



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 |
| $\frac{3}{8}$ " 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 3/8 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.

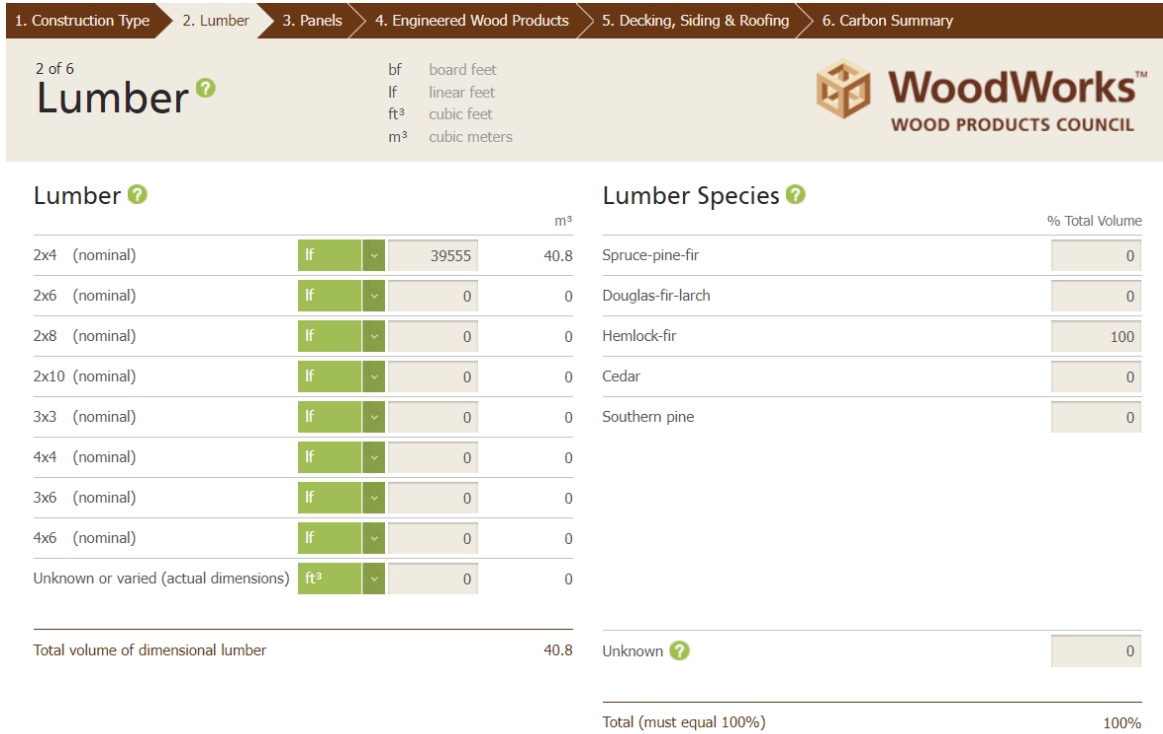


Figure 5: Lumber Input

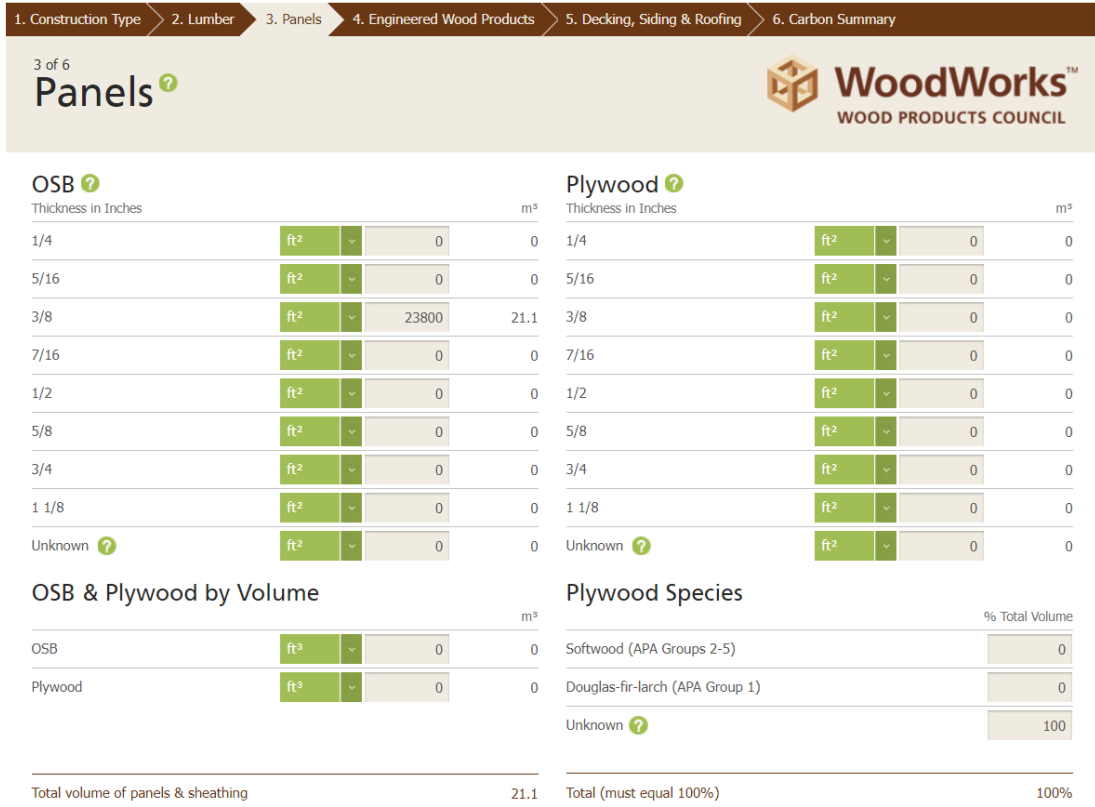


Figure 7: OSB Input

1/17/24, 6:32 PM

WoodWorks Carbon Calculator

Carbon Summary

Results

- Volume of wood products used (m³):**
62 m³ (2184 ft³) of lumber and sheathing
- U.S. and Canadians forests grow this much wood in:**
10 seconds
- Carbon stored in the wood:**
54 metric tons of CO₂
- Avoided greenhouse gas emissions:**
114 metric tons of CO₂
- Total potential carbon benefit:**
167 metric tons of CO₂

Project: NAU TimberStrong
Date: January 18, 2024

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.

Equivalent to:

- 35 cars off the road for a year**
- Energy to operate 18 homes for a year**

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 | |
| Aesthetic Materials | | | | | | | | | |
| Behr Exterior Paint | 2 | gallon | \$ 30.98 | 2 | \$ 62 | 0 | \$ - | \$ 62 | |
| Aesthetic 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

Certificate of Completion
is hereby granted to:
Mourtice Clitso
to confirm that they have completed
Stepladder Safety
1/18/2024
Score: 95

LADDER SAFETY TRAINING
www.laddersafety.org

Certificate of Completion
is hereby granted to:
Megan Alexander
to confirm that they have completed
Stepladder Safety
1/19/2024
Score: 100

LADDER SAFETY TRAINING
www.laddersafety.org

Certificate of Completion
is hereby granted to:
Jenna Hays
to confirm that they have completed
Stepladder Safety
1/18/2024
Score: 95

LADDER SAFETY TRAINING
www.laddersafety.org

Certificate of Completion
is hereby granted to:
Mariah Boler
to confirm that they have completed
Stepladder Safety
1/18/2024
Score: 95

LADDER SAFETY TRAINING
www.laddersafety.org

Certificate of Completion
is hereby granted to:
Natalie wahl
to confirm that they have completed
Stepladder Safety
1/18/2024
Score: 90

LADDER SAFETY TRAINING
www.laddersafety.org

Certificate of Completion
is hereby granted to:
Natali Farkouh
to confirm that they have completed
Stepladder Safety
1/18/2024
Score: 100

LADDER SAFETY TRAINING
www.laddersafety.org

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

Simpson Strong-Tie
LUS Galvanized Face-Mount Joist Hanger for 2x4 Nominal Lumber
★★★★★ (147) Questions & Answers (23)



BULK PRICE ELIGIBLE **98¢**
Buy 200 or more 88¢/unit

- Global leader in structural construction products since 1956
- Products designed and tested for strength and easy installation
- Diverse product line trusted by Pros and DIYers alike
- View More Details

Flagstaff Store
✓ 242 in stock Aisle 24, Bay 002

Joist Hanger Size: **2x4**

Pickup at Flagstaff Delivering to 86001

| | |
|--|---|
| Pickup Tomorrow 242 in stock FREE | Delivery Thursday, Jan 25 814 available FREE |
|--|---|

Get it as soon as tomorrow. Schedule your delivery in checkout.

- 1 + **Add to Cart**

Figure 9: Joist Hanger Cost

Home / [H/TSP Seismic & Hurricane Ties](#) / **Simpson H2.5ASS Hurricane Tie - Stainless Steel**

SKU: H2.5ASS


Simpson H2.5ASS Hurricane Tie - Stainless Steel

\$4.33

QUANTITY

- 1 +

ADD TO CART

 Ships Jan 24 when you order now





Figure 10: Hurricane Tie Cost



Simpson Strong-Tie Strong-Bolt 2 Wedge Anchor 1/2 X 2 3/4 25 per Pack STB2-50234R25

\$21.91

Simpson Strong-Tie Strong-Bolt 2 Wedge Anchor 1/2 X 2 3/4 Case 25 STB2-50234R25

AVAILABILITY: IN STOCK

DROP SHIPPED

SKU: 20614




- 1 + **ADD TO CART**   

Figure 11: Anchor Bolt Cost



SKU: LSTA18


Simpson LSTA18 18" 20 Gauge Strap Tie - G90 Galvanized

\$1.26

QUANTITY

- 1 +

Figure 12: Strap Tie Cost



SKU: LSTA24

Simpson LSTA24 24" 20 Gauge Strap Tie - G90 Galvanized

\$1.68

QUANTITY

- 1 +

Figure 13: Strap Tie Cost



SKU: LSTA36

Simpson LSTA36 36" 18 Gauge Strap Tie - G90 Galvanized

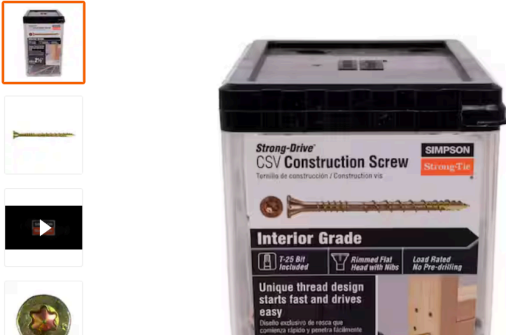
\$3.05

Figure 14: Strap Tie Cost

Simpson Strong-Tie

#10 x 2-1/2-in T25, Flat Head, Strong-Drive CSV Construction Screw - Yellow Zinc (240-Pack)

★★★★★ (2) Questions & Answers



\$21³² /package

- Global leader in structural construction products since 1956
- Products designed and tested for strength and easy installation
- Diverse product line trusted by Pros and DIYers alike
- [View More Details](#)


Package Quantity: 240

80 **240**

Pickup at Flagstaff Delivering to 86001

| | |
|--|---|
| Ship to Store Jan 29 - Jan 30 30 available FREE | Delivery Tuesday, Jan 30 30 available FREE |
|--|---|

Figure 15: Sheathing Screw Cost



SKU: SDWS16300QR150

0.160" x 3" Strong-Tie SDWS16300QR150 Framing Screw, Quik Guard Coating, Pkg 150

LENGTHS:


2-1/2" **3"** 3-1/2" 4"

QUANTITIES:

50 75 **150** 250 750 1000

\$40.55

Figure 16: Framing Screw Cost



SKU: SDWS16300QMB

0.160" x 3" Strong-Tie SDWS16300QMB Framing Screws, Pkg 250

★★★★★ 1 review

LENGTHS:


2-1/2" **3"** 3-1/2" 4"

QUANTITIES:

50 75 150 **250** 750 1000

\$62.88

Figure 17: Framing Screw Cost



SKU: SD9112SS-R100

#9 x 1-1/2" Strong-Tie SD9112SS-R100 Connector Screw - 316 Stainless Steel, Pkg 100

LENGTHS:

1-1/2" 2-1/2"

QUANTITIES:


100 500 2000 3000

\$42.30

QUANTITY

- 1 +

Figure 18: Hurricane Tie Screw Cost



TOP SELLER

SKU: SD9112R500

#9 x 1-1/2" Strong-Tie SD9112R500 Connector Screw - Class 55 Galvanized, Pkg 500

★★★★★ 2 reviews

QUANTITIES:

100 **500** 3,000

\$49.64

QUANTITY

- 1 +

Figure 19: Strap Screw Cost

BEHR PRO
1 gal. Black Flat Exterior Paint
 ★★★★★ (713) Questions & Answers (120)



\$30⁹⁸

Pay \$5.98 after \$25 OFF your total qualifying purchase upon opening a card. Apply for a Home Depot Consumer Card

- 100% acrylic formula with a flat, non-reflective appearance
- High hide and uniform finish
- Outstanding dirt-pickup resistance
- [View More Details](#)

Flagstaff Store

✓ 13 in stock Aisle 09, Bay 020

Paint Type: Exterior Paint

Sheen: Flat/Matte

Container Size: 1 Gallon

Figure 20: Paint Cost



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 |
|------------|
| Cash Sales |

| JOB ADDRESS |
|-------------|
| 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