ROOF ANCHORAGE FOR OLDER, WOOD-ROOFED BUILDINGS

Table of Contents

Page

List of Figures

List of Tables

1.0 SCOPE

This data sheet provides guidance for anchoring roof-support members and building columns against wind uplift on older (generally pre-1940s), wood-roofed buildings. These are plank-on-timber, plank-on-wood truss, plank-on-steel, or board-on-joist buildings built before wind uplift was considered in building construction. These “mill” buildings have brick or stone walls with roof-support members resting on interior building columns or on brick or stone walls with short or, in many cases, no anchors to prevent lifting. With no anchors, wind uplift is resisted only by the weight of the roof and parapets (when present). This data sheet does not apply to wood-frame construction in which roofs and walls have wood joists and wood studs, respectively.

Refer to the following data sheets for guidance on wind design for other building components, including walls and roof assemblies, and for safeguards during construction:

- Data Sheet 1-0, *Safeguards During Construction, Alteration and Demolition*
- Data Sheet 1-28, *Wind Design*
- Data Sheet 1-29, *Roof Deck Securement and Above-Deck Roof Components*
- Data Sheet 1-31, *Panel Roof Systems*
- Data Sheet 1-49, *Perimeter Flashing*

1.1 Hazards

Insufficient anchorage of roof-support members has been the major reason for wind damage to older, wood-roofed buildings. Figure 1.1-1 shows hurricane damage to a plank-on-timer building where the roof beams rested on the interior columns without any anchorage, with wind uplift resisted only by the weight of the roof and roof-support members. Hurricane winds then lifted the roof-support members off the building columns and the walls collapsed (Figure 1.1-2).

Fig. 1.1-3 shows the roof interior of a typical plank-on-steel building where roof-support members rest on interior columns. See Section 3.0 for construction details.

Fig. 1.1-1. Roof damaged in the 1938 New England Hurricane (after debris removal)

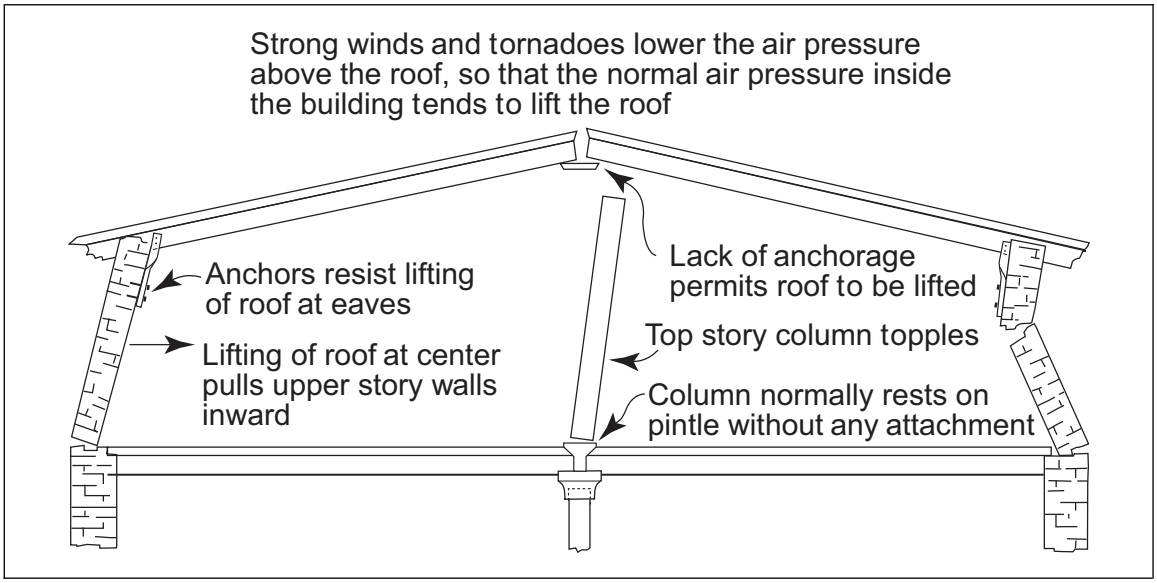

Fig. 1.1-2. Wind failure mode to plank-on-timber building with roof anchored at walls but not at columns

Fig. 1.1-3. Typical plank-on-steel building

1.2 Changes

February 2020. This data sheet has been completely revised. Major changes include the following:

A. Changed the title to *Roof Anchorage for Older, Wood-Roofed Buildings (from Roof Anchorage)*.

B. Revised the scope of the document to apply only to older, wood-roofed buildings (new construction should follow guidance in DS 1-28).

C. Deleted the following sections, which are now addressed in Data Sheet 1-28:

- 3.1.3 Connection to Concrete Block Wall

- 3.1.4 Wood Frame Buildings
- 3.1.5 Steel Buildings With Corrugated Roof Panels
- 3.1.6 Permanently Open Buildings

2.0 LOSS PREVENTION RECOMMENDATIONS

2.1 Introduction

2.1.1 Use FM Approved equipment, materials, and services whenever they are applicable and available. For a list of products and services that are FM Approved, see the *Approval Guide* and RoofNav, as applicable.

2.2 Construction and Location

2.2.1 Anchor roof-support members and building columns on older plank-on-timber, plank on wood truss, plank-on-steel and boards-on-joist buildings to resist wind uplift in accordance with the following recommendations.

2.2.1.1 Anchor roof-support members that are considered components (i.e., that directly support the roof deck; see definition in appendix A) for wind uplift pressures using Data Sheet 1-28, *Wind Design*, or RoofNav's Ratings Calculator. Use pressures for partially enclosed buildings when applicable.

Design pressures may be reduced using the actual effective wind area's (EWAs) in accordance with the American Society of Civil Engineers standard ASCE 7, or similar standards outside the United States.

Wind pressures from Data Sheet 1-28 or RoofNav's Ratings Calculator use an EWA of 10 ft^2 (0.93 m^2), which is used for fasteners securing cladding. EWAs for roof-support members should exceed 10 ft^2 (0.93 m^2). See definition of EWA in Appendix A.

2.2.1.2 Anchor roof-support members and building columns that are part of the main wind force-resisting system (MWFRS) for the wind pressures in ASCE 7 (2005, 2010, or 2016 as required by local code), or other local code.

2.2.1.3 Resistances provided by the weight of the roof and other building components can be included. Determine the weight on a beam from a parapet constructed of unreinforced masonry by multiplying the effective area of the wall above the beam (shaded area in Figure 2.2.1.3-1) by the unit weight of the construction material using Table 2.2.1.3-1.

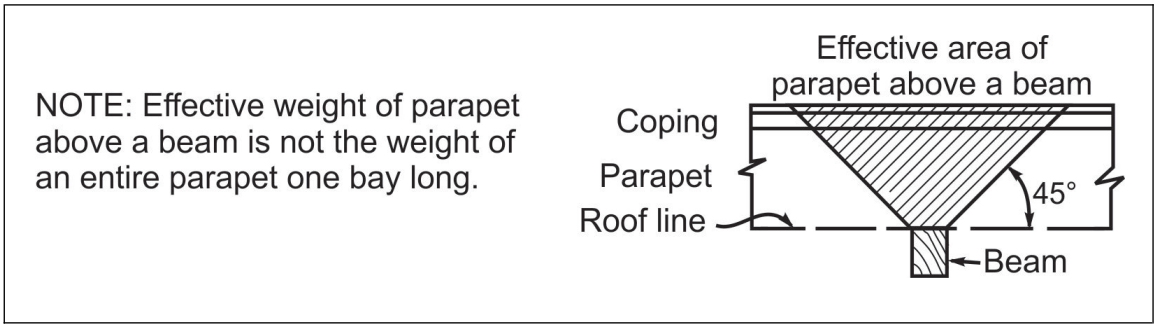

Fig. 2.2.1.3-1. Effective area of parapet above beam in unreinforced masonry wall

Table 2.2.1.3-1. Approximate Weight of Brick and Stone in Walls

Nominal Thickness in. (mm)	*Weight lb/ft^2 (kg/m^2)*	
	Brick	Stone
8 (200)	85 (415)	
12 (300)	120 (586)	170 (830)
16 (410)	160 (781)	255 (1245)
20 (510)	190 (928)	280 (1367)
24 (600)	225 (1099)	340 (1660)

2.2.1.4 Determine the weight of a masonry wall on attachment points for steel straps by multiplying the effective area of the wall (shaded area in Figure 2.2.1.4-1) by the unit weight of the construction material using Table 2.2.1.3-1.

Only the weight of an unreinforced masonry wall can be used against wind uplift because the mortar bond between masonry units has minimal uplift resistance. Modern reinforced masonry walls should have a grouted bond beam in the top course that is secured to the foundation. Refer to Data Sheet 1-49, *Perimeter Flashing*, for information on bond beams.

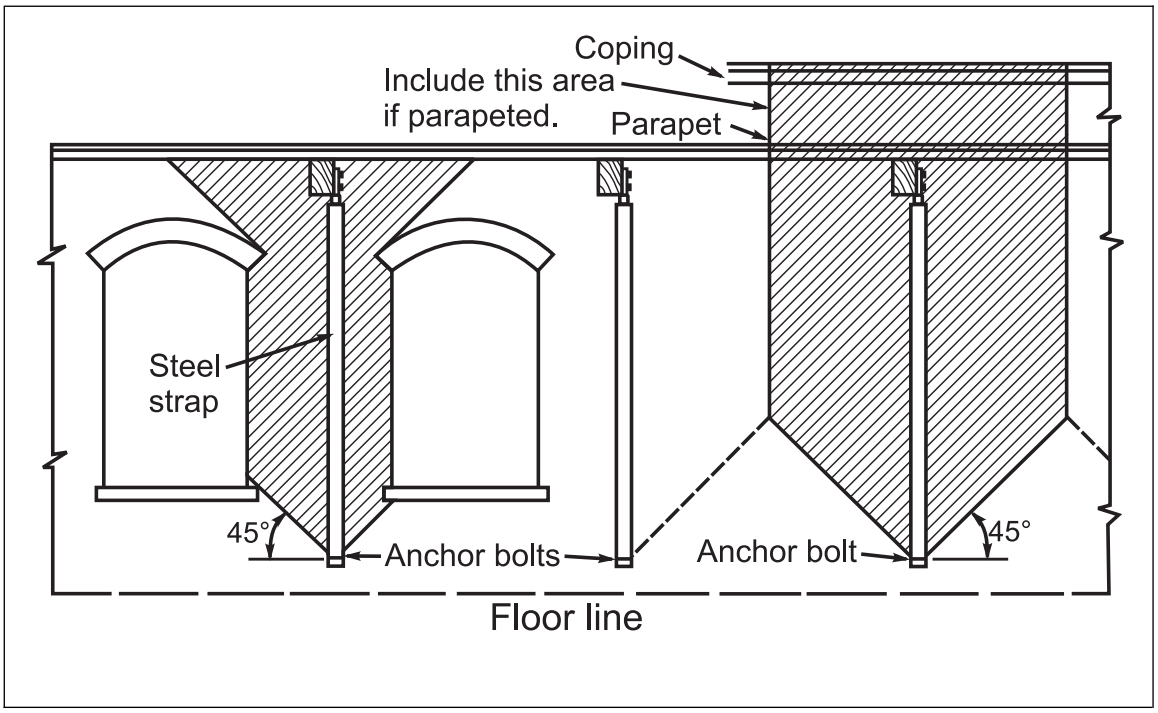

Fig. 2.2.1.4-1. Effective area of wall above anchor attachment points in unreinforced masonry wall

2.2.1.5 Design steel parts in accordance with the latest edition of the American Institute of Steel Construction (AISC) Steel Construction Manual or equivalent outside the United States.

If steel anchorage members will be subjected to a corrosive atmosphere, they may be galvanized or similarly treated to prevent corrosion.

2.2.1.6 Design wood connections in accordance with the latest edition of the American Wood Council's National Design Specification (NDS) for Wood Construction.

2.2.1.7 Design anchors for structural concrete in accordance with the latest edition of ACI 318, Building Code Requirements for Structural Concrete or equivalent outside the United States.

2.2.1.8 Design anchors for masonry according to the latest edition of TMS 402/602, Building Code Requirements and Specification for Masonry Structures.

If the building contains heavy, vibrating machinery, expansion shields attached to masonry may pull out. This can be prevented by using through bolts. If sizable holes have been made through floors to install anchors at columns and walls, fill them with FM Approved fire stopping material to prevent the passage of fire or leakage of water.

3.0 SUPPORT FOR RECOMMENDATIONS

3.1 General

Unanchored roof-support members and building columns can usually be easily discovered since many of these buildings were constructed with open areas with these connections exposed. See Figures 3.1-1 through 3.1-5 showing unanchored connections. Hardware, such as steel straps, angles, through bolts, and lag screws needed for securement should be clearly visible. See Figures 3.1-6 through 3.1-9 and 3.1-11 for anchored connections. Nails and spikes toenailing heavy members on plank-on-timber buildings to each other do not provide adequate anchorage.

Roof beams at the perimeter of plank-on-timber buildings may be secured to brick walls with steel straps attached to the wall as in Figures 3.1-6 and 3.1-7. Elsewhere, the designers may have relied on the dead load of the thick wood or steel beams, wood planking and built-up tar and gravel roofing to hold the roof members down.

Although these types of plank-on-timber buildings are not constructed today, a large number are still in service, especially in the northeastern United States. Many still house manufacturing, while others have been and continue to be renovated for office, residential, or retail use. Renovations provide an opportunity to properly secure the roof members and columns, although these can be easily anchored any time.

Fig. 3.1-1. Wood roof members resting on a wood column

Fig. 3.1-2. Closeup of wood roof beam resting on wood column with metal column cap

Fig. 3.1-3. Closeup of column cap (green) in Figure 1.1-3 (the column cap is not secured to the column)

Fig. 3.1-4. Wood roof beam rests on metal plate in brick wall

Fig. 3.1-5. Base of unanchored building column resting on floor

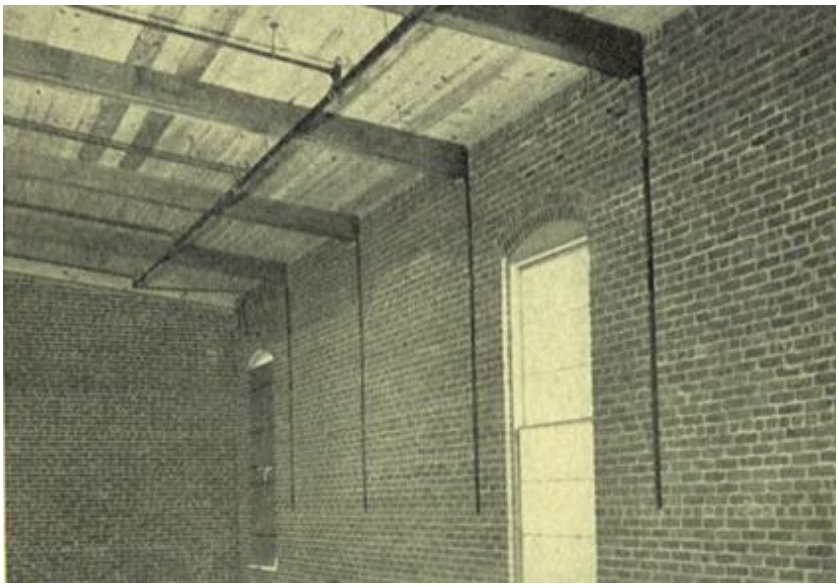

Fig. 3.1-6. Wood roof beams in wall pockets anchored with long steel straps and masonry anchors into brick walls

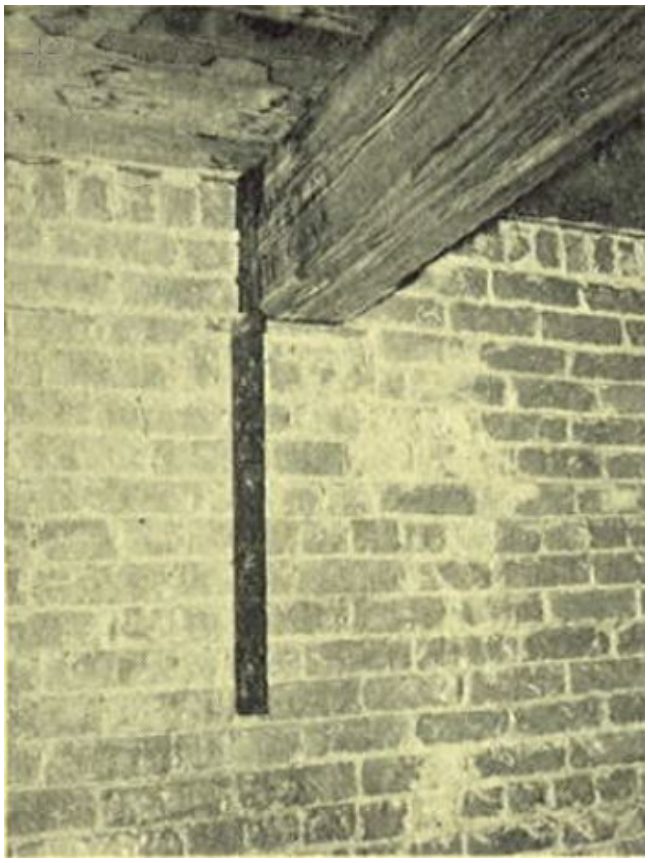

Fig. 3.1-7. Wood roof beam anchored with short steel straps and masonry anchors

Fig. 3.1-8. Metal bracket added during renovation to anchor roof beam to the top of the building column (courtesy WinnResidential LP)

Fig. 3.1-9. Closeup of metal bracket in Figure 3.1-8 (courtesy WinnResidential LP)

Fig. 3.1-10. Metal bracket in Figures 3.1-8 and 3.1-9 (courtesy WinnResidential LP)

Fig. 3.1-11. Base of wood column secured to new concrete floor poured over the original wood plank floor (courtesy WinnResidential LP)

3.2 Loss History

The largest wind event damaging plank-on timber, plank-on-steel, and boards-on-joist buildings was the 1938 “Great New England Hurricane,” also known as the “Long Island Express,” that struck the New England region of the United States on September 21, 1938. Figures 3.2-1 and 3.2-2 show damage to plank-on-timber buildings from this hurricane.

Fig. 3.2-1. Plank-on-timber textile mill in Pawcatuck, CT damaged by the 1938 hurricane

Fig. 3.2-2. Plank-on-timber textile mill damaged by the 1938 hurricane

The 1-minute sustained wind speed at first landfall on Long Island, NY was 121 mph (54 m/s), and it was 115 mph (51 m/s) at landfall in Connecticut. Category 3 winds affected CT, NY, and RI, while Category 2 winds

affected MA. Categories are per the Saffir-Simson scale with 1-minute sustained wind speeds. Landfall wind speeds are from the reanalysis of this storm by the National Weather Service in 2014. The original landfall wind speed in Long Island, NY was 98 mph (44 m/s).

4.0 REFERENCES

4.1 FM

Data Sheet 1-1, *Firesafe Building Construction and Materials*
Data Sheet 1-28, *Wind Design*
Data Sheet 1-31, *Metal Roof Systems*
Data Sheet 1-49, *Perimeter Flashing*

4.2 Other

American Concrete Institute (ACI). ACI 318, *Building Code Requirements for Structural Concrete*.

American Institute of Steel Construction (AISC). *Steel Construction Manual*.

American Wood Council (AWC). ANSI/AWC NDS-2018, *National Design Specification (NDS) for Wood Construction*.

American Society of Civil Engineers (ASCE). ASCE 7, *Minimum Design Loads for Buildings and Other Structures*. (ASCE-2005, ASCE-2010, or ASCE-2016 as required by local code).

The Masonry Society (TMS). TMS 402/602-16, *Building Code Requirements and Specification for Masonry Structures*.

APPENDIX A GLOSSARY OF TERMS

Boards-on-joist construction: Consists of wood floor(s) and roof supported by closely spaced wood joists. See DS 1-1 Firesafe Building Construction and Materials for details.

Bond beam: A beam of reinforced concrete block or reinforced concrete at eave height that is secured with steel reinforcement and grouted concrete blocks supported. Must be connected by steel reinforcement and concrete grout to the foundation.

Building, enclosed: A building that does not meet the criteria for open or partially enclosed buildings (see Flow Chart A and Section 3.2.3 in DS 1-28).

Building, partially enclosed: A building in which there are sufficient openings to increase the internal pressure beyond that considered for an enclosed building (see Flow Chart A and Section 3.2.3).

Components and cladding: Building elements that receive direct wind such as the cladding or directly support building elements that receive direct wind such as purlins and joists.

Effective wind area (EWA): The area assumed to be supported by a construction component for the purpose of wind load transfer. For roof cover, roof deck, or wall panel fastening, the effective wind area should not exceed that supported by the fastener or clip (generally reflected in the tables in this document).

Main wind force-resisting system (MWFRS): Connected structural members that provide support and stability for the overall structure and that generally receive wind load from more than one surface.

Plank-on-timber construction: also known as “heavy timber”, “mill”, or slow-burning construction”. It consists of large wood members. See DS 1-1 *Firesafe Building Construction and Materials* for details.

Secondary roof framing: Structural framing, such as joists, purlins or beams, that immediately supports the roof deck.

Tropical cyclone-prone region: See definition in Appendix A of Data Sheet 1-28.

APPENDIX B DOCUMENT REVISION HISTORY

The purpose of this appendix is to capture the changes that were made to this document each time it was published. Please note that section numbers refer specifically to those in the version published on the date shown (i.e., the section numbers are not always the same from version to version).

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- 3.1.6 Permanently Open Buildings

June 2009. Editorial changes were made.

May 2000. This document has been reorganized to provide a consistent format.

May 1998. This document was revised. .