NAU NORTHERN ARIZONA UNIVERSITY

2023-2024
TIMBERSTRONG REPORT

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Team Information

All team members' names, cell phone numbers and email addresses including the faculty advisor and any practicing engineers serving as mentors. Additionally, identify the team “Captain” and the 4-6 members who are designated as the “Builders” if competing in the construction portion of the event.

Table 1: Team Information

Name	**Email**	**Phone Number**	**Title**
Jenna Hays	jkh328@nau.edu	907-602-1530	Team Captain, Builder
Mourtice Clitso	mbc234@nau.edu	928-489-8583	Builder
Mariah Boler	mjb752@nau.edu	360-473-6127	Builder
Megan Alexander	mma679@nau.edu	623-745-6221	Builder
Natalie Wahl	nw383@nau.edu	253-254-1419	Builder
Natali Farkouh	nf353@nau.edu	661-916-3053	Builder
Colton Davis	crd329@nau.edu	623-224-1344	Team Member
Marwen Chaabouni	mc4352@nau.edu	928-310-2871	Team Member
Alexa Godkin	ahg78@nau.edu	907-723-5322	Team Member
Mark Lamer	mark.lamer@nau.edu	928-523-3435	ASCE Faculty Advisor

Team History

2021-2022

Figure 1: 2022 Structure Photo 1

Figure 2: 2022 Structure Photo 2

2021-2022 was NAU's first time competing in the larger-scaled TimberStrong Competition. Our team had very little experience in structural design, and a lot of our members did not realize the scale of the time commitment for the project. We learned a lot of the basics of structural design during this year, and also learned the importance of communication within the team and accountability for deadlines. During the 90-minute competition construction we ran out of screws, so we had to use hammers and nails for the remainder of the structure. As seen in the photos, we ran out of time to finish our roof. We learned to always plan out materials beforehand, and that it is better to buy extra materials than to not have enough.

2022-2023

Figure 3: 2023 Structure Photo 1

Figure 4: 2023 Structure Photo 2

2022-2023 was our second year working as a team on the TimberStrong project. We had a better basis for the structural design requirements and the construction aspects of the competition. Our team struggled with communication between design and construction; our roof ended up being constructed differently than how we had originally planned due to these communication issues. This blunder resulted in an incomplete load path in the connection between the roof and second-story walls. We learned that design and construction should work very closely together, and have implemented that in our team composition this year by requiring each member to work on both design and construction, rather than just one or the other.

Structural Design Calculations

Structural Design calculations followed Allowable Stress Design using the American Wood Council National Design Specifications and Supplement and Special Design Provisions for Wind and Seismic. All hand calculations can be found in Appendix B. A summary of the design results is shown below in Table 2.

Table 2: Design Summary

Design	**Member/Result**
Single 2x4 Hem Fir Stud	All framing members
Double 2x4 Hem Fir Stud	Cantilever beam
⅜” Sheathing	All sheathed panels
6d Nails	All diaphragm and shear wall nailing
6” Nail Spacing	Around all diaphragm and shear wall edges except specified in 4” Nail Spacing. Also along the cantilever beam inside of the floor diaphragm
4” Nail Spacing	Along the shear wall edges for the 1st story sidewalls and both front (north) walls
H2.4ASS Roof Tie Downs	All roof rafters
LSTA24, Used Horizontally	Above and below all openings
LSTA24, Used Vertically	At the end of each total wall between stories
LSTA36, Used Horizontally	Above doorway and along Beam 6 (shown in design calculations) in the floor diaphragm
STB2-50234R25 Anchor Bolt	At the end of each total wall on the 1st story, with one at the end of each individual shear wall on the north (front) wall
Cantilever Deflection - Load at 4’	0.7776 in.
Cantilever Deflection - Load at 3’-9”	0.5927 in.
Cantilever Deflection - Load at 3’-6”	0.5172 in.
Average Diaphragm Factor of Safety	1.544
Average Shear Wall Factor of Safety	1.568

Sustainable Design Calculations

A structure scaled 100 times larger than the actual design would use 39,555 linear feet of 2x4's and 23,800 square feet of ⅜ in. OSB. This would result in a volume of 2184 cubic feet wood products used and a volume of 54 metric tons of carbon stored in the wood.

Figure 5: Lumber Input

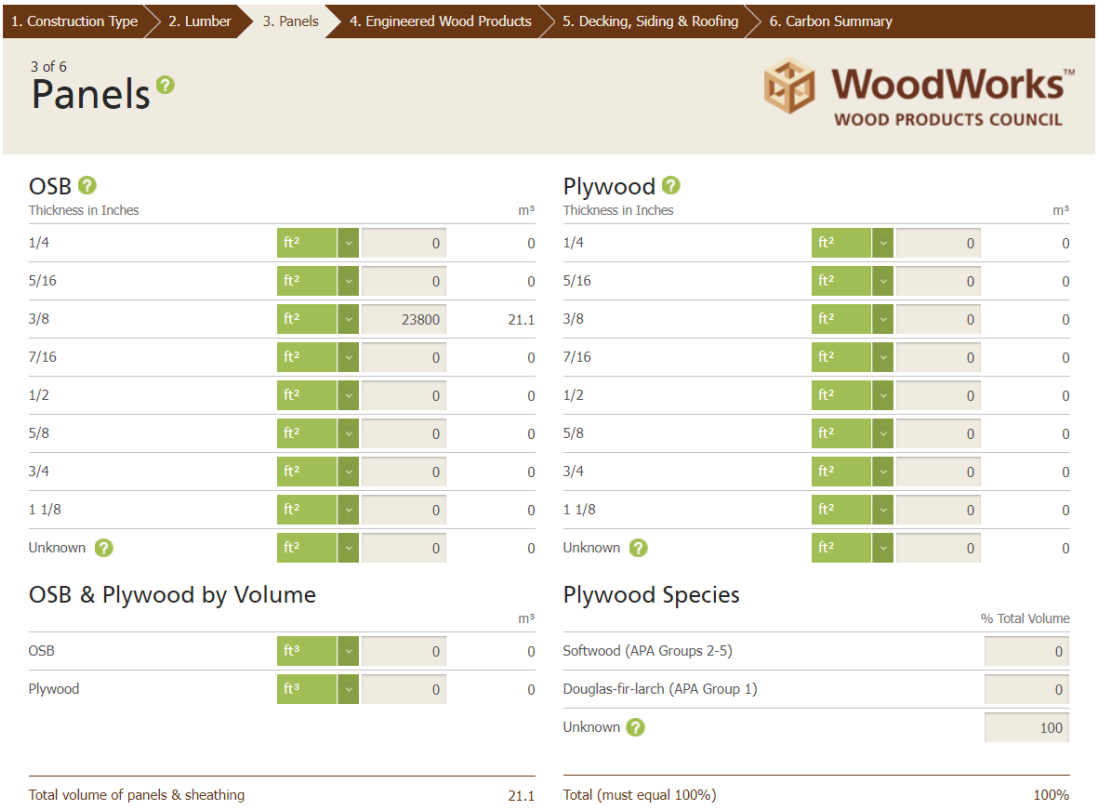

Figure 7: OSB Input

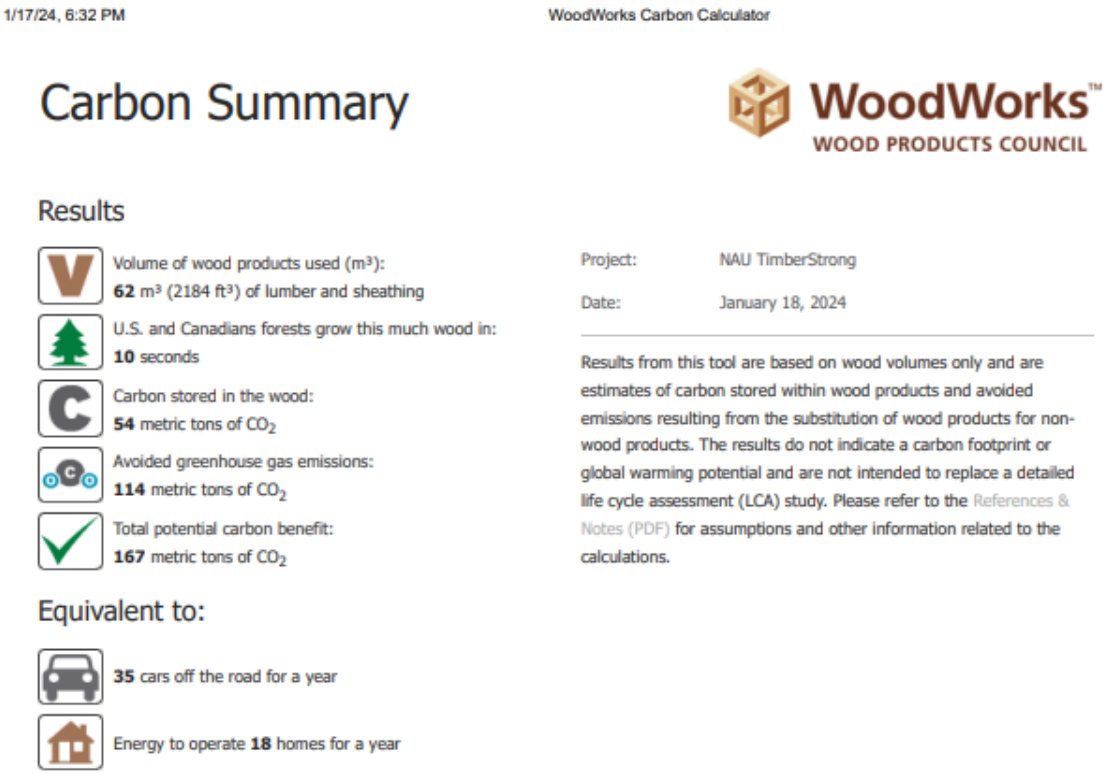

Figure 8: Carbon Summary Output

Budget

Cost References are shown in Appendix A.

Table 1: Estimated Project Budget

Material Cost Estimate								
Description	Quantity	Unit	Unit Cost	Purchased		Donated		Total
Wall Framing (1st Floor)								
2x4-8ft Wall Stud	25	piece	$ 5.87	25	$ 147	0	$ -	$ 147
2x4-8ft Top Plate	4	piece	$ 5.87	4	$ 23	0	$ -	$ 23
4x8ft-3/8 in OSB	6	sheet	$ 29.73	6	$ 178	0	$ -	$ 178
Subtotal					$ 349		$ -	$ 349
Wall Framing (2nd Floor)								
2x4-8ft Wall Stud	14	piece	$ 5.87	14	$ 82	0	$ -	$ 82
2x4-8ft Top Plate	4	piece	$ 5.87	4	$ 23	0	$ -	$ 23
4x8ft-3/8 in OSB	4	sheet	$ 29.73	4	$ 119	0	$ -	$ 119
Subtotal					$ 225		$ -	$ 225
Floor System								
2x4-8ft Floor Joist	8	piece	$ 5.87	8	$ 47	0	$ -	$ 47
2x4-10ft Cantilever Beam	2	piece	$ 7.45	2	$ 15	0	$ -	$ 15
4x8ft-3/8 in OSB	2	sheet	$ 29.73	2	$ 59	0	$ -	$ 59
Subtotal					$ 121		$ -	$ 121
Roof System								
2x4-8ft Joists Stud	10	piece	$ 5.87	10	$ 59	0	$ -	$ 59
4x8ft-3/8 in OSB	2	sheet	$ 29.73	2	$ 59	0	$ -	$ 59
Subtotal					$ 118		$ -	$ 118
Lumber Subtotal					$ 813		$ -	$ 813
Simpson Strong-Tie Connectors								
H2.5ASS Stainless Steel Hurricane Tie	4	piece	$ 4.33	0	$ -	4	$ 17	$ 17
LSTA18 Light Strap Tie	10	strap	$ 1.26	0	$ -	10	$ 13	$ 13
LSTA24 Light Strap Tie	9	strap	$ 1.68	0	$ -	9	$ 15	$ 15
LSTA36 Light Strap Tie	4	strap	$ 3.05	0	$ -	4	$ 12	$ 12
LUS24 Face-Mount Joist Hangers	4	piece	$ 0.98	0	$ -	4	$ 4	$ 4
STB2-50234R25 Anchor Bolt (Box of 25)	1	box	$ 21.91	0	$ -	1	$ 22	$ 22
Connector Subtotal					$ -		$ 83	$ 83
Simpson Strong-Tie Fasteners								
Strong Drive CSV Construction Screw (Box of 240)	2	box	$ 21.32	0	$ -	2	$ 43	$ 43
Strong Drive SDWS Framing Screw (Box of 150)	1	box	$ 40.55	0	$ -	1	$ 41	$ 41
Strong Drive SDWS Framing Screw (Box of 250)	1	box	$ 62.88	0	$ -	1	$ 63	$ 63
Strong Drive SD Connector SS Screw (Box of 100)	1	box	$ 42.30	0	$ -	1	$ 42	$ 42
Strong Drive SD Connector Screw (Box of 500)	1	box	$ 49.64	0	$ -	1	$ 50	$ 50
Fastener Subtotal					$ -		$ 238	$ 238
Asthetic Materials								
Behr Exterior Paint	2	gallon	$ 30.98	2	$ 62	0	$ -	$ 62
Asthetic Subtotal					$ 62		$ -	$ 62
Total Cost of Materials					$ 875		$ 321	$ 1,196

Structure Removal Plan

After the competition is complete, the team will disassemble the structure in the reverse order that it was built. The roof will be completely taken apart: the sheathing will be removed and the roof members will be separated. Each second story wall will be disconnected from its neighboring wall, but kept as a panelized component. The same process will occur for the floor and first story walls.

The pieces will then be loaded back into the NAU ASCE trailer and transported back to Flagstaff, where the structure will be donated to a community member with young family members so it can be used as a playhouse. The community member will be given the complete plan set of the structure so that they can replicate the screw placement and component positioning to rebuild the structure.

Team Statement

All team members have read and understood the rules for the competition, including Section 4.5 Safety and the OSHA Standards 1926

Ladder Safety Training Certificates

Sponsors

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

Signatures

We certify that the information in this report is valid.

Team Captain:

Name	Signature	Date

Faculty Advisor:

Name	Signature	Date

Appendix A - Cost References

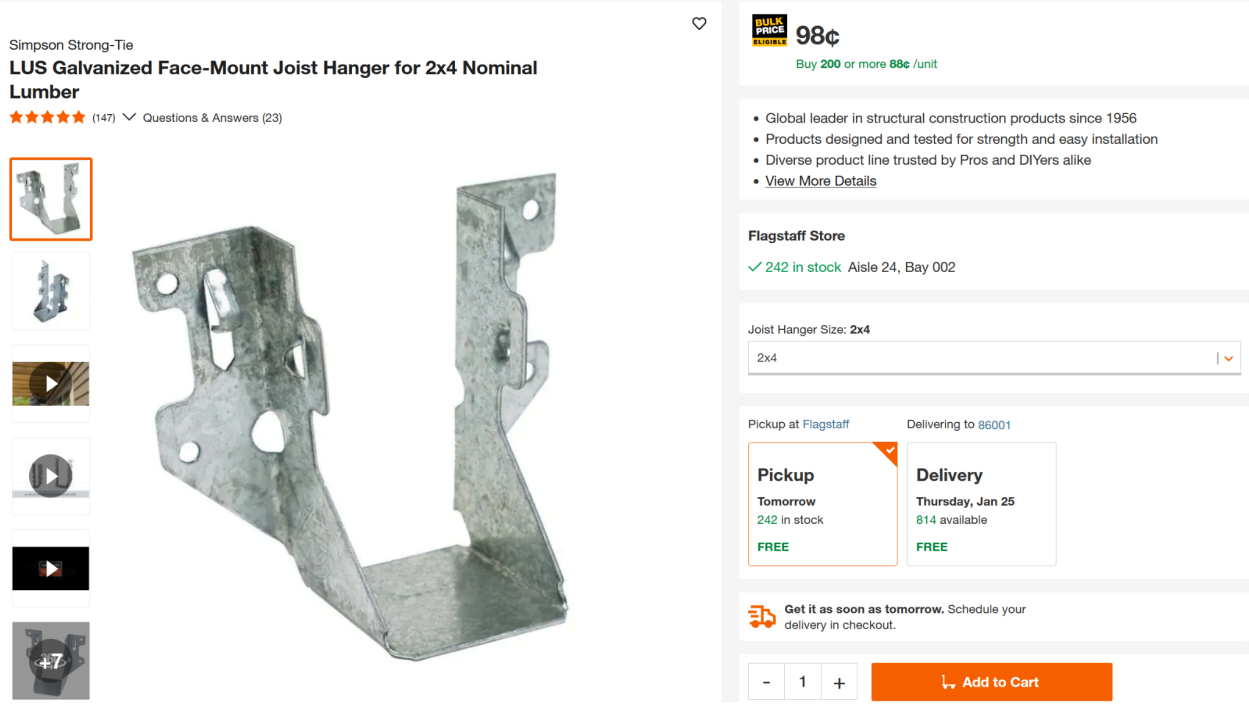

Figure 9: Joist Hanger Cost

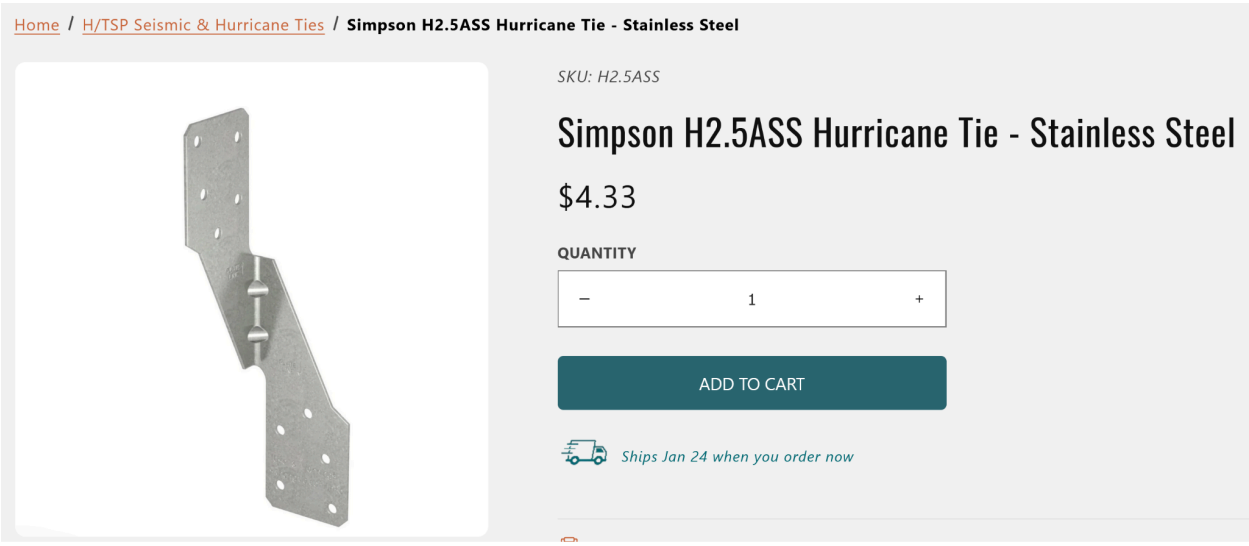

Figure 10: Hurricane Tie Cost

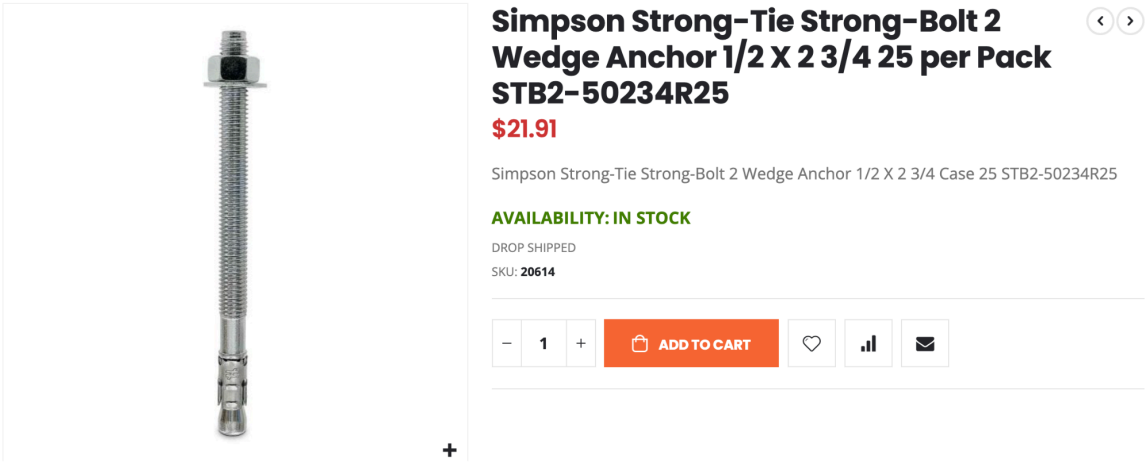

Figure 11: Anchor Bolt Cost

Figure 12: Strap Tie Cost

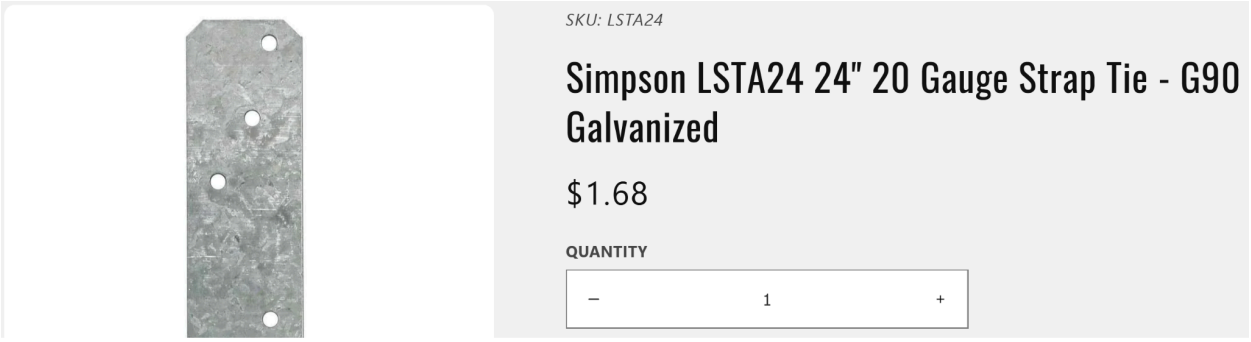

Figure 13: Strap Tie Cost

Figure 14: Strap Tie Cost

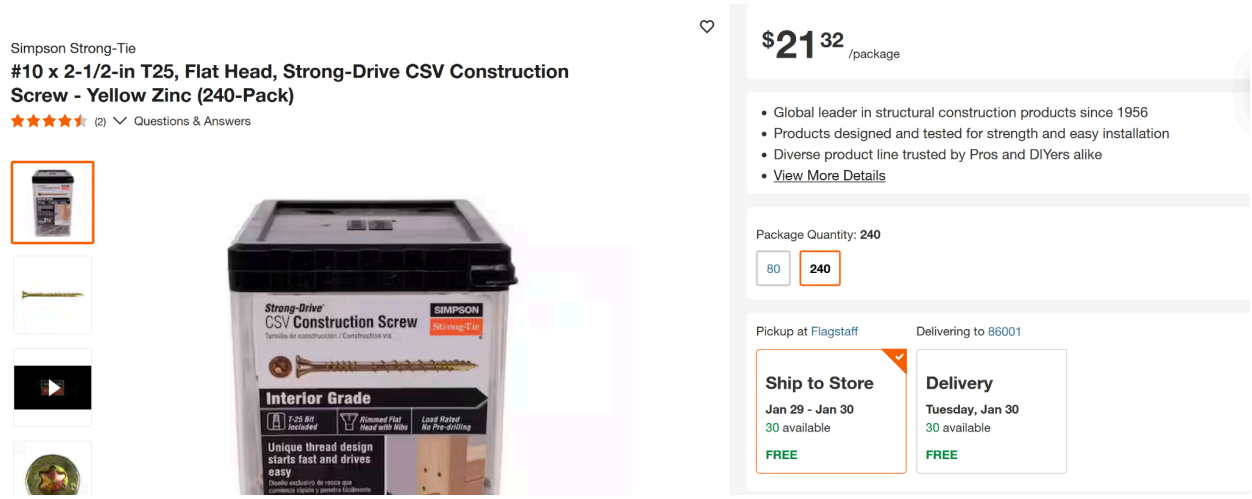

Figure 15: Sheathing Screw Cost

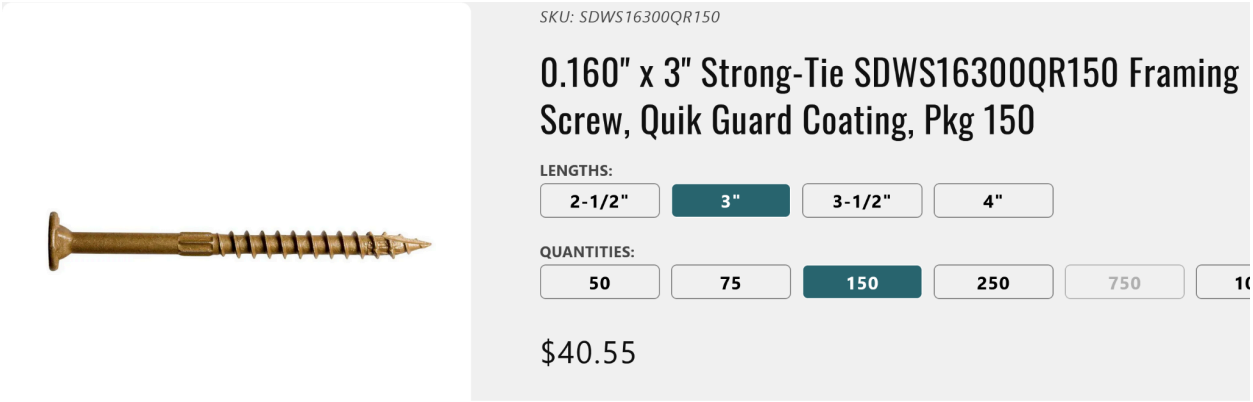

Figure 16: Framing Screw Cost

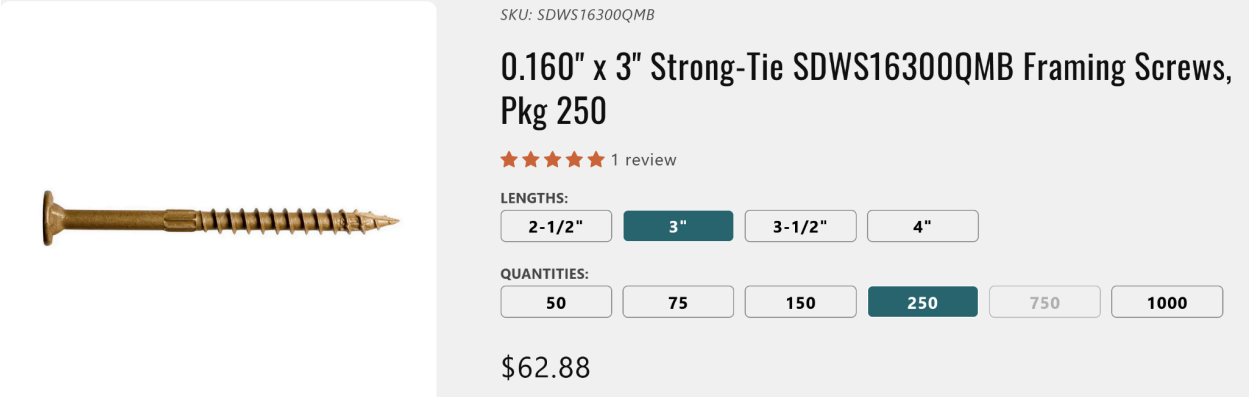

Figure 17: Framing Screw Cost

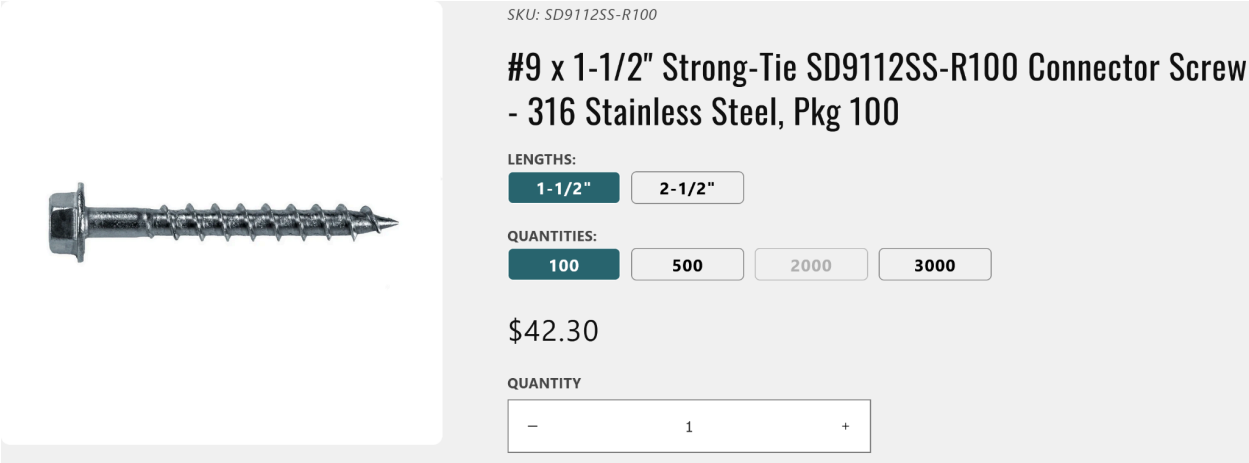

Figure 18: Hurricane Tie Screw Cost

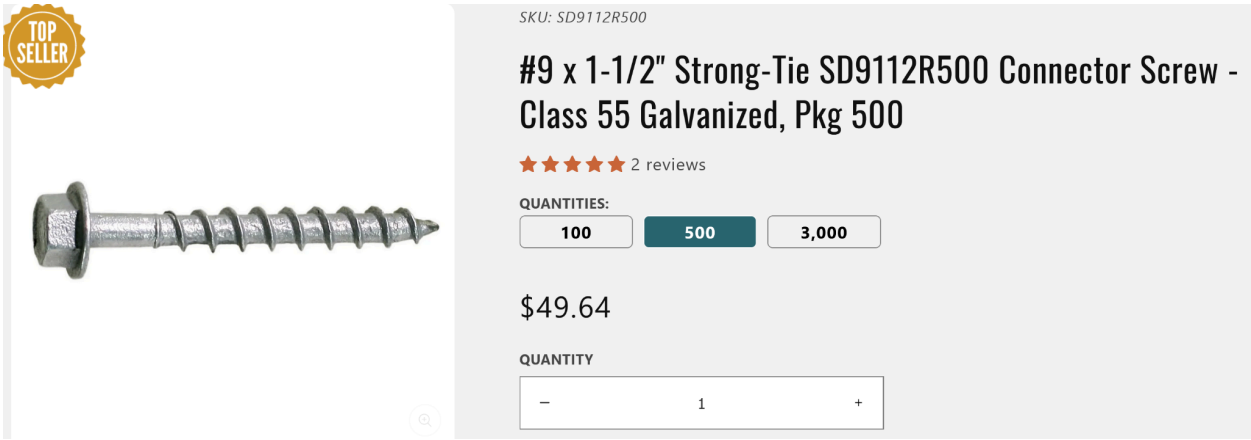

Figure 19:Strap Screw Cost

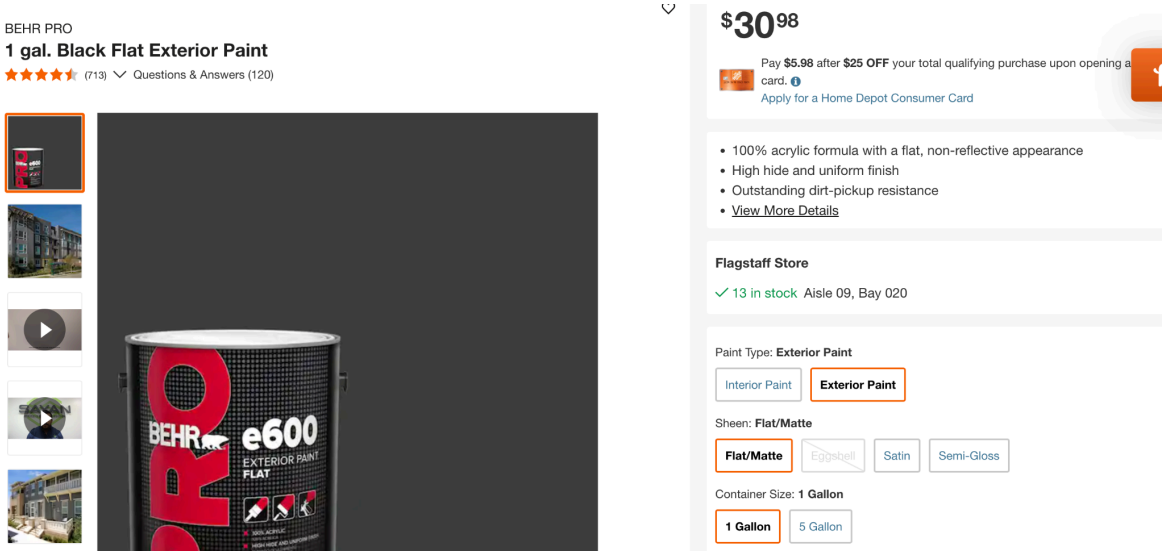

Figure 20: Paint Cost

HomCo Lumber & Hardware

HomCo Lumber & Hardware
1763 East Butler Avenue
Flagstaff AZ 86001
(928)779-6111
Fax: (928)779-0695

CUSTOMER COPY

ORDER
2401-C14876 PAGE 1 OF 1

SOLD TO	JOB ADDRESS
Cash Sales	MISC

ACCT NO.	JOB
CASH	0
ENTRY DATE	1/18/2024 12:37:04 PM
CUST PICKUP	
BRANCH	1000
CUSTOMER PO#	
STATION	B223
CASHIER	LASITA
SALESPERSON	HOUSE
ORDER ENTRY	LASITA
MODIFIED BY	LASITA

Item	Description	D	Ordered	Sold	Remain	UM	Price	Per	Amount
248HF	HEM FIR 2X4X8' 2&BTR KD S4S		1		1	PC	1100.0000	MF	5.87
1532W	WAFERWOOD 4X8X15/32 (1/2") OSB		1		1	PC	929.0000	MS	29.73
2410HF	HEM FIR 2X4X10' 2&BTR KD S4S		1		1	PC	1117.0000	MF	7.45

Figure 21: Lumber Cost

Appendix B - Hand Calculations