2024 – 2025 ASCE TIMBER-STRONG

Phase 1

ASTROJACKS ENGINEERING
Allison Harris, Colton Davis, Giselle Mata, Jesa'Lyn Waggoner

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Section 1: Team Information

TABLE 1: TEAM INFORMATION

Name	Email	Phone Number	Title
Colton Davis	crd329@nau.edu	623-224-1344	Team Captain, Builder
Allison Harris	amh2429@nau.edu	623-377-8213	Builder
Jesa'Lyn Waggoner	jr3595@nau.edu	928-978-5521	Builder
Giselle Mata	gm768@nau.edu	520-245-7951	Builder
Oscar Delgado Aragon	Ov63@nau.edu	N/A	Builder
Harrison Bennon	Hnb233@nau.edu	N/A	Builder
Zach Millett	Ztm67@nau.edu	N/A	Team Member
Megan Alexander	Mma679@nau.edu	N/A	Team Member
Rebecca De Conto	Rd776@nau.edu	N/A	Team Member
Mark Lamer	Mark.lamer@nau.edu	928-523-3435	ASCE Faculty Advisor

Section 2: Team History

2021-2022

The 2021-2022 TimberStrong competition marked Northern Arizona University's first time competing in this larger-scale event. With this being NAU's first time participating in the TimberStrong Competition, our team underestimated the time commitment required to be put into the project. The 2021-2022 TimberStrong team's timeline served as a steep learning curve, where NAU gained foundational knowledge in structural design and emphasized the importance of clear communication as well as accountability for meeting deadlines. On build Day, during the 90-minute construction phase, we had run out of necessary material to properly build our structure and had to improvise on the spot to try and piece together our structure. As can be pictured in Figure 1 below, we ran out of time to finish the roof. From this years' experience we learned the importance of thorough material planning, and the importance of purchasing extra supplies to avoid unexpected circumstances such as shortages.

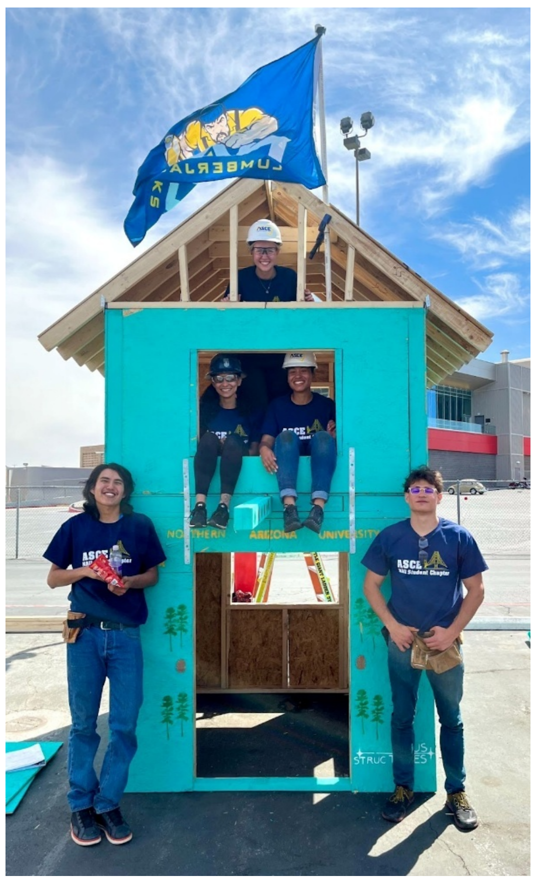


FIGURE 1: 2021-2022 TEAM

2022-2023

The 2022-2023 NAU TimberStrong Team entered its second year of participation with a better understanding of the design and construction requirements. A challenge faced happened due to poor communication between the design and construction teams resulting in the roof being built differently than planned. This complication led to an incomplete load path between the roof and the second-story walls. This issue gave light to the importance of close collaboration between design and construction. To address this moving forward, we've adjusted our team structure to ensure that every member contributes to both the design and construction aspects, rather than focusing on just one specific area.

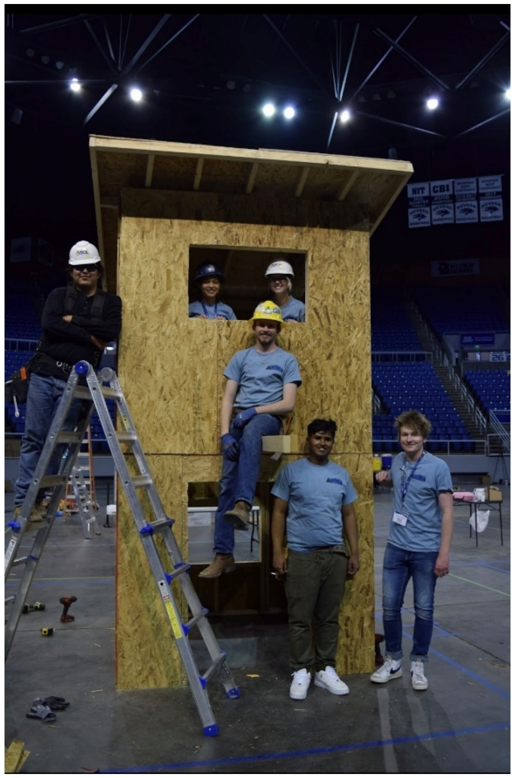


FIGURE 2: 2022-2023 TEAM

2023-2024

The 2023-2024 Timber Strong competition team encounter a few challenges in their project, for example not following industry standard practices and transferring loads through the structure. Not using industry standard practices led to inefficiencies in their project and affected their performance. Also, issues with the load paths causes issues with the force distribution, this affect how stable the design was. These issues showed we need to pay more attention to the standard practices and fundamental engineering principles. As a team we will be strict to follow the industry standards and focus on proper load transfer in the structures.

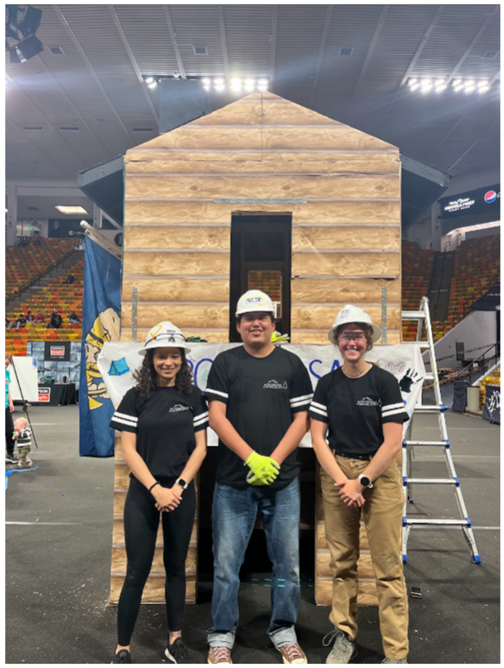


FIGURE 3: 2023-2024 TEAM

Section 3: Structural Design Calculations

Allowable Stress Design was used for the Structural Design Calculations, we sued the American Wood Council National Design Specifications and supplement and Special Design provisos for Wind and Seismic. The hand calculations can be Found in Appendix A and below is a summary of design results.

Single 2x6 Hem Fir	Ridge beams, floor joists, and fascia boards
Single 2x4 Hem Fir Stud	All other members
Double 2x4 Hem Fir Stud	Cantilevered beam
3/8 in Sheathing	All sheathed panels
6d Nails	Shear wall nailing for 2nd story North and South walls, 2nd story East and West walls, 1st story East and West Walls, 1st story South wall.
8d Nails	Shear wall nailing for 1st story North wall. Diaphragm nailing for roof and floor.
6” Nail Spacing	Along shear all edges for 2nd story East and West walls, 1st story East and West walls, and 1st story North wall. Along diaphragm edges for roof and floor.
4” Nail Spacing	Along shear wall edges for 2nd story North and South walls, and 1st story South wall.
LUS26	Ends of all floor members
H3SS Roof Tie Downs	All roof rafters
LSTA24, Used Horizontally	Above and below all openings, above 1st story North wall door
LSTA24, Used Vertically	At end of each total wall between stories
STB2-50234R25 Anchor Bolt	At end of each wall on 1st story, and at end of each individual shear wall for 1st story North wall
Cantilever Deflection – Load at 4’	0.62"
Cantilever Deflection – Load at 3’9”	0.53"
Cantilever Deflection – Load at 3’ 6”	0.50"

Average Roof Diaphragm Factor of Safety	2.046
Average Floor Diaphragm Factor of Safety	2.329
Average Diaphragm Factor of Safety	**2.188**
Average 1st Story Shear Wall Factor of Safety	1.91
Average 2nd Story Shear Wall Factor of Safety	1.57
Average Shear Wall Factor of Safety	**1.77**

Section 4: Sustainable Design Calculations

The structure scaled 100 times larger than the actual design would require 60.968 linear feet of 2x4 lumber, 12,245 linear feet of 2x6 lumber, and 35,544 square feet of 3/8 in OSB. The result is a total wood product volume of 114 cubic meters (4,031 cubic ft). The stored carbon within the wood amounts to approximately 97 metric tons of CO_2, while avoided greenhouse gas emissions reached 206 metric tons of CO_2. In total, this is equal to a potential carbon benefit of 304 metric tons of CO_2, which is the same as removing 64 cars from the road for a year or supplying energy to 32 homes for a year.

Lumber

bf	board feet
lf	linear feet
ft³	cubic feet
m³	cubic meters

Lumber

Lumber (m³)			
2x4(nominal)	lf	60968.3	62.8
2x6(nominal)	lf	12245.8	19.9
2x8(nominal)	lf	0	0
2x10(nominal)	lf	0	0
3x3(nominal)	lf	0	0
4x4(nominal)	lf	0	0
3x6(nominal)	lf	0	0
4x6(nominal)	lf	0	0
Unknown or varied (actual dimensions)	ft³	0	0
Total volume of dimensional lumber			82.7

% Total Volume	
Spruce-pine-fir	0
Douglas-fir-larch	0
Hemlock-fir	100
Cedar	0
Southern pine	0
Unknown	0
Total (must equal 100%)	100%

WoodWorks™ WOOD PRODUCTS COUNCIL

FIGURE 4: LUMBER INPUT

Panels

WoodWorks™
WOOD PRODUCTS COUNCIL

OSB

Thickness in Inchesm³			
1/4	ft²	0	0
5/16	ft²	0	0
3/8	ft²	35544.6	31.5
7/16	ft²	0	0
1/2	ft²	0	0
5/8	ft²	0	0
3/4	ft²	0	0
1 1/8	ft²	0	0
Unknown	ft²	0	0

Thickness in Inchesm³			
1/4	ft²	0	0
5/16	ft²	0	0
3/8	ft²	0	0
7/16	ft²	0	0
1/2	ft²	0	0
5/8	ft²	0	0
3/4	ft²	0	0
1 1/8	ft²	0	0
Unknown	ft²	0	0

OSB & Plywood by Volume

m³			
OSB	ft³	0	0
Plywood	ft³	0	0
Total volume of panels & sheathing			31.5

% Total Volume	
Softwood (APA Groups 2-5)	0
Douglas-fir-larch (APA Group 1)	0
Unknown	100
Total (must equal 100%)	100%

FIGURE 5: PANEL INPUTS

Carbon Summary

WoodWorks™
WOOD PRODUCTS COUNCIL

Results

Volume of wood products used (m^3):
114 m^3 (4031 ft^3) of lumber and sheathing

U.S. and Canadians forests grow this much wood in:
19 seconds

Carbon stored in the wood:
97 metric tons of CO_2

Avoided greenhouse gas emissions:
206 metric tons of CO_2

Total potential carbon benefit:
304 metric tons of CO_2

Equivalent to:

64 cars off the road for a year

Energy to operate **32** homes for a year

Project: AstroJacks Timberstrong

Date: January 30, 2025

Results from this tool are based on wood volumes only and are estimates of carbon stored within wood products and avoided emissions resulting from the substitution of wood products for non-wood products. The results do not indicate a carbon footprint or global warming potential and are not intended to replace a detailed life cycle assessment (LCA) study. Please refer to the References & Notes (PDF) for assumptions and other information related to the calculations.

FIGURE 6: CARBON SUMMARY

Section 5: Budget

All the pricing for the materials for this project came directly from the Home Depot website for the location in Tucson, AZ [1]. The table reflects the estimated costs for lumber, OSB, and any other construction materials needed to complete this project.

TABLE 2: BUDGET

Material Cost								
Description	**Quantity**	**Unit**	**Unit Cost**	**Purchased**		**Donated**		**Total**
Wall Framing (1st Floor)								
2x4x8ft Wall Stud	29	Piece	$3.75	29	$108.75	0	$0.00	$108.75
4x8ft-3/8 OSB	3	Sheet	$17.98	3	$53.94	0	$0.00	$53.94
Subtotal					$162.69		$0.00	$162.69
Wall Framing (2nd Floor)								
2x4x8ft Wall stud	33	Piece	$3.75	33	$123.75	0	$0.00	$123.75
4x8ft-3/8 OSB	4	Sheet	$17.98	4	$71.92	0	$0.00	$71.92
Subtotal					$195.67		$0.00	$195.67
Floor System								
2x6-8ft Floor Joist	7	Piece	$10.22	7	$71.54	0	$0.00	$71.54
2x6x12ft Cantilever Beam	2	Piece	$15.22	2	$30.44	0	$0.00	$30.44
4x8ft-3/8 OSB	2	Sheet	$17.98	2	$35.96	0	$0.00	$35.96
Subtotal					$137.94		$0.00	$137.94
Roof System								
2x4-8ft Rafters	16	Piece	$3.75	16	$60.00	0	$0.00	$60.00
2x6-8ft Ridge Beam	6	Piece	$10.22	6	$61.32	0	$0.00	$61.32
4x8ft-3/8 OSB	4	Sheet	$17.98	4	$71.92	0	$0.00	$71.92
Subtotal					$193.24		$0.00	$193.24
Simpson Strong-Tie Connectors								
LUS 26	14	Each	$1.56	0	$0.00	14	$21.84	$21.84
H3 SS	16	Each	$1.17	0	$0.00	16	$18.72	$18.72
LSTA 24	23	Each	$2.37	0	$0.00	23	$54.51	$54.51
STB2-5023R25	10	Each	$20.95	0	$0.00	10	$209.50	$209.50
LUS Double 2x4	1	Each	$2.01	0	$0.00	1	$2.01	$2.01
Subtotal					$0.00		$306.58	$306.58
Simpson Strong-Tie Fasteners								
Strong Drive CVS Construction Screw (240)	2	Box	$21.32	0	$0.00	2	$42.64	$42.64
Strong Drive SDWS Framing Screw (250)	3	Box	$34.98	0	$0.00	3	$104.94	$104.94

Strong Drive SD CONNECTOR SCREW	1	Box	$14.67	0	$0.00	1	$14.67	$14.67
Subtotal					$0.00		$162.25	$162.25
Asthetic Materials								
BEHR Exterior Paint	5	Gallon	$29.98	5	$149.90	0	$0.00	$149.90
Subtotal					$149.90		$0.00	$149.90
Total Cost of Materials					$839.44		$468.83	$1,308.27

Section 6: Deconstruction Plan

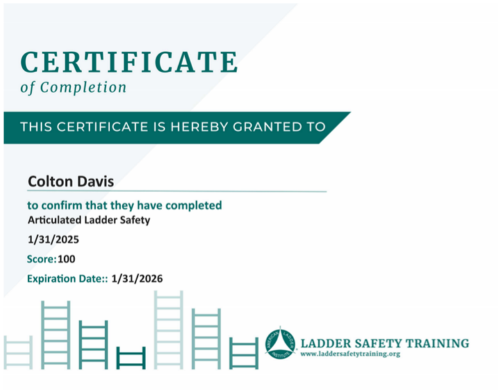
After the competition is over, the team will disassembly the structure carefully, in reserve order from the way it was constructed. First the roof will be fully taken apart, then then sheathing will be removed, and all roof members will be separated. Next the second story walls will be detached from each other but will stay panelized. This will be repeated on the first story walls and the floors, to stay organized while disassembling.

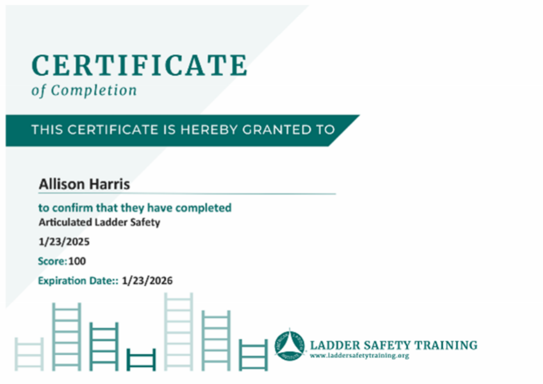
After the entire structure is taken down, all the materials will be transported back to Flagstaff, AZ on the trailer. The hardware from the structure will be donated to Habitat for Humanity in Flagstaff to support their future projects. The lumber will be donated to Snowbowl's Facilities Maintenance Department. The lumber will be repurposed for maintenance and construction needs. These donations will minimize the team's waste while also donating to the local community.

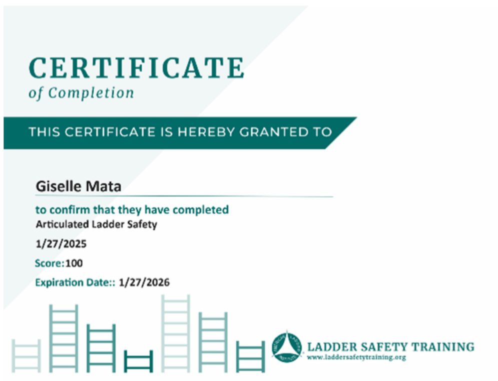
Section 7: Team Statement

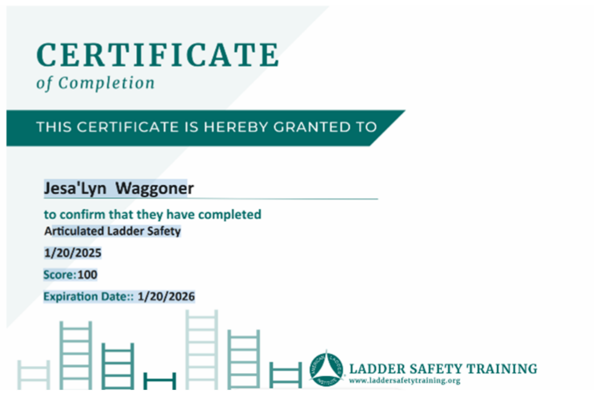
All team members have read and understood the rules for the competition, including Section 4.5 Safety and the OSHA Standards.

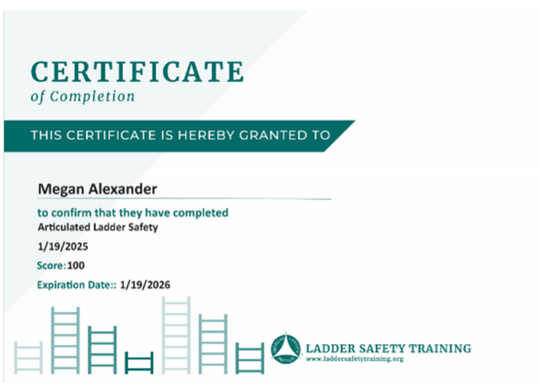
Section 8: Ladder Safety Training Certifications

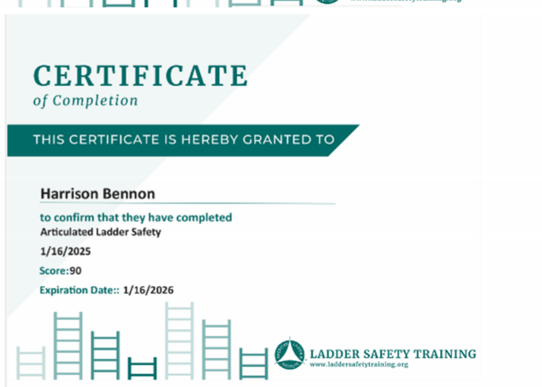


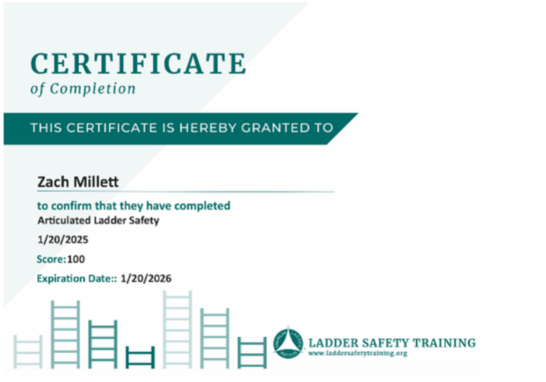


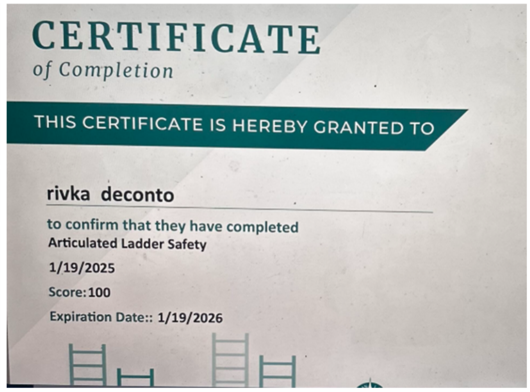









CERTIFICATE
of Completion
THIS CERTIFICATE IS HEREBY GRANTED TO
Zach Millett
to confirm that they have completed
Articulated Ladder Safety
1/20/2025
Score:100
Expiration Date:: 1/20/2026
LADDER SAFETY TRAINING


CERTIFICATE
of Completion
THIS CERTIFICATE IS HEREBY GRANTED TO
rivka deconto
to confirm that they have completed
Articulated Ladder Safety
1/19/2025
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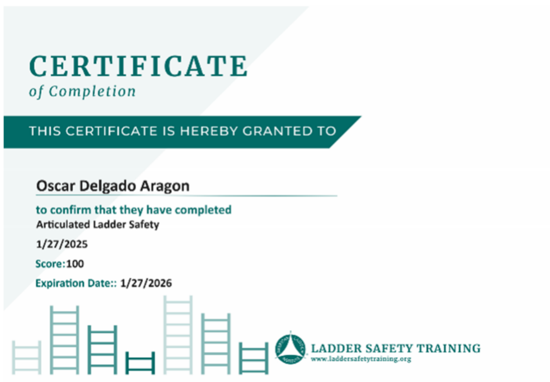
Expiration Date:: 1/19/2026


CERTIFICATE
of Completion
THIS CERTIFICATE IS HEREBY GRANTED TO
Oscar Delgado Aragon
to confirm that they have completed
Articulated Ladder Safety
1/27/2025
Score:100
Expiration Date:: 1/27/2026
LADDER SAFETY TRAINING

Section 9: Sponsors

We would like to thank the competition hosts and sponsors for supporting this opportunity for engineering students.

ASCE AMERICAN SOCIETY OF CIVIL ENGINEERS

AMERICAN WOOD COUNCIL

APA

SIMPSON Strong-Tie

Section 10: Signatures

Team Captain:

Name Signature Date

Faculty Advisor:

Name Signature Date

References

[1]Home Depot, “The Home Depot,” *Homedepot.com*, 2024. https://www.homedepot.com/

Appendices

Appendix A: Hand Calculations