Investigation of the November 8, 2021, Partial Collapse of Wood Roof Trusses during Construction of Dollar General Store, Orange City, Florida

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U.S. Department of Labor
Occupational Safety and Health Administration
Directorate of Construction

May 2022

REPORT

Investigation of the November 8, 2021, Partial Collapse of Wood Roof Trusses during Construction of Dollar General Store, Orange City, Florida

May 2022

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Directorate of Construction

TABLE OF CONTENTS **PAGE NO**

LIST OF FIGURES

LIST OF TABLES

1. Introduction

On October 19, 2021, at approximately 1:30 p.m., wood roof trusses collapsed and fell onto the ground floor at 1550 South Volusia Avenue, Orange City, Florida, where a Dollar General store was under construction (see Figure 1). Due to the collapse, two employees were injured after falling approximately 12 feet. A third employee cutting lumber on the ground floor inside the building, was fatally crushed by the falling trusses.

Local police and fire departments immediately responded and engaged in rescue. Personnel from OSHA's Jacksonville Area Office (AO) arrived at the scene after the incident. In November 2021, Federal OSHA's regional administrator for Region IV requested assistance from OSHA's National Office, Directorate of Construction (DOC) in Washington, DC, to assist in the technical assessment of the collapse and determine the cause of the incident.

A structural engineer from the Office of Engineering Services (OES) in DOC reviewed the construction documents and supporting calculations and conducted an independent analysis to determine the cause of the collapse.

DOC's investigation included the following items:

(1) Review of witness accounts.
(2) Review of construction plans and structural calculations.
(3) Review of actual construction activities and photographs taken during construction and after the incident.
(4) Structural analysis to determine the structure's adequacy and probable failure mechanism.

Based on the evidence collected, observations of the collapsed structure, and structural analyses performed, DOC concludes that:

1. The failure of the trusses occurred because of the out-of-plane buckling of the trusses due to inadequate bracings.
2. The truss erector did not consult a professional engineer to design and determine the size and location of temporary bracings, as is required by industry practice if the truss span exceeds 60 feet. The span of the failed trusses was 70 feet.
3. The temporary bracings provided by the erector were considered inadequate as per the industry requirements, even for trusses having spans 60 feet or less.
4. The load-bearing walls supporting the trusses at the site did not cause the collapse of the trusses.
5. The trusses as erected were unstable and therefore structurally inadequate for employees to use as anchors for fall protection.
6. Wind was not a causal factor.

Figure 1 – Site location map
(Modified from Google Maps)

2. Construction Project

The project consisted of constructing a one-story commercial building 70 feet wide and 130 feet long (see Figure 2). The ground floor was a 6-inch-thick concrete slab on grade. The framing walls (bearing walls) on four sides consisted of 2x6 lumber studs at 16 inches on center with double 2x6 top plates (see Figure 3). All framing walls were supported on a 2x6 bottom plate over 2-feet-wide continuous concrete footing. The north and south framing walls supported the roof trusses. The roof framing consisted of 66 wood piggyback base trusses spanning 70 feet in the north-south direction and spaced at 2 feet on center in the east-west direction (see Figure 4). The trusses were called piggyback because a piggyback base truss was used to support another smaller truss (piggyback truss) on its top chord at its north and south end. The framing walls on four sides and all piggyback base trusses had been constructed prior to the collapse. The smaller trusses were not installed at the time of the incident (see Figures 4 and 5).

Key participants in the project are listed below and shown in Figure 6:

Owner:	HSC Orange City, LLC, Daphne, AL (HSC)
Architect:	Adams Stewart Architects, LLC, Robertsdale, AL (Adams Stewart)
Structural Engineer:	Jade Consulting, LLC, Fairhope, AL (Jade Consulting)
General Contractor:	Fulcrum Construction Group LLC, Daphne, AL (Fulcrum)
Building Construction Contractor:	WW Build, Inc., Deland, FL (WW Build)
Framing Contractor:	Jeff Brown Construction LLC, Winter Springs, FL (Jeff Brown Construction)
Roof Truss Designer/Manufacturer:	A-1 Industries of Florida, Inc, Fort Pierce, FL (A-1 Roof Trusses)
Truss Erector:	Top Rank Construction Inc, Orlando, FL (Top Rank)

The property is owned by HSC, which contracted with Fulcrum as the general contractor (GC) to construct the building. Adams Stewart was the architect for the project, and Jade Consulting was the engineer of record. Both were retained by HSC. Fulcrum subcontracted with WW Build to construct structural components, including concrete slab, site concrete dumpster pad, building erection, and interior wood framing, masonry, and siding. WW Build subcontracted the wood framing construction with Jeff Brown Construction. Jeff Brown Construction is a sole proprietor and subcontracted the truss erection to Top Rank. The GC, Fulcrum, ordered the roof trusses from A1 Roof Trusses, who designed and manufactured the roof trusses.

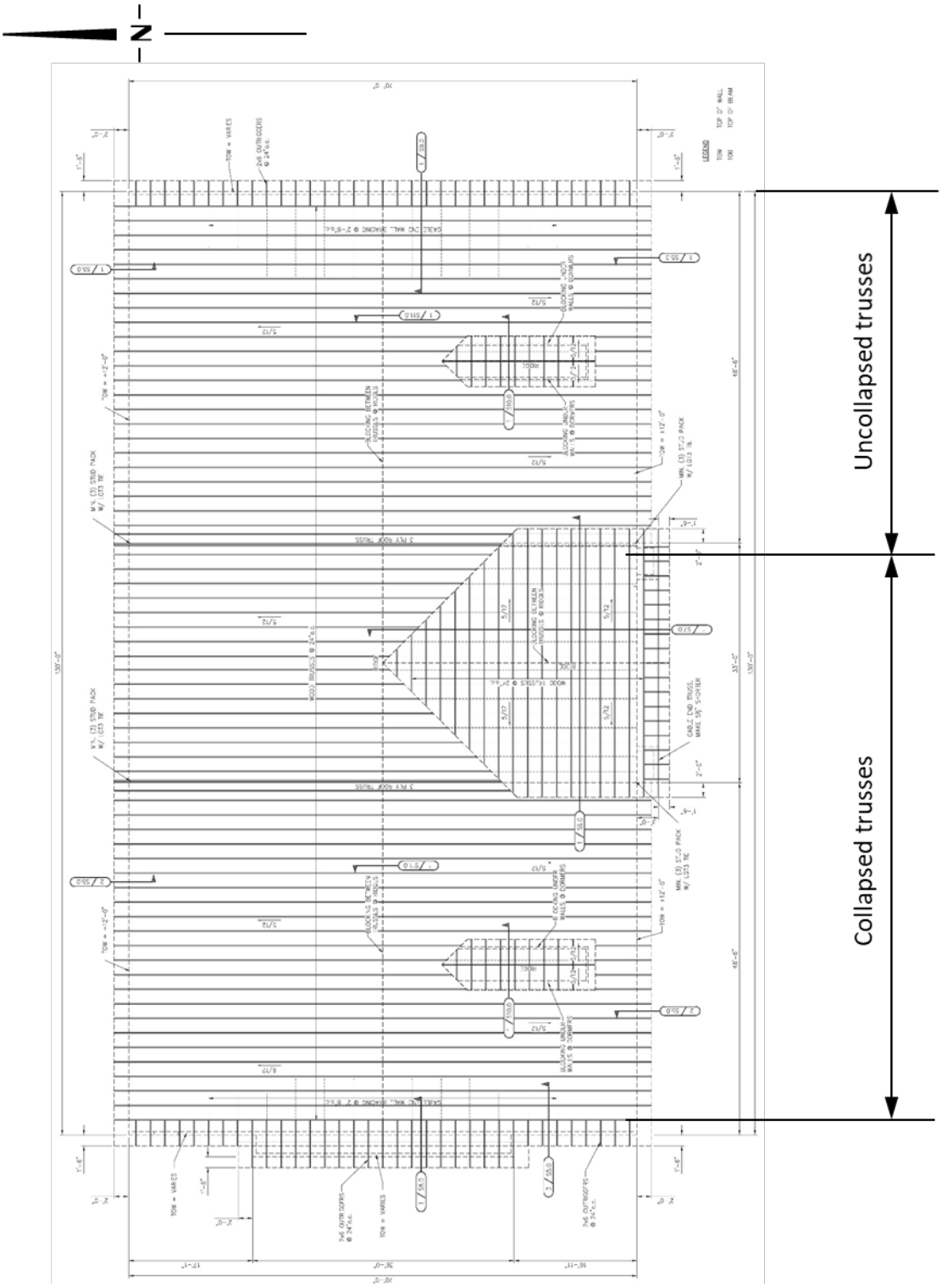


Figure 2 – Roof framing plan

Figure 3 – Bearing walls – looking west

(Courtesy of WW Build)

Figure 4 – Bearing walls and trusses – looking east

(Courtesy of WW Build)

Figure 5 – Bearing walls and trusses – looking north

(Courtesy of WW Build)

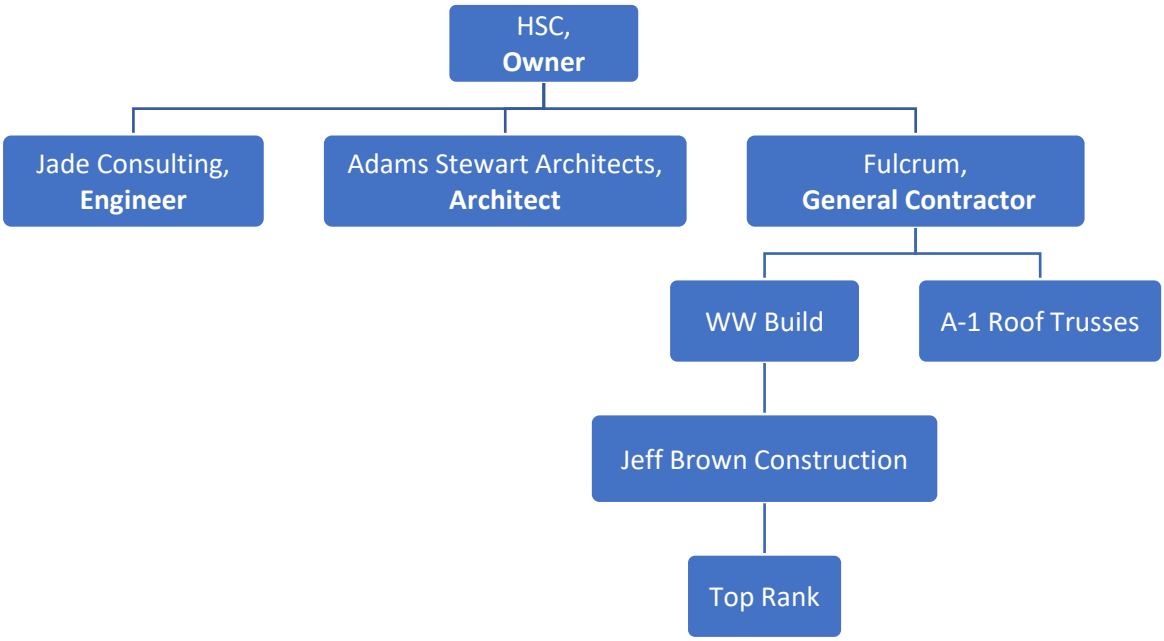


Figure 6 – Key Participants - Project hierarchy

3. Construction Activities

In September 2021, construction of the concrete slab floor began. Construction of the bearing walls started in October 2021. The bearing walls were installed on 2"x6" bottom plates anchored down to the concrete slab using anchor rods at 32 inches typical on center. The lower portion of the bearing walls was sheathed using ½ inch thick plywood and was laterally braced.

All trusses were delivered to the site on October 28, 2021. The setting of piggyback base trusses began on November 3, 2021. The first truss was erected the same day (November 3), approximately 9'-4" from the east wall (see Figure 7). The first truss was laterally braced at six locations using 2"x4" braces from vertical posts to the east wall (see Figure 8). On November 4, 2021, the last piggyback base truss near the west wall was erected and braced at multiple locations to the west wall (see Figure 9).

Due to inclement weather, no additional framing work was performed at the site over the next few days. Sheathing of the roof at the northeast section of the structure started on Nov. 8, 2021 (see Figure 10), while three Top Rank employees were working on straightening up some twisted roof trusses. One of the three Top Rank employees was working in the interior of the building, cutting lumber at ground level and passing the cut lumber to another employee standing on the top plate of the south wall, who handed the lumber to the third employee located inside the roof trusses. The third employee was adding more lateral bracing to the roof trusses. He also removed and relocated some of the already installed lateral bracings to straighten up the out of plum trusses.

Approximately 1:30 p.m., while the three Top Rank employees continued working on adding more bracings, trusses at the west side of the building started to fall toward the east (see Figure 11). Two Top Rank employees fell more than 12 feet onto the concrete floor and were injured. The Top Rank employee located on the ground cutting lumber was struck by fallen trusses and died instantly at the jobsite.

Figure 7 – Truss erection – looking northwest

(Courtesy of WW Build)

Figure 8 – Truss diagonal end braces at the east side – looking west

(Photo by WW Build)

Figure 9 – Truss diagonal end braces at the west side – looking west

(Photo by WW Build)

Figure 10 – Wall diagonal braces at the north side – looking southeast

Figure 11 – Collapsed roof trusses – looking southeast

4. Witness Account of the Incident

Three Top Rank employees were correcting bent roof trusses when the collapse occurred. The two surviving employees were eyewitnesses to the collapse and had pertinent information related to the investigation. The following is a summary of their description of the collapse.

- On the day of the incident, the three employees started work on the twisted roof trusses a little after 11:30 a.m.
- The trusses that they worked on were mostly designated A02 and A04.
- Around 1:30 p.m., the employee standing on the south wall heard a crack noise and observed the roof trusses move a little bit and were leaning toward the inside from where he was located. He then observed the trusses starting to fall toward the inside of the building.

5. Field Observations

Top Rank installed both diagonal and lateral braces (short lumber pieces) on the north and the south side of the trusses. Figure 12 shows the truss bracing installed on Nov. 4, 2021, after completion of piggyback base truss erection. Long diagonal and short member temporary lateral restraints installed on the north side of the trusses prior to the collapse were observed after the incident during OSHA's field investigation (see Figure 13). Additionally, OSHA found that bottom chord and web member bracing were not installed prior to the collapse (see Figure 14).

Figure 12 – Truss braces at the south side – looking north

(Photo by WW Build)

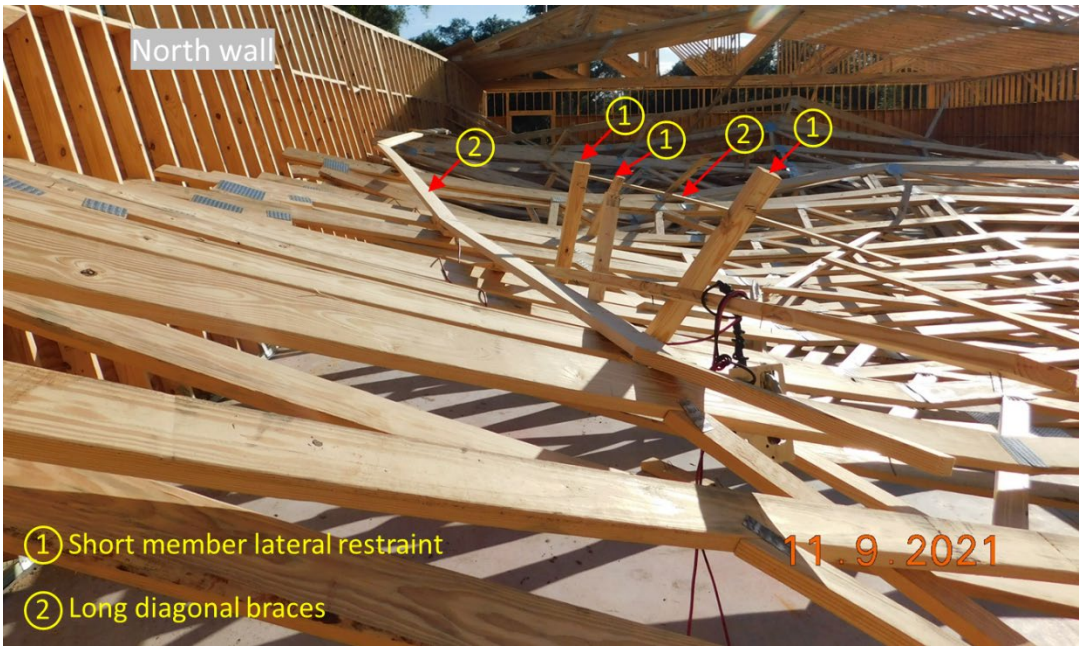


Figure 13 – Truss top chord braces at the north side after collapse – looking east

Figure 14 – Truss bottom chord – looking east
(Photo by WW Build)

After reviewing the construction progress photographs taken by WW Build, OSHA found that the wood trusses were not properly hoisted. The erector did not follow the Building Component Safety Information Guide[1] to Good Practice for Handling, Installing, Restraining, and Bracing of Metal Plate Connected Wood Trusses, by using a spreader bar to hoist the trusses since they were over 60 feet long (see Attachment A). Wood trusses were found twisted and bent (or buckled) (see Figure 15). The mid-panel splice at the bottom chord of the west-most truss was damaged due to out-of-plane buckling during hoisting (see Figure 16).

[1] See Reference 8 and Attachment A.

Figure 15 – Truss hoisting
(Photo by WW Build)

Figure 16 – Truss hoisting
(Photo by WW Build)

Photographs taken after the incident show that the trusses that remained in place at the east side of the building were buckled as installed (see Figure 17). Since these trusses were far away from those that collapsed, it is believed that the buckling of these trusses was likely not due to the collapse.

Figure 17 – Buckled trusses

During OSHA's field investigations, it was observed that wood trusses were stored incorrectly at the jobsite, in that the trusses were unloaded on rough terrain, which caused out-of-plane bending of the trusses (see Figures 18 to 20).

Figure 18 – Incorrect jobsite storage of trusses

Figure 19 – Incorrect jobsite storage of trusses

Figure 20 – Incorrect jobsite storage of trusses

6. Engineering Evaluation

6.1. Wall Framing

The wall framing, consisting of 2x6 lumber studs placed at 16 inches on center, was structurally sufficient and code compliant as designed. The building structural design required 2-2x6 (double) top plates and 1-2x6 (single) pressure treated bottom plates for the wall framing. The splices of the double top plates were staggered. This type of framing is considered conventional light framing and is in prescriptive compliance with the building code. During its field inspection, OSHA verified the dimensions and lumber grade used to build the frames (see Figures 21 to 23). OSHA observed diagonal braces installed on the exterior side of the walls (see Figures 3, 5, 8, 10, and 24). The bearing walls did not collapse, although the west portion of the north bearing wall was tilted outward (see Figures 10, 11, 13, and 20). Therefore, the north and south bearing walls did not appear to be a root cause of the collapse of the trusses.

Figure 21 – Bearing wall frame – studs

Figure 22 – Bearing wall frame – studs

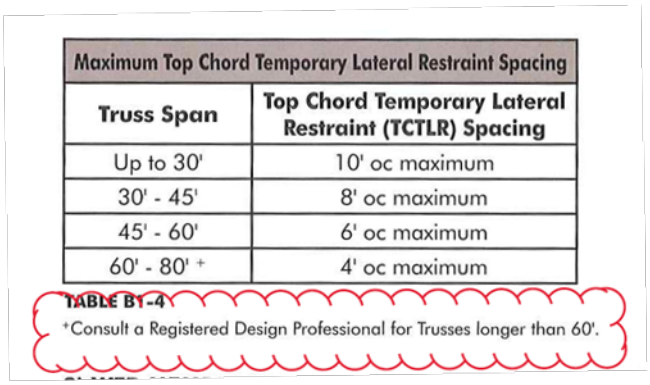
Figure 23 – Bearing wall frame – bottom plate

Figure 24 – Bearing wall frame – diagonal bracing

6.2. Truss Stability

Roof trusses are highly susceptible to collapse during erection before placement of roof sheathing. Therefore, it is a standard industry practice to maintain the structural stability of roof trusses by providing temporary bracing, i.e., ground bracing, top and bottom chord lateral and diagonal bracing, and web diagonal bracing during erection until the entire structure is complete. Roof trusses are light structural members, prone to instability and lateral-torsional buckling without these temporary bracings in place. In this case, due to the lack of adequate bracing, the installed trusses were in a state of instability and susceptible to collapse either due to buckling or under any significant lateral and gravity loads.

Details of the required bracings for trusses up to 60 feet in span are provided in Building Component Safety Information - Guide to Good Practice for Handling, Installing, Restraining & Bracing of Metal Plate Connected Wood Trusses, BCSI - Bl, 2018 edition, produced by Structural Building Components Association (SBCA). For trusses over 60 feet in span, the industry requires that a professional engineer determine the type, size, and location of temporary bracings (see Figure 25).



Maximum Top Chord Temporary Lateral Restraint Spacing	
Truss Span	**Top Chord Temporary Lateral Restraint (TCTLR) Spacing**
Up to 30'	10' oc maximum
30' - 45'	8' oc maximum
45' - 60'	6' oc maximum
60' - 80' +	4' oc maximum

TABLE B1-4
+Consult a Registered Design Professional for Trusses longer than 60'.

Figure 25 – BSCI requirement on trusses longer than 60 feet

OES performed structural analyses to determine:

1. Whether the roof trusses (piggyback base trusses) were designed properly for the prescribed loadings.
2. Whether the roof trusses would become unstable during erection due to the lack of temporary bracings.
3. Whether the roof trusses would be overstressed during hoisting.

The structural analyses of the roof's piggyback base truss A02 and A04 were performed using the commercially available software program STAAD.Pro. The following assumptions were used in the analysis.

- The member properties of the truss were obtained from the stamped truss design package and drawings.
- The truss was considered supported at one end by a hinge support and at the other end by a roller support.
- The self-weight of the A02 and A04 trusses was 458 pounds each.
- As part of the prescribed gravity loads for the completed structure, the following design loads taken from A-1 Roof truss drawings were considered in the analysis.
    - Top chord live load: 16 pounds per square foot (psf)
    - Top chord dead load: 10 psf
    - Bottom chord live load: 5 psf
    - Bottom chord dead load: 8 psf

- For the live load during erection, one employee weighing approximately 200 pounds was considered to be on the top chord on the south side of the truss.
- The analysis was done without load and strength reduction factors.
- The analysis considered the effective unbraced length in the weak axis equal to 80% of the actual unbraced length for the top chord.
- Wind load was not considered in the analysis.

The analyses indicated the following:

1. A1 Roof Trusses properly designed the roof trusses (Piggyback base truss of 1 ply) for the prescribed loadings shown on the truss document.
2. During the erection, only the top chord of each piggyback base truss was laterally braced, and the top chords were braced at approximately 8 locations only. Even without one employee standing on a truss, the truss was overstressed beyond its ultimate capacity under its own weight. Due to the lack of required lateral restraints, the installed trusses were unstable and ready to collapse due to out-of-plane buckling. The trusses were structurally inadequate for employees to use as an anchor for fall protection.
3. The 70 feet long trusses were not properly hoisted. The trusses were prone to be overstressed during rigging due to out-of-plane buckling (i.e., twisting and bending), likely damaging the wood trusses and resulting in an unsafe condition.

Post-incident examination revealed that the actual bracing provided to ensure the stability of the trusses was far less than is required by industry practice, see Table 1.

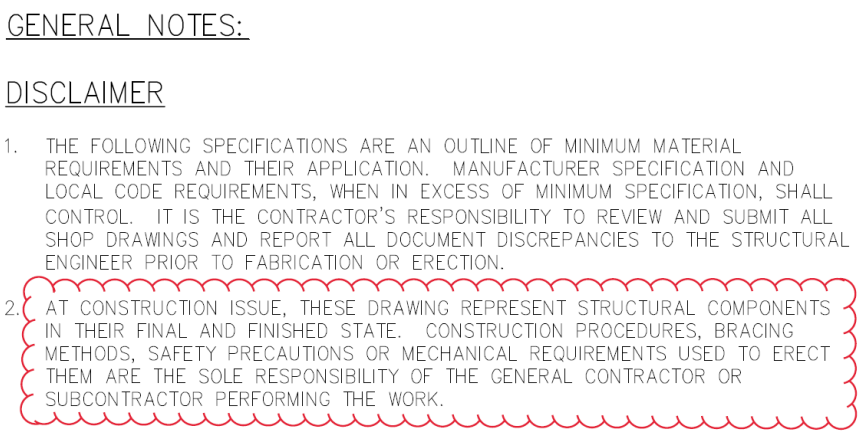
Table 1 BCSI Requirements of Temporary Bracing During Truss Installation[2]

Items	Bracings required	Reference[3]
Top chord lateral bracing	6 feet o.c. maximum for truss span 45 to 60 feet 4 feet o.c. maximum for truss span 60 to 80 feet	Table B1-4
Top chord diagonal bracing	1st bracing covering five trusses and subsequent braces covering four trusses	Figure B1-24
Bottom chord lateral bracing	10 to 15 feet apart maximum	Figure B1-28
Bottom chord diagonal bracing	20 feet apart maximum	Figure B1-28
Web diagonal bracing	10 to 15 feet apart (located at each of the bottom chord lateral bracings) and 20 feet apart maximum in a transverse direction	Figure B1-26
Ground bracing	To be located at each of the top chord lateral bracings	Figures B1-16/17

[2] See Reference 8 for figures and tables list in the table.
[3] See Attachment A for details.

7. Discussion

Section 2303.4.1.3 of the 2020 Florida Building Code[4] requires that "The owner or the owner's authorized agent shall contract with any qualified registered design professional for the design of the temporary installation restraint/bracing and the permanent individual truss member restraint/bracing for all trusses with clear spans 60 feet (18 288 mm) or greater." HSC, property owner, contracted with Fulcrum as its general contractor to construct the building. Article 1.1 of the written contract between HSC and Fulcrum states, "The Work shall be performed by contractor strictly in accordance with the Contract Documents which consist of the Contract and the plans, drawings, specifications, addenda and other documents identified in Schedule B attached hereto and all modifications issued hereafter thereof (the Contract Documents")." Jade Consulting, engineer of record, disclaimed in its structural design drawing S0.0 (see Figure 26), that "Construction procedures, bracing methods, safety precautions or mechanical requirements used to erect them are the sole responsibility of the general contractor or subcontractor performing the work."


GENERAL NOTES:

DISCLAIMER

1. THE FOLLOWING SPECIFICATIONS ARE AN OUTLINE OF MINIMUM MATERIAL REQUIREMENTS AND THEIR APPLICATION. MANUFACTURER SPECIFICATION AND LOCAL CODE REQUIREMENTS, WHEN IN EXCESS OF MINIMUM SPECIFICATION, SHALL CONTROL. IT IS THE CONTRACTOR'S RESPONSIBILITY TO REVIEW AND SUBMIT ALL SHOP DRAWINGS AND REPORT ALL DOCUMENT DISCREPANCIES TO THE STRUCTURAL ENGINEER PRIOR TO FABRICATION OR ERECTION.
2. AT CONSTRUCTION ISSUE, THESE DRAWING REPRESENT STRUCTURAL COMPONENTS IN THEIR FINAL AND FINISHED STATE. CONSTRUCTION PROCEDURES, BRACING METHODS, SAFETY PRECAUTIONS OR MECHANICAL REQUIREMENTS USED TO ERECT THEM ARE THE SOLE RESPONSIBILITY OF THE GENERAL CONTRACTOR OR SUBCONTRACTOR PERFORMING THE WORK.

Figure 26 – Disclaimer in structural design drawing S0.0

The contractual agreement between Fulcrum and WW Build clearly stated that WW Build "…shall perform the Work according to the plans, specifications and schedules prepared by Todd Stewart, Architect (herein Architect) and Jade Consulting, LLC (herein Engineer)…"[5]

[4] See Attachment B.
[5] See Reference 9.

The contractual agreement between WW Build and Jeff Brown Construction stated that "Subcontractor will comply with all statutes and regulations that established safety requirements (including, but not limited to those of OSHA and any state agency regulating job-site safety)." See below excerpt from the aforementioned contract document.

during the warranty period stated herein. Subcontractor will comply with all statutes and regulations that establish safety requirements (including, but not limited to those of OSHA and any state agency regulating job-site safety). By signing this Agreement, Subcontractor knowingly and willingly accepts full responsibility for the safe operation of all of its activities and the protection of other persons and property during the course of this project. Any controversy or claim arising out of or related to

Jeff Brown Construction, sole proprietor, subcontracted the truss erection to Top Rank. There was no written contract between Jeff Brown Construction and Top Rank. Therefore, the responsibility for providing temporary support during construction rests solely with the framer, Jeff Brown Construction, and its truss erection subcontractor, Top Rank.

A1 Roof Trusses recommended multiple times in its truss design drawings that "Failure to follow provisions of BCSI in handling and installation of trusses can result in serious injuries. Do not permit inexperienced and uninstructed people to install trusses. See "WARNING" note below. BCSI recommends retaining a registered professional engineer for the design of temporary bracing." In the truss placement drawings, A1 Roof Trusses also required that "FOR BRACING & ERECTION DETAILS REFER TO BCSI-03 AND/OR ENGINEER OF RECORD."

Jeff Brown Construction and its subcontractor, Top Rank, failed to follow the generally accepted standard industry practice of storage and hoisting of trusses; providing temporary top chord lateral restraints, diagonal and web member plane diagonal bracings; and proper ground bracings during erection of the trusses, in accordance with the BCSI, produced by the Structural Building Components Association.

As the first-tier subcontractor, WW Build was on-site during the installation of the roof trusses and photographed the conduct of its subcontractors. However, WW Build did not

raise any concerns about Jeff Brown Construction and Top Rank's faulty construction activities.

8. Conclusions

Based on the above, OES concluded that:

1. The failure of the trusses occurred because of the out-of-plane buckling of the trusses due to inadequate bracings.
2. The truss erector did not consult a professional engineer to design and determine the size and location of temporary bracings, as is required by industry practice if the truss span exceeds 60 feet. The span of the failed trusses was 70 feet.
3. The temporary bracings provided by the erector were considered inadequate as per industry requirements, even for trusses having spans 60 feet or less.
4. The load-bearing walls supporting the trusses at the site did not cause the collapse of the trusses.
5. The trusses as erected were unstable and therefore structurally inadequate for employees to use as anchors for fall protection.
6. Wind was not a causal factor.

9. References

1. Architectural drawing T1 for Dollar General Store #22913 prepared by Adams Stewart Architects LLC, Robertsdale, AL.
2. Civil Site Plan drawings C0 for Dollar General Store #22913 prepared by Adams Stewart Architects LLC, Robertsdale, AL.
3. Structural drawings S01-S11 for Dollar General Store #22913 prepared by Adams Stewart Architects LLC, Robertsdale, AL.
4. Roof truss design and layout drawings prepared by A1 Truss, Fort Pierce, FL.
5. Photographs of the incident taken by OSHA's Jacksonville Area Office.
6. Photographs of the incident taken by WW Build Inc.
7. Photographs of the incident taken by the Police Department.
8. Building Component Safety Information, Guide to Good Practice for Handling, Installing, Restraining & Bracing of Metal Plate Connected Wood Trusses; jointly by Structural Building Components Association, 2018 Edition, June 2018.
9. Contract Agreement, HSC Orange City, LLC and Fulcrum, July 6, 2021.
10. Uniform subcontract, Fulcrum Construction Group LLC, Job No.: 21-037, July 27, 2021.
11. Purchase Order # FULC-DGOC-0003, WW Build, Inc, October 25, 2021.
12. 2020 Florida Building Code, Building, the 7th Edition.

Attachment A

BCSI Building Component Safety Information

BCSI

BUILDING COMPONENT SAFETY INFORMATION

Guide to Good Practice for Handling, Installing, Restraining & Bracing of Metal Plate Connected Wood Trusses

PRODUCED BY
STRUCTURAL BUILDING COMPONENTS ASSOCIATION

Published – June 2018

- ❑ Comply with the Owner's or the Owner's retained Registered Design Professional's Permanent Building Stability Bracing, Anchorage, Connections and field assembly requirements. This information is typically provided in the Construction Documents.

- ❑ Install Structural Sheathing as soon as possible. Trusses hold their profiles best when they have been properly plumbed, restrained and braced with Structural Sheathing. **Sheath early... sheath often!**

- ❑ During construction, distribute material and equipment loads (e.g., plywood, drywall, roofing, tools, etc.) on the Trusses to stay within the design load limit for each Truss. Make sure the Trusses are adequately restrained and braced BEFORE placing any Construction Loads on them. Only install HVAC units, fire sprinklers, etc., on Trusses if the Trusses have been designed to accommodate these specific loads. Review the Truss Design Drawings for the assumed loads and locations.

Note: Temporarily braced structures are NOT suitable for use or occupancy. Restrict access to construction personnel only. DO NOT inhabit or store anything of value in temporarily braced structures.

BUILDING DESIGNER INFORMATION

The following information is provided to help guide the Building Designer when using Trusses.

There are two situations under which building construction is performed:

1. Structures that require a Registered Design Professional (RDP)
2. Structures that DO NOT require a RDP

For Structures that require a RDP, the Building Designer is defined as:

> The Registered Design Professional who contracts with the Owner for the design of the Building Structural System and/or who is responsible for the preparation of the Construction Documents.

For Structures that DO NOT require a RDP, the Building Designer is defined as:

> The Owner of the Building or the person that contracts with the Owner for the design of the Building Structural System and/or who is responsible for the preparation of the Construction Documents.

BUILDING DESIGNER CHECKLIST

REQUIRED INFORMATION IN THE CONSTRUCTION DOCUMENTS

Be sure to specify the following in the Construction Documents:

- ❑ Trusses with clear spans of 60' or greater require that the Owner contract with a Registered Design Professional for the design of the Temporary Installation Restraint/Bracing and the Permanent Individual Truss Member Restraint/Bracing.

- ❑ Trusses with clear spans of 60' or greater require that the Owner contract with a Registered Design Professional to provide special inspections to assure that the Temporary Installation Restraint/Bracing and the Permanent Individual Truss Member Restraint/Bracing is installed properly.

The following information is required in the Construction Documents for developing the design of the Trusses for the Building:

- ❑ All Truss and Structural Element orientations and locations
- ❑ Information to fully determine all Truss profiles
- ❑ All Structural Element and Truss support locations and bearing conditions (including the allowable bearing stress)
- ❑ The location, direction, and magnitude of all dead, live, and lateral Loads applicable to each Truss including, but not limited to, Loads attributable to: roof, floor, partition, mechanical, fire sprinkler, attic storage, rain and ponding, wind, snow (including snow drift and unbalanced snow), seismic, and any other Loads on the Truss.
- ❑ All Anchorage designs required to resist uplift, gravity, and lateral loads
- ❑ Truss-to-Structural-Element Connections, but not Truss-to-Truss Connections
- ❑ Permanent Building Stability Bracing, including Truss Anchorage Connections to the Permanent Building Stability Bracing
- ❑ Criteria related to serviceability issues including:
  - Allowable vertical, horizontal or other required deflection criteria
  - Any dead Load, Live Load and in-service creep deflection criteria for flat roofs subject to ponding loads
  - Any Truss camber requirements

proper performance of individual Trusses within the roof or floor system. Permanent Lateral Restraint and Diagonal Bracing shall provide sufficient support at right angles to the plane of the Truss to hold every Truss member in the position assumed for it to properly carry the applied design loads. If properly planned, the Temporary Installation Restraint/Bracing applied during Truss installation can be used as permanent Lateral Restraint and Diagonal Bracing, making the completion of the permanent Lateral Restraint and Diagonal Bracing more efficient.

Finally as indicated in Section 2303.4.4 of the 2018 IBC, the Registered Design Professional (RDP) (or where there is no RDP, the Building Designer [see Chapter 2 of ANSI/TPI 1]) is responsible for the proper transfer of design Loads and the Anchorage design of each Truss to the supporting structure. When the flow of Loads has been accounted for and all the Load resisting systems for the Building have been adequately designed, constructed and installed, the structural framing for the Building is complete.

SPECIAL DESIGN REQUIREMENTS

Special design requirements, such as wind Bracing, portal Bracing, seismic Bracing, Diaphragms, shear walls, or other Load transfer elements and their Connections to Trusses shall be considered separately by the Building Designer, who shall determine the size, location, and method of Connections for all Bracing as needed to resist these forces.

UNLOADING & LIFTING

NOTICE Avoid Lateral Bending (See Figure B1-2).

FIGURE B1-2

Beginning with the unloading process, and throughout all phases of construction, exercise care to avoid lateral bending of Trusses, which can cause damage to the lumber and Metal Connector Plates.

Due to treatment effects, fire-retardant-treated Trusses require special care when handling to prevent chord and web member breakage. Limit exposure to the elements per manufacturer's recommendations.

JOBSITE HANDLING

Make sure Trusses in a bundle are securely connected together prior to moving.

⊘ **DO NOT** rely on banding to securely transfer bundles on the jobsite.

Banded Truss bundles, in a vertical position, should be picked up along the Top Chords.

PHOTO B1-2

PHOTO B1-3

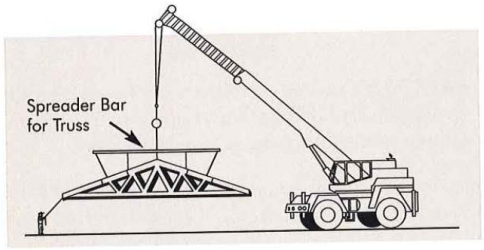


FIGURE B1-3

Proper banding and smooth ground allow for unloading of Truss bundles without damage. Trusses should be unloaded as close to the Building site as possible to minimize handling. Use care to not damage Trusses with the forks of the forklift.

⊘ **DO NOT** break banding until erection/installation begins.

⊘ **DO NOT** drag or push Trusses along ground.

⊘ **DO NOT** lift banded Trusses by the banding.

⊘ **DO NOT** store unbraced bundles upright.

PHOTO B1-4

DO NOT store Trusses on uneven ground.

PHOTO B1-5

If Trusses are stored vertically, they shall be braced in a manner that will prevent tipping or toppling.

PHOTO B1-6

CAUTION Exercise care when removing banding to avoid damaging Trusses and prevent personal injury. Gloves and safety glasses should be worn.

Trusses may be unloaded directly on the ground at the time of delivery or stored temporarily in contact with the ground after delivery. If Trusses are to be stored horizontally for more than one week, place Blocking of sufficient height beneath the stack of Trusses on 8' to 10' intervals (or as required) to minimize Lateral Bending and to lessen moisture gain from the ground (See Figure B1-4).

Trusses stored for more than one week shall be protected from the environment in a manner that provides adequate ventilation of the Trusses. If tarpaulins or other protective covers are used, the ends shall be left open for ventilation. Tight-fitting coverings are not recommended, since they can trap moisture.

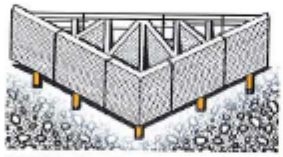


FIGURE B1-4

NOTICE Avoid Lateral Bending

Trusses are relatively deep, narrow Structural Building Components that are extremely flexible if bent perpendicular to their plane. Use care when handling Trusses to limit the amount of Lateral Bending, which can cause damage to the lumber and/or plates.

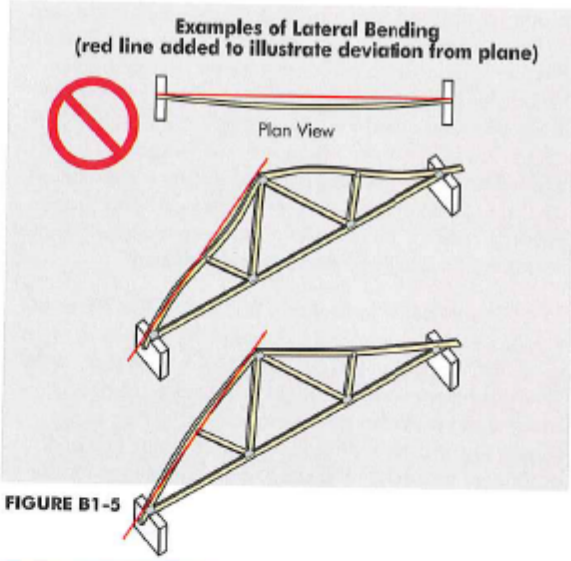


FIGURE B1-5

CRANE USE & PROPER TRUSS HANDLING

A common method for hoisting Trusses into place is to use a crane and rigging. Inadequate or improperly used hoisting equipment can result in damage to Truss members and/or connector plates. This section provides very basic guidelines to help avoid this type of damage.

PHOTO B1-7
Spreader Bar is too short for this Truss.

PHOTO B1-8

RESPONSIBILITY

Crane equipment and use should comply with OSHA standards and, unless agreed to expressly through Contract, is the responsibility of the crane operator and/or Contractor. All OSHA standards referred to in this document can be found on the OSHA website at osha.gov/cranes-derricks/index.html.

KEY CONSIDERATIONS

- Always obtain the correct crane size; never exceed load capacity.
- Always properly stabilize the crane onsite.
- Always use proper rigging equipment.
- Use special hoisting equipment as needed. See hoisting recommendations for Truss bundles (page 6) or single Trusses (page 8).
- Crane operator and ground crew need to know basic hand signals (see examples in Figure B1-6).

equipment should be inspected regularly by a competent individual to ensure everything is in proper working order and that any worn or defecitve parts are repaired or replaced. Equipment and worksite inspections should adhere to the latest "Mobile Crane Inspection Guidelines for OSHA Compliance Officers" published by OSHA.

LOAD POSITIONING & MOVEMENT

Position the load to be hoisted as close to the Building site as possible to minimize hoisting distance. Load movement using crane equipment and rigging should comply with OSHA regulations [OSHA 29 CFR 1926.1417, Subpart CC].

NOTICE Check Truss bundle banding prior to moving bundles.

DO NOT rely on banding to hoist and move bundles on the jobsite.

RIGGING EQUIPMENT

Use materials such as slings, chains, cables and nylon straps of sufficient strength to carry the weight of the Truss or Truss bundle. Use slings, taglines and Spreader Bars properly to avoid damage to the Truss members and Connections.

All rigging equipment and use should comply with OSHA regulations [OSHA 29 CFR 1926.1425, Subpart CC], which provide guidelines on safe working loads permitted for the different types of rigging equipment. This standard also requires regular inspection of all rigging equipment by a competent individual and replacement or repair of damaged or defective parts.

HOISTING TRUSSES

NOTICE Avoid Lateral Bending when hoisting Trusses (see Figure B1-7).

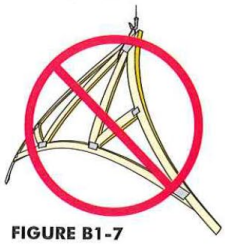


FIGURE B1-7

NOTICE Do not lift single Trusses by the peak using a hook as shown in Figure B1-8A, as this can cause damage to the chords, Webs and/or Truss Plates.

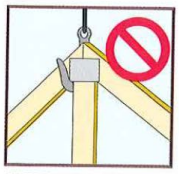


FIGURE B1-8A

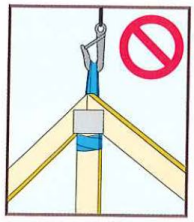


FIGURE B1-8B

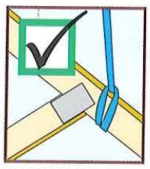


FIGURE B1-8C

NOTICE Do not lift single Trusses by the Webs as shown in Figure B1-8B, as this will cause Lateral Bending in the Truss and damage to the Truss Plates and web member.

NOTICE Connect lifting devices to the Truss Top Chord with only closed-loop attachments (see Figure B1-8C). Refer to the section entitled "Mechanical Hoisting Recommendations for Single Trusses" beginning on page 8 for additional information regarding the correct hoisting methods for single Trusses of various span lengths.

NOTICE A Spreader Bar used to hoist a Truss shall be of sufficient strength and rigidity to carry the weight and to resist bending of the Truss. Spreader Bars should comply with design specifications established by ASME [ANSI/ASME B30.5-2014] and prescribed by the equipment manufacturer.

SPECIAL CONSIDERATIONS

- Use special care in adverse weather conditions. Buildings under construction become more dangerous when constructed in high-wind conditions. Lightning can also pose a serious risk. It is the responsibility of the crane operator or Contractor to recognize adverse weather conditions and take prompt and appropriate action to ensure safety.
- Avoid using a crane in close proximity to electrical power lines unless the power has been disconnected by the local power company [OSHA 29 CFR 1926.1407-1411].
- If you are using a crane within five miles of an airport, contact the airport 30 days prior to crane use to learn about any required safety regulations [FAA: 14 CFR Part 77].

HOISTING & PLACEMENT OF TRUSS BUNDLES

Trusses that have been banded securely together to form a bundle are stiffer than single Trusses; therefore, hoisting recommendations for bundles are different as there is less likelihood of damage due to out-of-plane bending (see Photo B1-9).

RECOMMENDATIONS FOR HOISTING TRUSS BUNDLES

NOTICE Determine the weight of the Truss bundle. The actual unit weight of a Truss depends on many factors including the size and species of lumber, the moisture content of the lumber and the Truss configuration. A good rule to estimate the weight of the bundle is to use 15 pounds per foot of Truss length times the number of Trusses in the bundle.

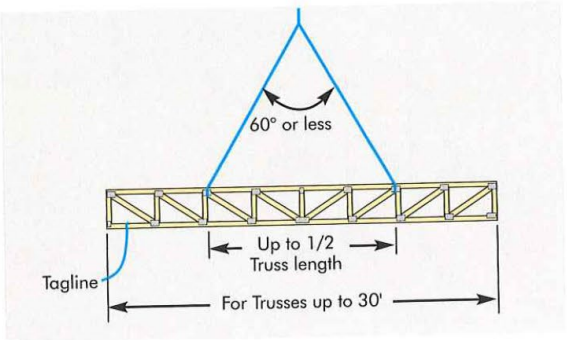


FIGURE B1-10B

TRUSSES UP TO 60': For single Trusses between 30' and 60', use a Spreader Bar 1/2 to 2/3 of the Truss length. Attach Truss to the Spreader Bar with lines that slope inward or "toe-in," as shown.

⚠ **CAUTION** Lines that "toe-out" can cause the Truss to buckle.

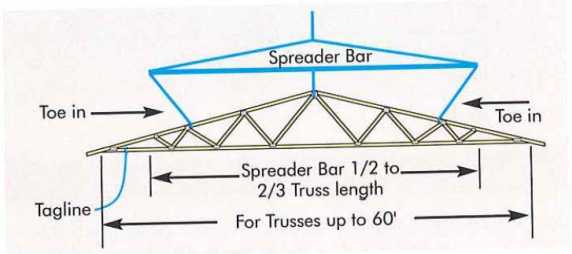


FIGURE B1-11A

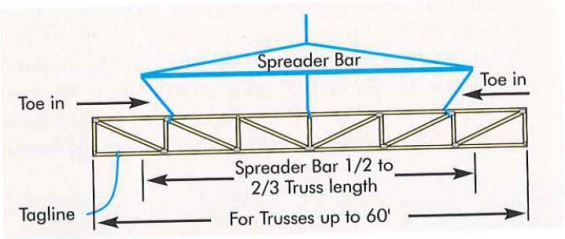


FIGURE B1-11B

TRUSSES UP TO AND OVER 60': For single Trusses over 60', use a Spreader Bar 2/3 to 3/4 of the Truss length. The Spreader Bar prevents Lateral Bending and should be attached to Top Chords and Webs at 10' intervals. Locate the Spreader Bar at or above mid-height of the Truss to prevent overturning.

NOTICE Design the Spreader Bar of any material with sufficient strength and rigidity to carry the weight and to resist bending of the Truss. If in doubt, seek professional guidance.

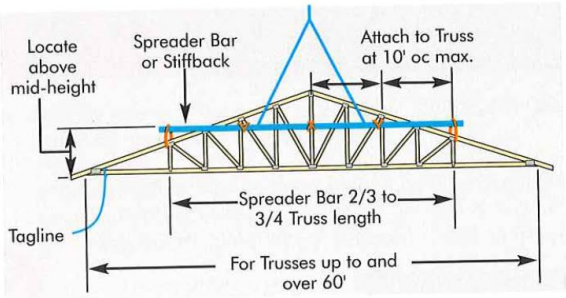


FIGURE B1-12A

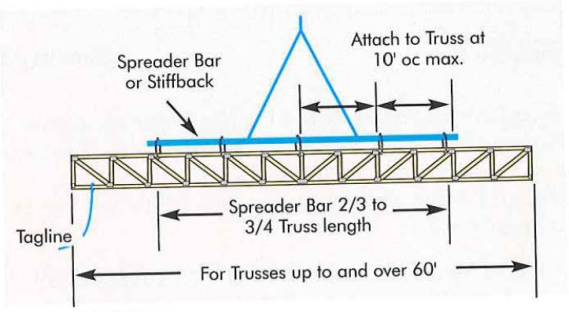


FIGURE B1-12B

INSTALLATION OF SINGLE TRUSSES BY HAND

Lifting by hand is allowed, provided excessive Lateral Bending is prevented (see Figure B1-5).

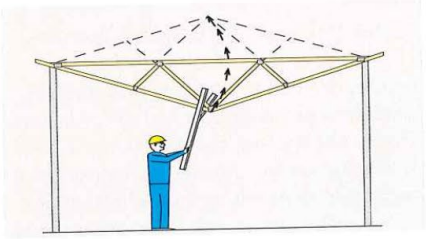


FIGURE B1-13

Trusses with spans less than or equal to 20' can be raised into position by lifting near the peak

Trusses with spans less than or equal to 30' should be raised into position by lifting at Top Chord joints nearest the quarter points of the span.

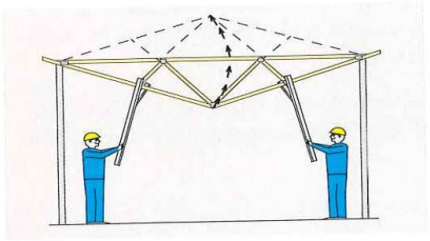


FIGURE B1-14

RESTRAINT/BRACING MATERIAL & CONNECTIONS

⚠ **CAUTION** Inadequate size and/or fastening of Bracing material is a major cause of erection dominoing.

Minimum size of lumber used as Lateral Restraint and Diagonal Bracing is 2x4 stress-graded lumber, unless another size is specified by the Building Designer.

Minimum Nail Size
10d (0.128x3")
12d (0.128x3.25")
16d (0.131x3.5")

TABLE B1-1

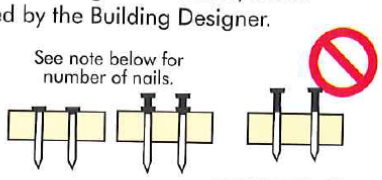


FIGURE B1-15

Minimum nail size in Table B1-1 applies for all Lateral Restraint and Diagonal Bracing members (except when end-grain nailed [see **BSCI-B2**, Option 2], which require minimum 16d deformed-shank nails [i.e., ring- or screw-shank]).

- Use at least 2-10d (0.128x3"), 2-12d (0.128x3.25") or 2-16d (0.131x3.5") nails into each Truss for both Lateral Restraint and Diagonal Bracing members.
- Drive nails flush, or use double-headed nails for easy removal.

BEGINNING THE ERECTION/ INSTALLATION PROCESS (see BCSI-B2)

It is important for the Contractor to provide substantial Bracing for the first Truss erected. Trusses making up the rest of the first set are tied to the first Truss and rely upon it for stability. Likewise, after this first set of Trusses is adequately Diagonally Braced, the remaining Trusses installed rely on this first set for stability. Performance of the Truss Bracing system depends to a great extent on how well the first set of Trusses is restrained and braced.

GROUND BRACE - EXTERIOR (see BCSI-B2)

Exterior Ground Bracing ties the first set of Trusses off to a series of braces that are attached to stakes driven into the ground and securely anchored. The Ground Brace itself should be restrained and braced as shown in Figures B1-16 and 17 or it is apt to buckle. Additional Ground Braces, placed inside the building in the opposite direction, are also recommended.

Locate Ground Braces for the first Truss directly in line with all rows of Top Chord Temporary Lateral Restraint (TCTLR).

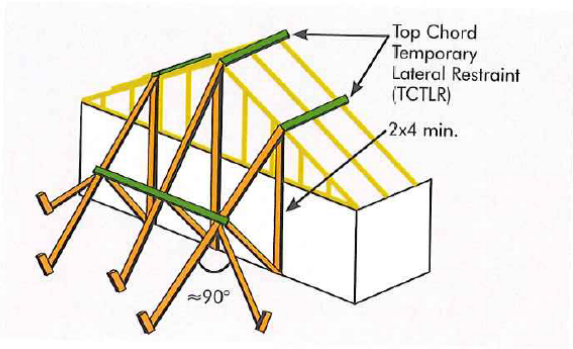


FIGURE B1-16

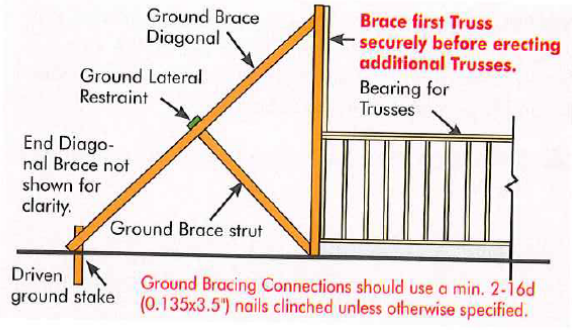


FIGURE B1-17

GROUND BRACE - INTERIOR (See BCSI-B2)

☑ Where the height of the Building or ground conditions prohibit Bracing from the exterior, stabilize the first Truss with Ground Bracing attached to the interior at the floor level, provided the floor is capable of supporting the Ground Bracing forces. Install the first Truss near the middle of the Building and brace similar to Exterior Ground Bracing shown below. Restrain and Diagonally Brace the first set of Trusses before removing Ground Braces and setting remaining Trusses.

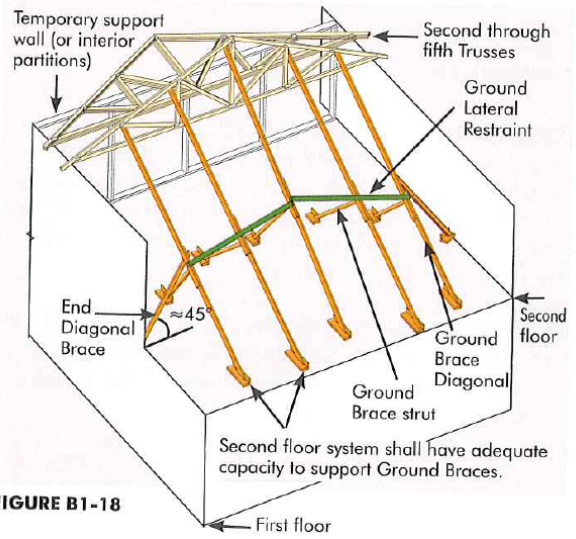


FIGURE B1-18

TEMPORARY INSTALLATION RESTRAINT/ BRACING REQUIREMENTS FOR THE VARIOUS PLANES OF A ROOF TRUSS

Temporary Installation Restraint/Bracing must be applied to **ALL** of the following planes of the Trusses to ensure stability:

1) Top Chord Plane (roof plane)
2) Web Member Plane (sloping or vertical plane perpendicular to Trusses)
3) Bottom Chord Plane (ceiling plane)

⚠ **CAUTION** It is critical to install Lateral Restraint and Diagonal Bracing for the Top Chord and Web Member Plane immediately to prevent out-of-plane buckling of the Truss.

1) TOP CHORD TEMPORARY INSTALLATION RESTRAINT/BRACING is the most important step for the Contractor. Truss Top Chords are susceptible to lateral buckling. See **BCSI-B2** for more information.

The top chord Lateral Restraint and Diagonal Bracing approach provided below applies to all sloping chord Trusses, scissors Trusses, 2x_ parallel chord Trusses and piggyback Trusses. **Note:** 2x_Trusses with depths less than 1/15th of the span at any location away from bearings require more complex Temporary Installation Restraint/Bracing. Consult a Registered Design Professional.

⚠ **WARNING** Exact spacing between Trusses should be maintained as the Lateral Restraint and Diagonal Bracing is installed to avoid the hazardous practice of trying to remove this material to adjust spacing. This act of "adjusting spacing" can cause Trusses to topple if the restraint and Bracing is disconnected at the wrong time.

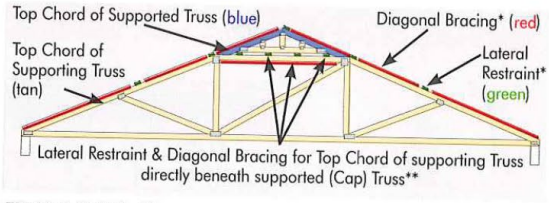


FIGURE CFSB1-25

***Note:** Refer to Table B1-4 and Figure B1-24 for spacing of Temporary Lateral Restraint and Diagonal Bracing on the sloped Top Chords of the supported and supporting Truss.

****Note:** Refer to TDD and Figure B3-47 for spacing of permanent Lateral Restraint and Diagonal Bracing, respectively, on the flat portion of the supporting Truss or as specified in the Construction Documents.

Maximum Top Chord Temporary Lateral Restraint Spacing	
Truss Span	**Top Chord Temporary Lateral Restraint (TCTLR) Spacing**
Up to 30'	10' oc maximum
30' - 45'	8' oc maximum
45' - 60'	6' oc maximum
60' - 80' +	4' oc maximum

TABLE B1-4

+Consult a Registered Design Professional for Trusses longer than 60'.

2) WEB MEMBER PLANE requires temporary/permanent Diagonal Bracing, such as shown in Figures B1-25 and 26, which is critical in preventing Trusses from leaning or dominoing. Install 2x_ Diagonal Bracing on Web members (vertical Webs whenever possible) at or near Bottom Chord Lateral Restraint. Structural Sheathing can be substituted. See **BCSI-B2** for additional information pertaining to Web Member Plane **Temporary** Diagonal Bracing and **BCSI-B3** for information pertaining to **Permanent** Restraint and Bracing for the Web Member Plane.

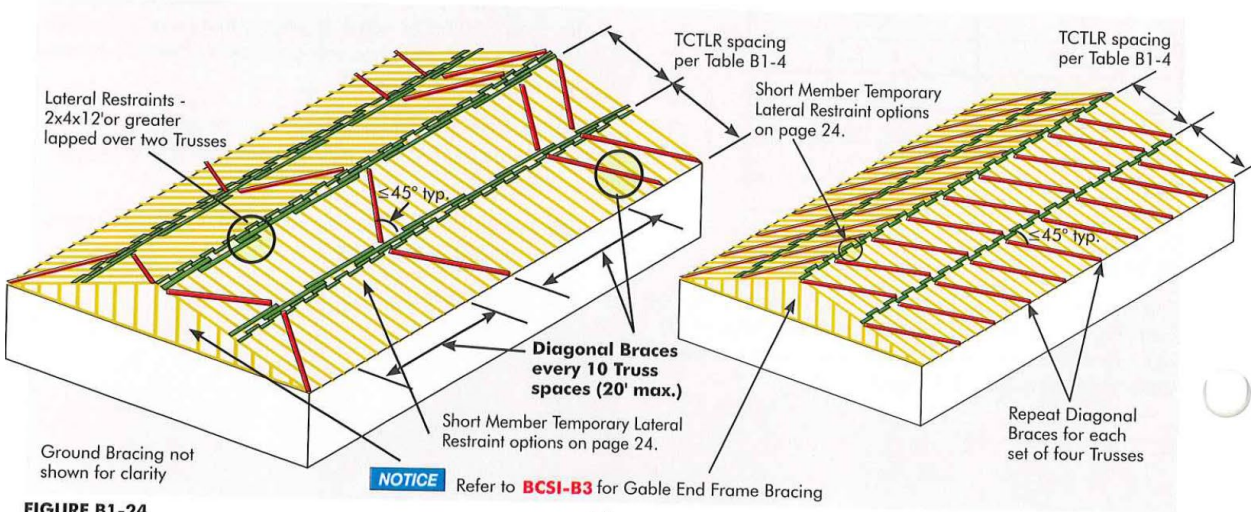


FIGURE B1-24

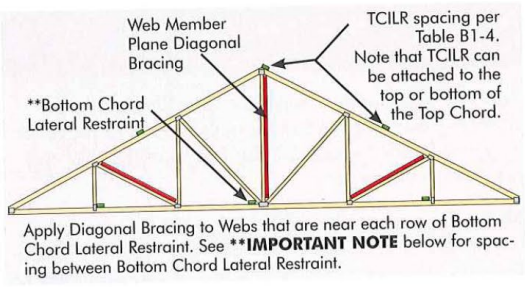


FIGURE B1-25

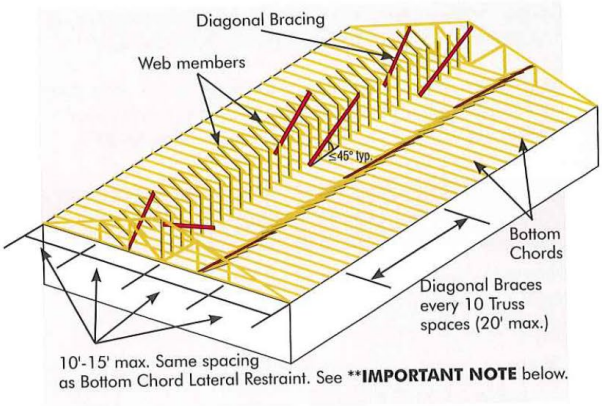


FIGURE B1-26

Webs that require Continuous Lateral Restraint (CLR) must also be Diagonally Braced for rigidity. Install Diagonal Bracing along the same Web Member Planes that require CLR. Refer to the Truss Design Drawings to determine which webs, if any, require CLR. Installing the CLR and Diagonal Bracing as Trusses are installed saves time.

Note: Web members that require more than one row of CLR shall have the CLRs and Diagonal Bracing installed as the Trusses are installed.

3) BOTTOM CHORD TEMPORARY LATERAL RESTRAINT (BCTLR) AND DIAGONAL BRACING is required to maintain on-center spacing for the Bottom Chord and to laterally "stiffen" the group of Trusses. Place Continuous Lateral Restraint and Diagonal Bracing on top of the Bottom Chord (Figures B1-27 and 28). This material can be removed after the permanent ceiling Diaphragm is in place or remain to become part of the Permanent Building Stability Bracing (PBSB) system.

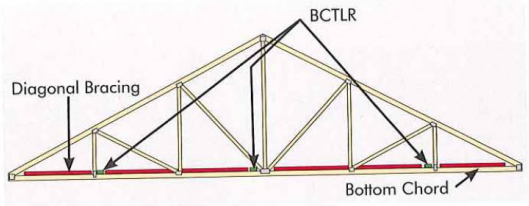
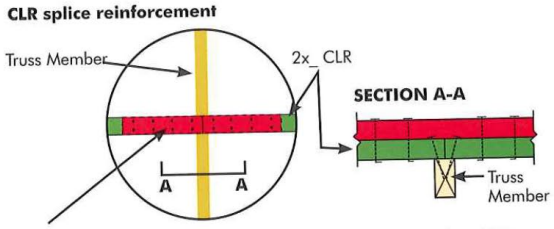


FIGURE B1-27

CLR splice reinforcement



Minimum 2' 2x_ Scab block centered over CLR splice. Attach to CLR with minimum 8-16d (0.135x3.5") nails each side of splice or as specified by the Building Designer

****IMPORTANT NOTE:** Install Bottom Chord **Temporary** Lateral Restraint (BCTLR) in rows no more than 15' oc. Install Bottom Chord **Permanent** Lateral Restraint (BCPLR) at the spacings specified in the TDD and Construction Documents. The maximum oc spacing of permanent Lateral Restraint is 10' but can be less if required by the TDD and/or Building Designer.

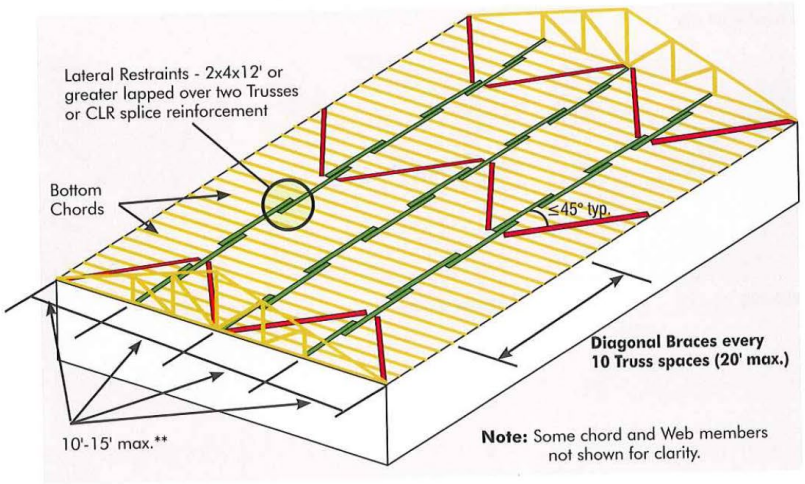


FIGURE B1-28

Attachment B

Florida Building Code, the 7th Edition (2020)

2303.4.1.3 Trusses spanning 60 feet or greater.

The owner or the owner's authorized agent shall contract with any qualified *registered design professional* for the design of the temporary installation restraint/bracing and the permanent individual truss member restraint/bracing for all trusses with clear spans 60 feet (18 288 mm) or greater.

.....

2303.4.2 Truss placement diagram.

The truss manufacturer shall provide a truss placement diagram that identifies the proposed location for each individually designated truss and references the corresponding truss design drawing. The truss placement diagram shall be provided as part of the truss submittal package, and with the shipment of trusses delivered to the job site. Truss placement diagrams that serve only as a guide for installation and do not deviate from the *permit* submittal drawings shall not be required to bear the seal or signature of the truss designer.

2303.4.3 Truss submittal package.

The truss submittal package provided by the truss manufacturer shall consist of each individual truss design drawing, the truss placement diagram, the permanent individual truss member restraint/bracing method and details and any other structural details germane to the trusses; and, as applicable, the cover/truss index sheet.

.....

2303.4.6 TPI 1 specifications.

In addition to Sections 2303.4.1 through 2303.4.5, the design, manufacture and quality assurance of metal-plate-connected wood trusses shall be in accordance with TPI 1. Job-site inspections shall be in compliance with Section 110.4, as applicable.

2303.4.7 Truss quality assurance.

Trusses not part of a manufacturing process in accordance with either Section 2303.4.6 or a referenced standard, which provides requirements for quality control done under the supervision of a third-party quality control agency, shall be manufactured in compliance with Sections 1704.2.5 and 1705.5, as applicable.