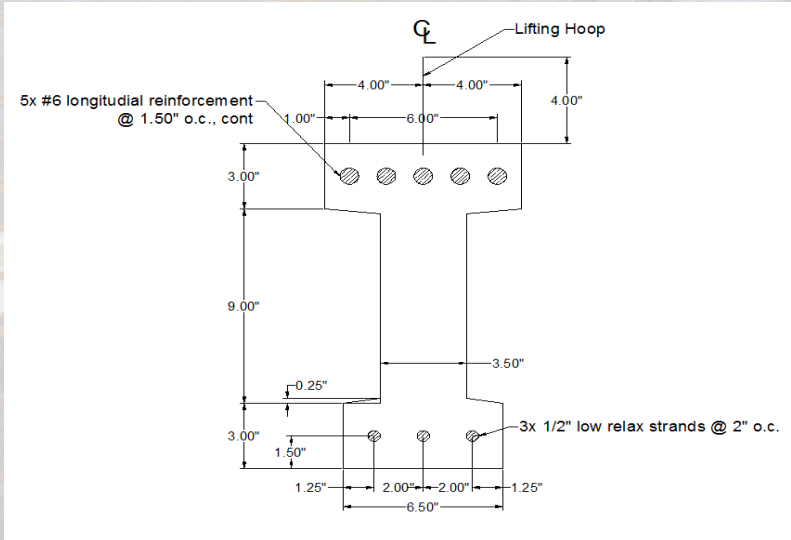
Alternative 2



Alternative 3



Alternative 4



Alternative Comparisons

Alternatives	Concrete Mix	Unit Weight (pcf)	Cracking Load (kips)	Ultimate Load (kips)
1	Normal	146.1	31.88	38.34
2	Normal	146.1	34.48	38.22
3	Lightweight	124.6	33.04	35.23
4	Lightweight	124.6	22.56	37.15

*f'c = 8,000 psi

** f'ci = 6,000 psi

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Selected Design

Decision Matrix		Deflection (in)**	Weight (lb/ft)**	Cost ($)**	P Crack (kip)	P Ult. (kip)**	Practiality/ Innovation/ Conformance With Code	Release	Factored Total
Beam Option	Weight*	15.00	15.00	10.00	30.00	20.00	5.00	5.00	100.00
Alt. 2	Actual	6.12	81.42	613.82	32.42	36.72		OK - 100	
Beam NW	Weighted Value	11.28	12.01	10.00	30.00	19.90	2.00	5.00	90.19
Alt. 4	Actual	8.13	65.17	627.53	30.42	36.54		OK - 100	
Beam LW	Weighted Value	15.00	15.00	9.78	30.00	20.00	3.00	5.00	97.78

*Sum of weighted values eqauls 100

- Alternatives were placed into two groups according to their concrete mix
  - Normal weight ⟹ Alternative 2
  - Lightweight ⟹ Alternative 4
- Compared by weighted values of importance
- Alternative 4 is best option

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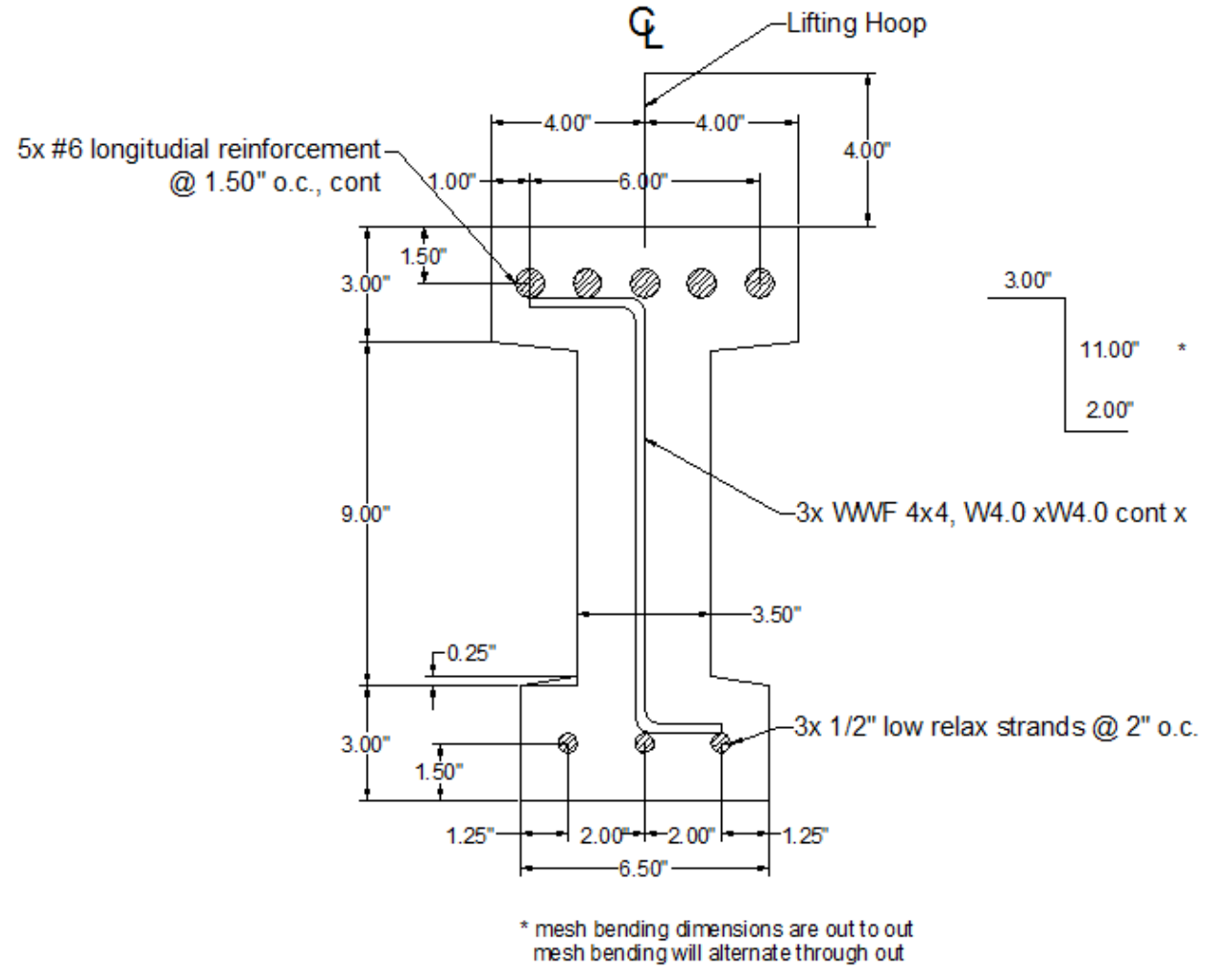
** $Weighted\ Value = \left(\frac{Lower\ Value}{Larger\ Value}\right) * Weight$

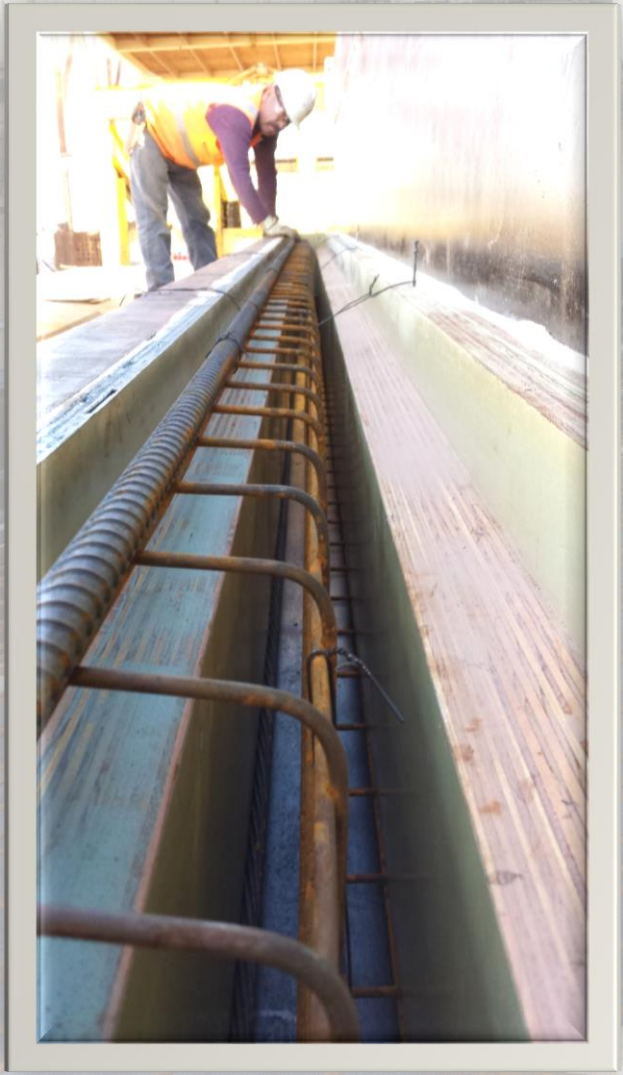
Final Design

- Due to manufacturer restrictions, f'ci < 6,000 psi
- Concrete Mix Design
  - Lightweight: 130 pcf
  - Self consolidating concrete
  - Compressive strength at release: 5,000 psi
  - Compressive strength at ultimate: > 6,000 psi
- Steel Components
  - 5 - #6 compressive reinforcement steel through out
  - 3 - 0.5 in. prestressed strains through out
  - 3 - Wielded Wire Mesh

Final Design



Beam Manufacturing



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Pre-Test Analysis

6 - 4” by 8” cylinders

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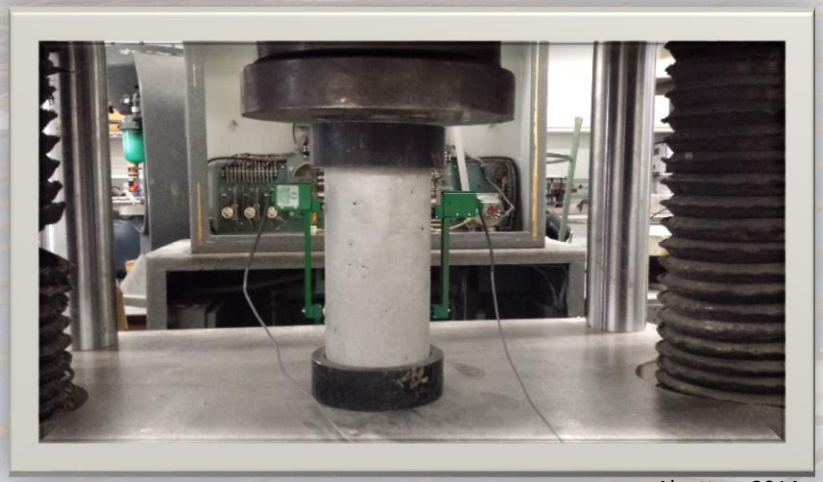
Compression Strength Test



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Split-Cylinder Tensile Test

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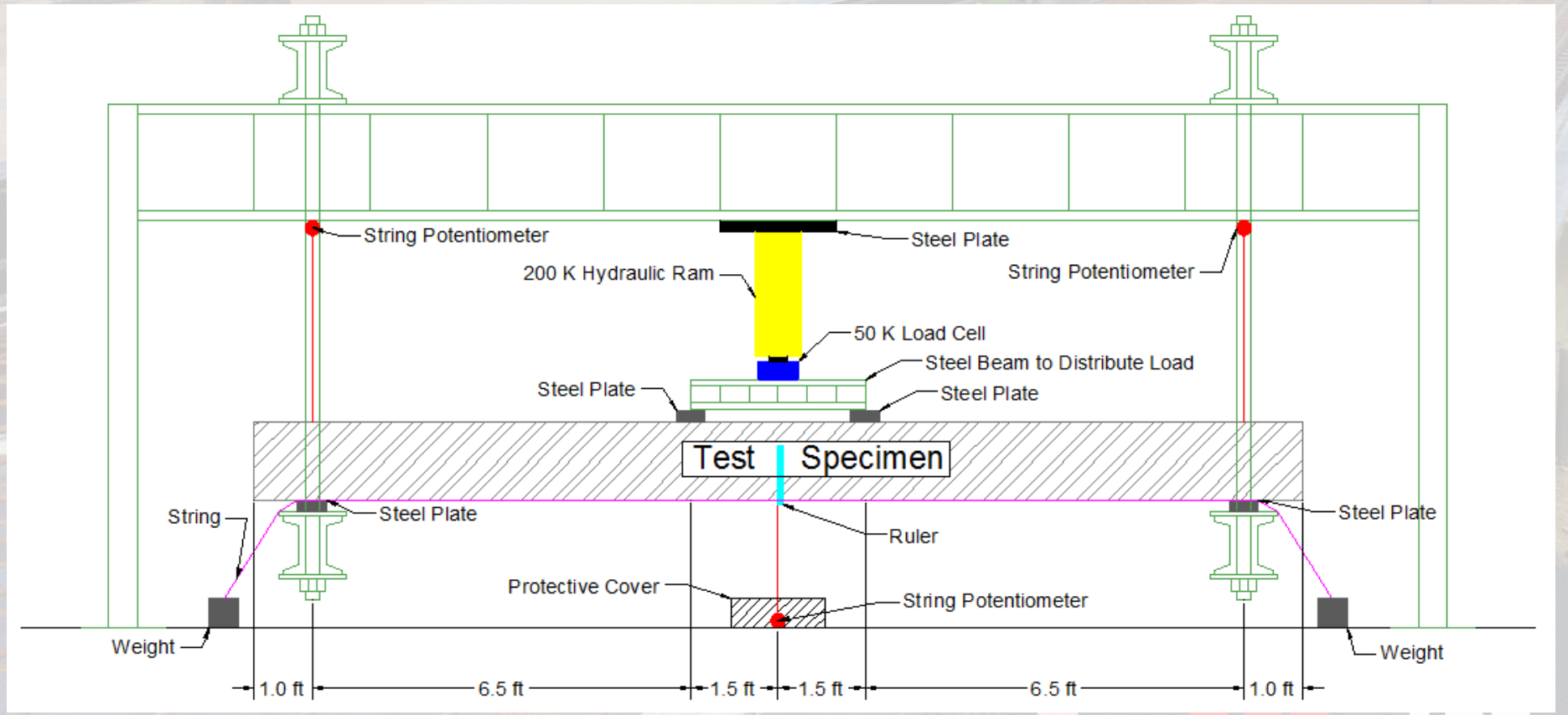
Predicted Figures

- Compression Test Results
  - Average Strain: 0.00291 in./in.
  - Average f'c: 8.58 ksi
  - Average Ec: 4244.79 ksi
- Split-Cylinder Tensile Test Results:
  - Average Tensile Strength: 0.57 ksi
  - Flexural Tensile Strength: 0.71 ksi

- Predicted Loads
  - Cracking = 31.4 kips
  - Ultimate = 39.0 kips
- Deflection
  - At ultimate load = 4.6 in

Testing

- Applied load measured by 50 K load cell
- Actual deflection measure by string potentiometers
- All values imported into computer to develop a Load vs. Deflection graph



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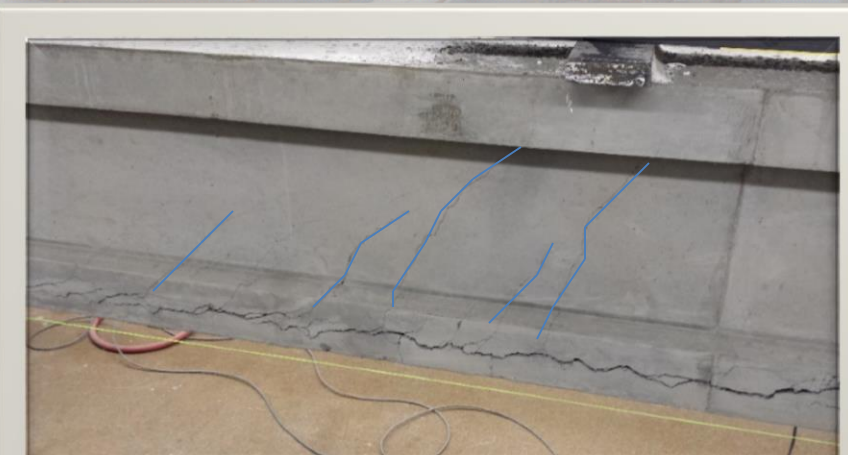
Pre-Test

After Failure



Cause of Failure

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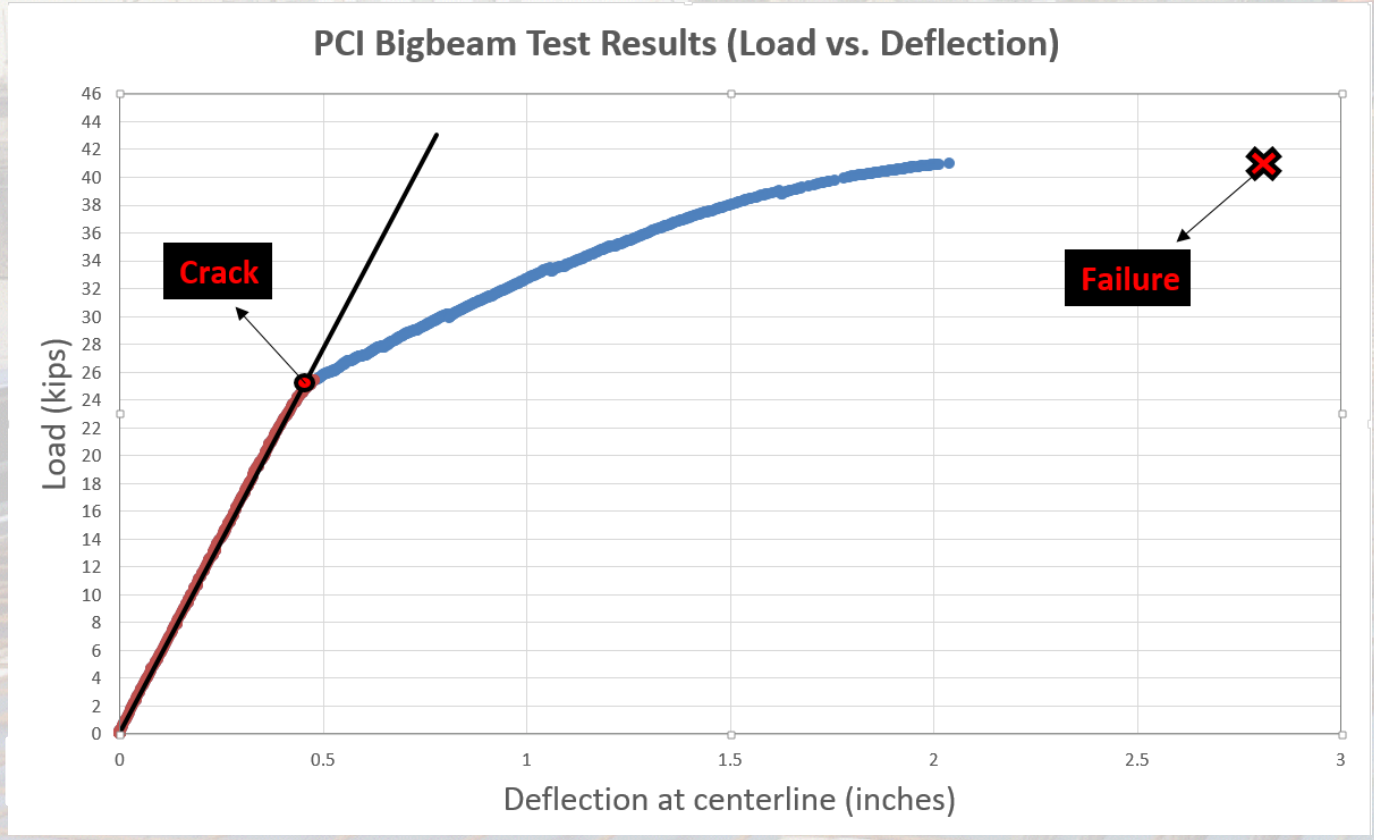
Post Test Analysis



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Actual Loads

- Cracking = 25.6 kips
- Ultimate = 41.0 kips

Actual Deflection

- At ultimate = 2.8 in.

Predicted and Actual Comparisons

	Predicted Value	Actual Value	Percent difference
Cracking Load	26.4 kips	25.6 kips	3.0%
Ultimate Load	39.0 kips	41.0 kips	5.0%
Deflection	4.6 in.	2.8 in.	39%

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Cost

Individual Labor Cost			
Staff Position	Project Engineer	Engineer 1	Data/Analyzation Technician
Base Pay ($/hr)	150	90	65
Benefits (%)	30	36	20
Actual Pay ($/hr)	195	125	78
Profit (%)	10	10	10
Total ($/hr)	215	135	86

Task Name	Overhead ($150/hr)	Project Engineer ($215/hr)	Engineer 1 ($135/hr)	Data/Analyzation Technichian ($86/hr)	Cost Per Task
Final Design and Analysis					
Choose Alternative		1	1	2	$522.00
Develop Shop Drawing	1	4	6	10	$2,680.00
Response 2000 Report				12	$1,032.00
Beam Fabrication					
Shop Drawings Sent to Client		1			$215.00
Beam Manufacturing					$1,184.71
Beam Transportation					$500.00
Beam Testing					
Predition Analysis (Response	1	4	6	10	$2,680.00
Test Preperation		2	4	12	$2,002.00
Testing		1	2	4	$829.00
Analyze Results	1	4	2	12	$2,312.00
				Total Labor Cost	$13,956.71

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Cost

Labor & Materials Costs		
Final Design and Analysis		
	Analysis	$4,234.00
	Computer Programs	$250.00
	Design Phase Subtotal	$4,484.00
Beam Fabrication and Testing		
	Beam Materials	$1,184.71
	Beam Fabrication	$1,899.71
	Beam Testing	$7,823.00
	Testing/Analysis Phase Subtotal	$9,722.71
Subtotal Cost		
		$14,206.71
Profit		
	Profit of 10%	$1,420.67
Total Cost		$15,328.00

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Project Impacts

- Environmental
  - Precast facilities are better equipped to discard hazardous waste
  - Concrete forms can be used multiple times
  - Minimum transport of concrete mixes reduces concrete waste
- Educational
  - Acquired prestressed concrete knowledge
  - Established good relationships with professionals

Acknowledgements

- Abdullah Kassab of TPAC
- Dr. Robin Tuchscherer of NAU
- PCI Student Education Committee

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http://www.merchantcircle.com/business/Tpac.A.Division.of.Kiewit.Western.Co.602-262-1360/picture/view/621290


Questions?