

# *Spirit*

American Society of Civil Engineers  
Concrete Canoe



Brent Allman

Ariel Suarez

Hannah Williams

Shuo Zhang

**NORTHERN**  
**ARIZONA**  
**UNIVERSITY**

# Project Description

- Construct a thin shelled, lightweight concrete canoe that complies with the 2014 ASCE Pacific Southwest Regional Conference and ASCE National Rules and Regulations



# Project Management



*Hannah Williams*

*Project Manager,  
Reinforcement Lead*

*Brent Allman  
Concrete Lead*

*Ariel Suarez  
Structural Analyst I*

*Shuo Zhang  
Structural Analyst II*

# Project Management

*Thomas  
Nelson  
Technical Advisor  
Project Engineer  
Hubbard and Merrel*



*Mark Lamer  
Client  
PE, MEng., Instructor  
NAU*



# Project Management

- Mentorship Program
  - Technical knowledge
  - Skills
  - Creative problem-solving
  
- 4 Principles
  - Engineering design
  - Communication
  - Teamwork
  - Professionalism

[www.nau.edu/cefns](http://www.nau.edu/cefns)



Hannah

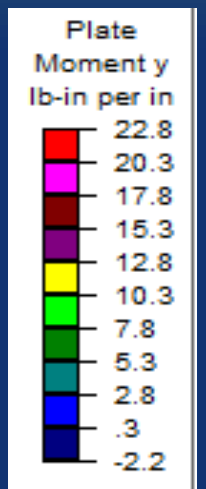
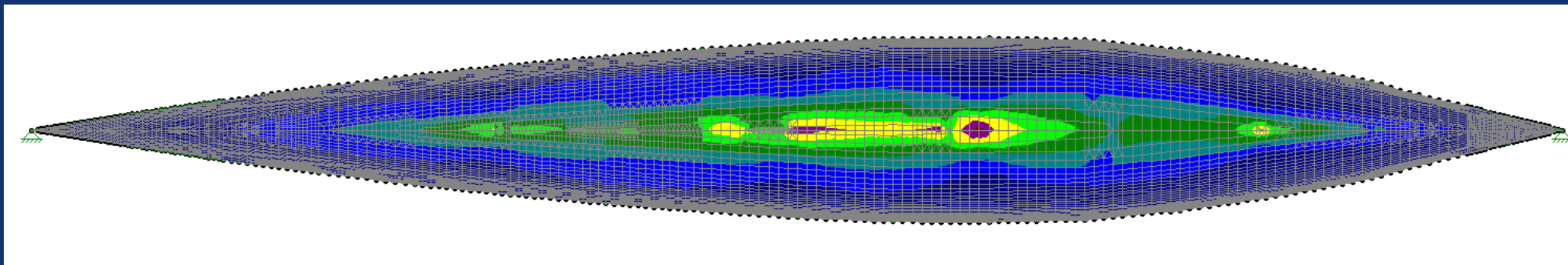
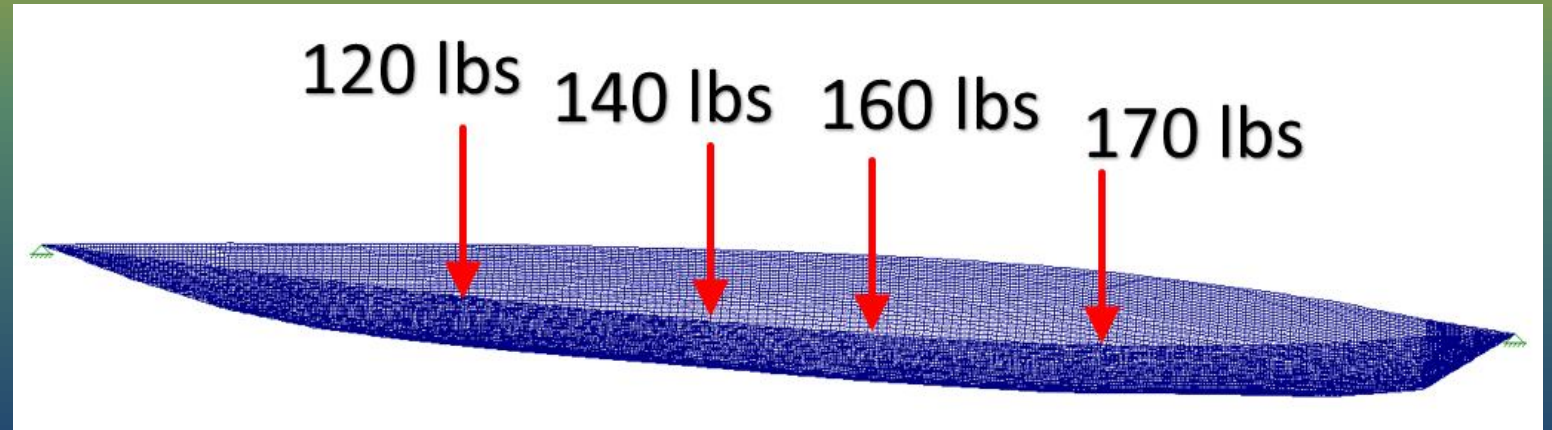
# Background Information

- Baseline: Night Fury
  - Structural Analysis
  - Concrete Mix Design
  - Construction



# RISA 3D Model

- Freeboard
  - 4 Person: 3.2 in
  - 2 Male: 5.2 in
  - 2 Female: 5.7 in
- RISA 3D
  - Hydrostatic Forces
  - Material Properties



# Reinforcement

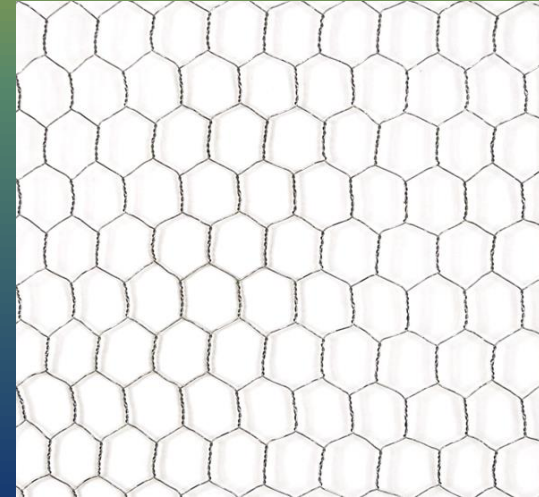
White/Green Stucco  
Fiberglass Mesh



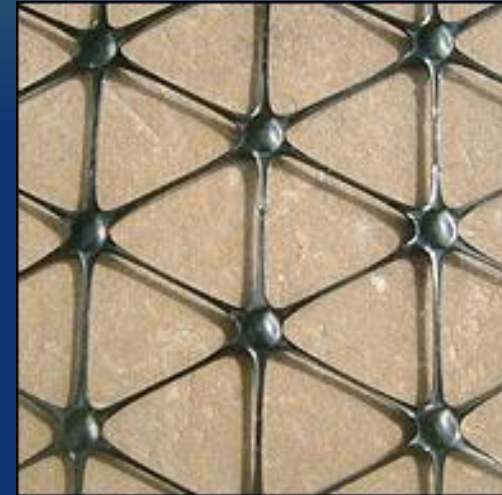
HexForce Fiberglass  
Mesh



Chicken Wire



Geogrid



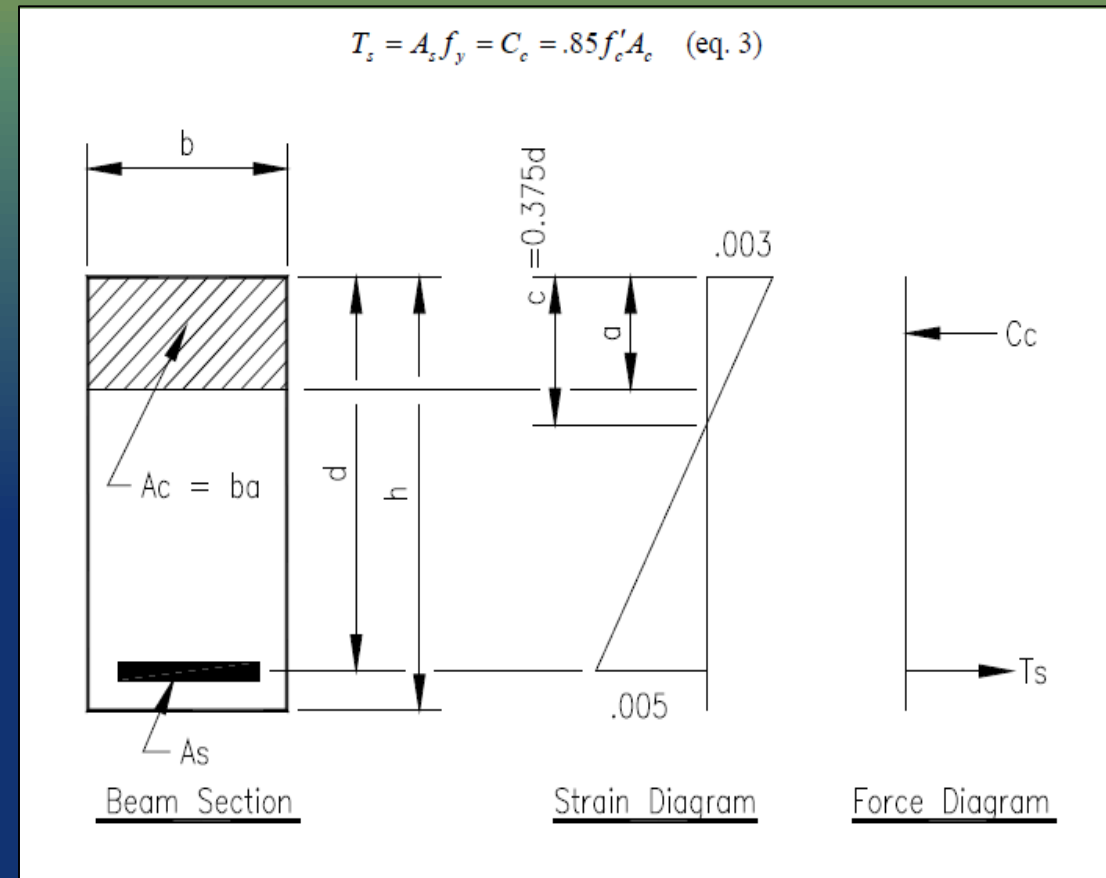


# Reinforcement

<b>Criteria</b>	<b>Weight Factor</b>	<b>White/Green Stucco Fiberglass Mesh</b>	<b>HexForce Fiberglass Mesh</b>	<b>Chicken Wire</b>	<b>Geogrid</b>
<b>Flexibility, Workability, Molding w/ Shape of Canoe</b>	0.30	0.60	0.90	0.30	0.00
<b>Weight</b>	0.10	0.30	0.30	0.30	0.30
<b>POA</b>	0.15	0.45	0.45	0.45	0.45
<b>Bonding with Concrete</b>	0.45	0.90	0.00	0.90	0.00
<b>TOTAL</b>	1.00	2.25	1.65	1.95	0.75

# Reinforcement Analysis

- Assumed Modulus of Elasticity,  $E = 2400$  ksi
- Tensile stress per strand = 6.19 ksi
- Hooke's Law,  $\sigma = \epsilon E$
- Resultant strain per strand = 0.0026 in/in
- $M_{\text{capacity}} = 14$  lb-in/in  $>$   $M_{\text{trans.demand}} = 10.2$  lb-in/in



# Concrete Mix Design

<b>Spirit Mix</b>	<b>Reason for Use</b>
<b>Lime Type S</b>	-Shrinkage reduction -Improve workability
<b>Portland Cement</b>	-Key cementitious material
<b>Poraver .5mm-1mm</b>	-Light weight aggregate to reduce weight of canoe -Sustainability (recycled glass)
<b>Mortar Sand</b>	-Aggregate (structural filler) -Increase strength
<b>Fibermesh<sup>®</sup> 150</b>	-Control cracking -Aid in tensile strength

# Concrete Mix Design Testing

	Last Year	This Year
Shrinkage (in.)	0.20	0.01
Strength (psi)	1,570	4,536
Slump (in.)	9.1	1.0

## Shrinkage Ring Method



## Compression Test Machine



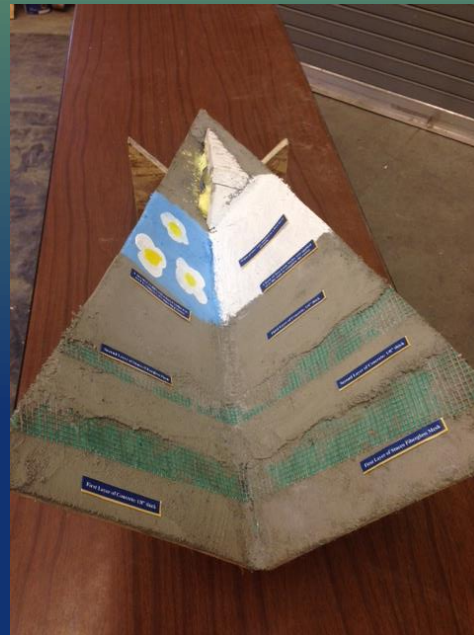
## Slump Test



# Construction



Female Mold



Cross Section

Overall thickness = 0.5 in



Pin Method



Casting Bulkheads

Dry unit weight, 98.1 pcf >  
Unit weight of water, 62.4 pcf

*Our pride and joy,*



*Spirit*



# Impacts

## Economical

Building canoe every year



## Environmental

Waste material



## Educational

Real-world application

# Cost and Hours Summary

<i>Personnel Hours</i>				
<b>Title</b>	<b>Quantity</b>	<b>Unit</b>	<b>Unit Cost</b>	<b>Total Price</b>
Project Manager	255	hours	\$80/hr.	\$20,400.00
Structural Analyst I	240	hours	\$70/hr.	\$16,800.00
Structural Analyst II	220.5	hours	\$65.5/hr.	\$14,442.75
Concrete Designer/Lab Technician	212	hours	\$50/hr.	\$10,600.00
<b><i>Total Cost for Hours</i></b>				<b>\$49,242.75</b>

Testing	<b>\$10,000.00</b>
Analysis	<b>\$2,500.00</b>

<b>Assumed Design Cost</b>	<b>\$ 61,743</b>
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# Conference





# *Spirit*

## Special Thanks

Thomas Nelson

Dr. Robin Tuchscherer

Mark Lamer

Dr. Bridget Bero

Ramon Aguilar

Cynthia Alvarez

Jeremy DeGeyter

NAU ASCE Student Chapter



CEFNS



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# References

- Slide 2 Pictures: Pic #1 – [www.pswc2014.weebly.com](http://www.pswc2014.weebly.com)  
Pic #2 – Taken by PSWC 2013 Participant
- Slide 3 Pictures: Pic #1 – PSWC 2014 Attendee
- Slide 4 Pictures: Pic #1 – Provided by Thomas Nelson  
Pic #2 – Provided by Mark Lamer
- Slide 5 Pictures: Pic #1 – Taken by Hannah Williams  
Pic #2 – Taken by PSWC 2013 Participant
- Pic #3 – Taken by Hannah Williams
- Slide 6 Picture: PSWC 2013 Attendee
- Slide 7 Pictures: All pics – Taken from RISA 3D Analysis
- Slide 8 Pictures: Pic #1 – Taken by Hannah Williams  
Pic #2 – [www.ebay.com](http://www.ebay.com)  
Pic #3 – [www.critter-cages.com](http://www.critter-cages.com)
- Pic #4 – [www.farmforestry.co.uk](http://www.farmforestry.co.uk)
- Slide 9 Picture:  
<http://engineersoutlook.files.wordpress.com/2013/05/balance-design-stress-strain-diagram.png>
- Slide 10 Pictures: Pic #1 – Provided by Thomas Nelson  
Pic #2 – Provided by Mark Lamer

- Slide 12 Pictures: Pic #1 – Taken by Gerardo Gonzalez  
Pic #2 – Taken by Ariel Suarez  
Pic #3 – Taken by Shuo Zhang
- Slide 13 Pictures: Pic #1 – Provided Team *Night Fury*  
Pic #2 – Taken by Hannah Williams  
Pic #3 – Taken by Hannah Williams  
Pic #4 – Taken by Hannah Williams
- Slide 14 Pictures: Pic #1 – Taken by Shuo Zhang  
Pic #2 – Taken by Shuo Zhang
- Slide 15 Pictures: Pic #1 – [www.nau.edu](http://www.nau.edu)  
Pic #2 – [www.deviantart.com](http://www.deviantart.com)
- Slide 17 Pictures: All pics – Taken by PSWC 2014 NAU Participants
- Slides 1 & 19 Pictures: [www.nau.edu](http://www.nau.edu)
- All logos provided by respective companies
- Northern Arizona University Concrete Canoe Team (2013). “Night Fury.” NCCC Design Paper, Northern Arizona University, Flagstaff, AZ.

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