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A Guide to Using ASCE 7-16

For EverGuard® TPO/PVC Roofing Systems

December 2020

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Introduction

The purpose of this Guide is to provide fundamental information on code requirements, wind design, how to navigate ASCE 7-16 when selecting appropriate roofing systems, and suggestions on roof system application.

Guide Limitations

This Guide is limited to:

- 2016 edition of ASCE 7, "Minimum Design Loads and Associated Criteria for Buildings and Other Structures" (ASCE 7-16).
- Buildings with roof slopes less than 7 degrees (approximately 1½:12 roof slope).
- Building heights less than 60 ft.
- EverGuard® TPO/PVC Roofing Systems that:
  - are conventionally mechanically attached.
  - use Drill-Tec™ RhinoBond® plates and fasteners.
  - are adhered over insulation boards.

About GAF

Founded in 1886, GAF has grown to become North America's largest manufacturer of commercial and residential roofing. Professional roofing contractors have long preferred the rugged, dependable performance that a GAF roof can offer. We are the leading roofing manufacturer in North America, with plants strategically located across the U.S. A member of the Standard Industries family of companies, GAF is part of the largest roofing and waterproofing business in the world. We protect what matters most.

For more information, visit www.gaf.com.

ASCE 7

ASCE 7, "Minimum Design Loads for Buildings and Other Structures" (ASCE 7) is a consensus standard developed and maintained by the American Society of Civil Engineers. It describes the means for determining dead, live, soil, flood, tsunami, snow, rain, atmospheric ice, earthquake, and wind loads, and their combinations for general structural design.

Three editions of ASCE 7 are used in the U.S., the 2005, 2010 and 2016. The 2016 edition has several significant changes that affect the wind design of roofing systems.

Roofing systems are considered Components and Cladding (C&C). The design procedures for C&C are located in Chapter 30, Wind Loads—Components and Cladding (C&C).

The following design parameters are used to determine design wind uplift pressures:

- Roof slope (must be less than 7 degrees)
- Building dimensions (width, length and height)
- Basic wind speed, V
- Risk Category (I, II, III or IV)
- Exposure coefficient (B, C or D)
- Topography factor, k_{zt}
- Wind directionality factor, k_d
- Ground elevation factor, k_e

There are some noteworthy differences between the three ASCE 7 editions and they include: the wind speed maps, roof zones, enclosure classifications, external pressure coefficients, and the equation to calculate velocity pressures.

See Appendix A for additional information on the differences between the 2005, 2010 and 2016 editions of ASCE 7.

Important Considerations

GAF manufactures and sells roofing materials and does not practice architecture or engineering. GAF is not responsible for the performance of its products when damage to its products is caused by such things as improper building design, construction flaws, or defects in workmanship.

The design responsibility remains with the architect, engineer, roofing contractor, or owner. These guidelines should not be construed as being all-inclusive. Please consult your design professional for more information.

The guidelines contained herein are for information purposes only, and are not intended as a substitute for independent evaluation by the building owner or its consultants to determine with certainty whether a particular roofing system is suitable for a building. GAF makes no representation or warranty (express or implied) as to the suitability of its roofing systems for buildings.

Information contained in this Guide is presented in good faith and, to the best of GAF's knowledge, does not infringe upon any patents, foreign or domestic.

Step-by-step Procedure

The following provides a step-by-step procedure for how to use design wind data to select appropriate roofing systems and help determine roof zone layouts as prescribed in ASCE 7-16.

Step 1 – Determine the Applicable Building Code

Determine which building code edition is applicable with the authority-having-jurisdiction. The applicable edition of ASCE 7 will vary by the edition of the International Building Code (IBC), see below:

IBC Edition	Applicable ASCE-7 Edition
2009	ASCE 7-05
2012	ASCE 7-10
2015	ASCE 7-10
2018	ASCE 7-16

Therefore, **ASCE 7-16 is applicable in municipalities that have adopted the 2018 IBC** or where it has been adopted as a local ordinance or amendment.

Step 2 – Locate Design Wind Uplift Pressures

IBC requires "wind design data" be shown on the drawings and/or in the project specifications. Look for the following information which is required:

- Basic design wind speed, *V,* and allowable stress design wind speed, V_{asd}
- Risk Category
- Wind Exposure (wind direction)
- Applicable internal pressure coefficient
- Design wind uplift pressures

Other items that should be addressed on the project documents include:

Components and Claddings: ASCE 7 classifies roofing systems as Components and Cladding or "C&C." Therefore, the design wind loads applicable for roofing systems will be labeled as Components and Cladding or C&C.

Effective Wind Area (EWA) or Tributary Area (TA): This is a term used by ASCE 7 to define the tributary area for the element or component being considered for wind design. ASCE 7 uses EWA sizes of 10, 20, 50, 100, 200, 500 and 1000 sq. ft. Construction documents may show design wind loads for some or all of these EWA sizes, but **10 sq. ft. is typically used for roofing systems.**

Safety Factor: It is very important to determine if a safety factor was applied to the wind uplift pressures, because it affects selecting a roofing system. This will be further discussed in Steps 4 and 5.

Step 3 – Identify the Design Method Used

There are two design methods in ASCE 7 used to determine design wind loads: Allowable Stress Design (ASD) and Strength Design. Strength Design is also referred to as Ultimate Design or LRFD. Designers may use either method, but **roof systems are typically designed using ASD**.

Keep in mind that the wind speed maps in ASCE 7-16 are based on Ultimate Design and accordingly, design wind uplift pressures are often calculated and presented as Ultimate Design values.

Wind load data should be labeled as ASD or Ultimate Design values. If they are not identified, confirm which method was used. If only Ultimate Design values were provided, they can be converted to ASD by using a reduction factor of 0.6.

This is expressed as:

ASD value = [Ultimate Design value] x [Reduction Factor = 0.6]

Step 4 – Apply a Safety Factor

When using the ASD method, it is common engineering practice to apply a "safety factor" to design wind uplift pressures. A safety factor of 2 is typically recommended. This will determine design wind uplift resistance loads.

This is expressed as:

Design wind uplift resistance loads = [ASD design wind uplift pressure] x [Safety Factor]

Important note: *There are some listing agencies that apply a safety factor to the wind ratings of tested roofing assemblies. If this is the case, then you do not have to apply a safety factor to the design wind uplift pressures. See Step 5 for more information.*

Step 5 – Select a Wind Rated Roofing System

The primary method for determining a roof system's wind uplift resistance—aka, capacity—is through physical testing. The tested wind uplift resistance capacity of a roofing system should be equal to or greater than the calculated design wind uplift resistance loads.

This is expressed as:

Tested wind uplift resistance capacity ≥ Design wind uplift resistance loads

A roofing system's tested wind uplift resistance capacity is often referred to as the "**wind rating**."

Where Can I Find Wind Ratings?

Wind ratings for tested roofing systems can be found in approval listings. These are the most commonly used listing services:

- FM Approvals - RoofNav
- UL - Product iQ
- SPRI - Directory of Roofing Assemblies (DORA)
- Florida Department of Business and Professional Regulation - FBC Product Approvals
- Miami-Dade County - Product Control Approvals Listings
- Texas Department of Insurance (TDI) - Product Evaluation Index

Each of the approval listings use different ways to identify and label the wind ratings, see the table below for a summary:

Listing Service	Roof System Identifier	Wind Rating Term
FM's RoofNav	"RoofNav Assembly" Number	Wind Uplift
UL's Product iQ	"TGIK" Number	Uplift Resistance
SPRI's DORA	"ID" Number	Tested Wind Uplift Load Capacity
FBC Product Approvals	"FL" Number	Maximum Design Pressure (MDP)
Miami-Dade County Product Control Approvals	"Notice of Acceptance (NOA)" Number	Maximum Design Pressure (MDP)
TDI Product Evaluation Index	"RC Report" Number	Maximum Design Pressure (MDP)

What About the Safety Factor?

There is one significant difference among the approval listings, as mentioned in Step 4. Several of the listings apply a safety factor to their wind ratings. In other words, they take the tested wind resistance capacity for a roofing system and divide it by two to get the wind rating.

RoofNav, UL Product iQ and DORA **DO NOT** apply the safety factor to their wind ratings. So you need to apply a safety factor to the design wind uplift pressures when using these listing services to choose roofing systems.

FBC Product Approvals, Miami-Dade County Product Control Approvals and TDI Product Evaluation Index, **DO** apply the safety factor to their wind ratings. So, you do not apply a safety factor to the design wind uplift pressures when using these listing services to choose roofing systems.

Therefore, the use of a safety factor with design wind uplift pressure calculations depends on which listing service is used.

Below is a summary of the listing services and where to address the safety factor (SF).

Listing Service	Wind Rating Includes SF?	Apply SF to the Design Wind Uplift Pressures?
FM's RoofNav	No	Yes
UL's Product iQ	No	Yes
SPRI's DORA	No	Yes
FBC Product Approvals	Yes	No
Miami-Dade County Product Control Approvals	Yes	No
TDI Product Evaluation Index	Yes	No

Clarification on FM Global's RoofNav

FM Global's RoofNav is used primarily for:

- Finding Wind Uplift Ratings for roofing systems
- Determine design wind uplift loads (necessary for FM-insured buildings)

Wind uplift ratings: Wind uplift ratings for roofing systems are determined by physical testing per FM 4474. The ratings of 1-60, 1-75, 1-90, etc. do not have a safety factor built in. For example, a 1-60 rating means the roof failed in testing somewhere between 60 to 74 psf.

RoofNav Ratings Calculator: The Ratings Calculator determines design wind pressures per LPDS 1-28.
The Ratings Calculator applies the safety factor to the wind pressures when choosing the Wind Uplift Ratings, see below for an example from RoofNav.

Please keep in mind that the wind pressures determined by the Ratings Calculator may not meet building code requirements.

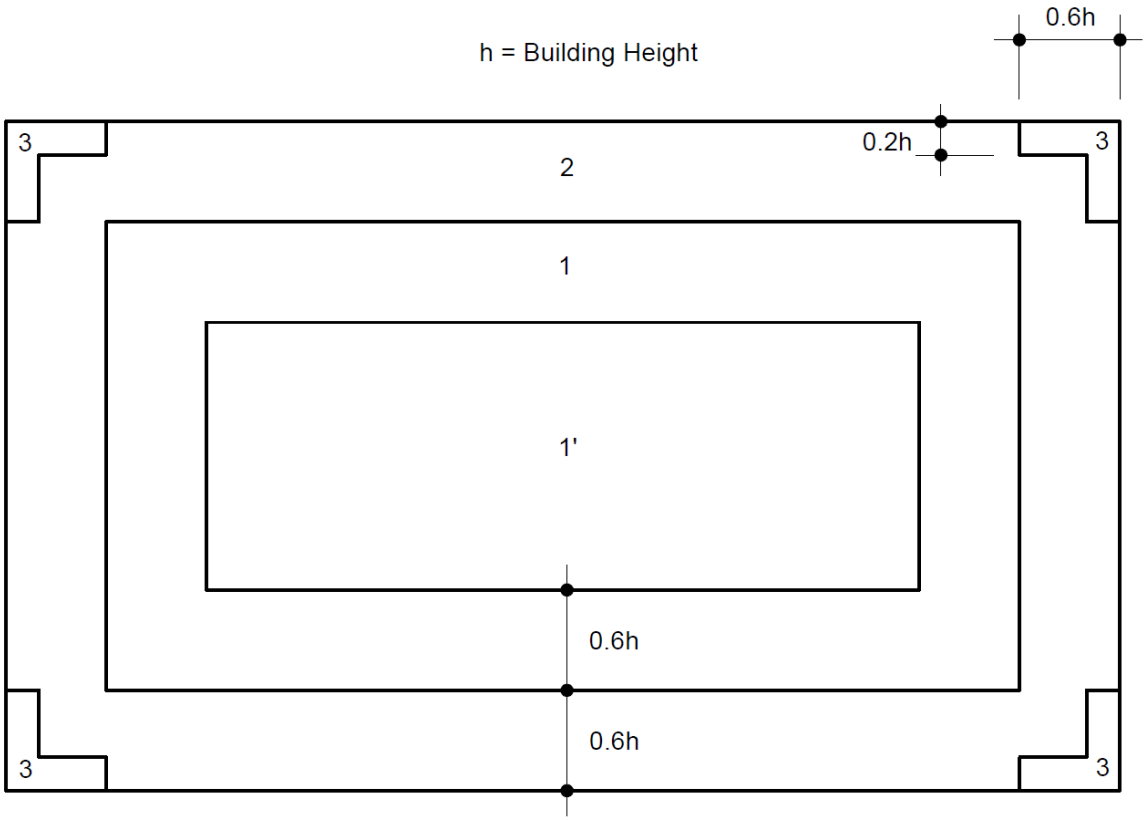
Roof Area Properties	Dimensions	100 x 200 ft (30.48 x 60.96 m)
	Height	15 ft (4.57 m)
	Slope	0.25 in 12 (1.2°)
	Min 3 ft (1 m) continuous parapet	N
Site Properties	Surface Roughness	C
	Wind Speed	115 mph
	In a Tropical Cyclone Prone region	N
	Enclosure Classification	Enclosed
Wind Pressures	Zone 1 Prime	30 psf (1.4 kPa)
	Zone 1	52 psf (2.5 kPa)
	Zone 2	69 psf (3.3 kPa)
	Zone 3	95 psf (4.5 kPa)
Wind Uplift Ratings	Zone 1 Prime	75 psf
	Zone 1	120 psf
	Zone 2	150 psf
	Zone 3	195 psf

Calculated Wind Pressures do not include a safety factor.

Wind Uplift Ratings are at least 2 times the Wind Pressures.

Step 6 – Determine the Roof Zone Layout

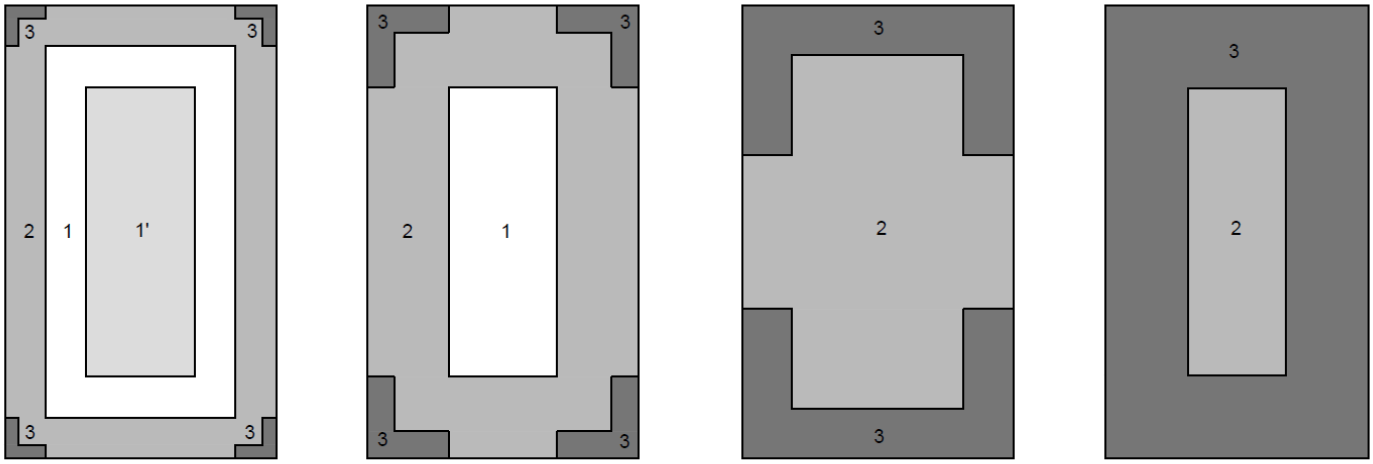
A major change in ASCE 7-16 is the configuration and layout of the roof zones for building heights that are 60 ft. or less, see Figure 1.



The dimensions of Roof Zones 1, 2 and 3 are based on a building's height and are determined as follows:

- Zone 3: This is the corner zone and it is "L-shaped." The length is 60 percent of the building height and the width is 20 percent of the building height.
- Zone 2: This is the perimeter zone and has a width equal to 60 percent of the building height.
- Zone 1: This is the "exterior" field zone and has a width equal to 60 percent of the building height.
- Zone 1': This the "interior" field zone and it is the remaining area left on the roof. It is important to note that Roof Zone 1' may not always exist.

For simple rectangular roof plans, ASCE 7-16 describes four possible scenarios for roof zone layout and it depends on the ratios of the building's width and length dimensions to the roof height, see Figure 2.



Buildings with width dimension > 2.4h

Buildings with width dimension > 1.2h, but < 2.4h

Buildings with width dimension < 1.2h and length dimension > 1.2h

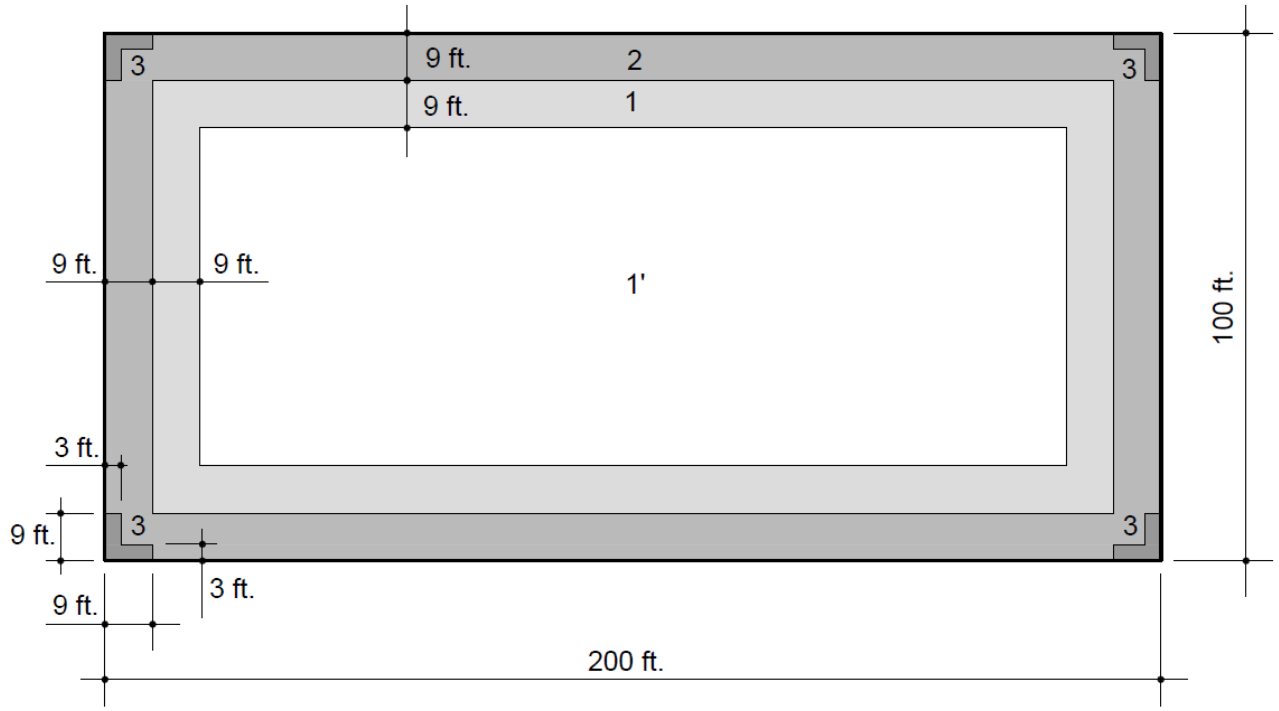
Buildings with length dimension < 1.2h

Figure 2: Four possible scenarios for roof zones depending on the ratios of plan dimensions to the roof height.

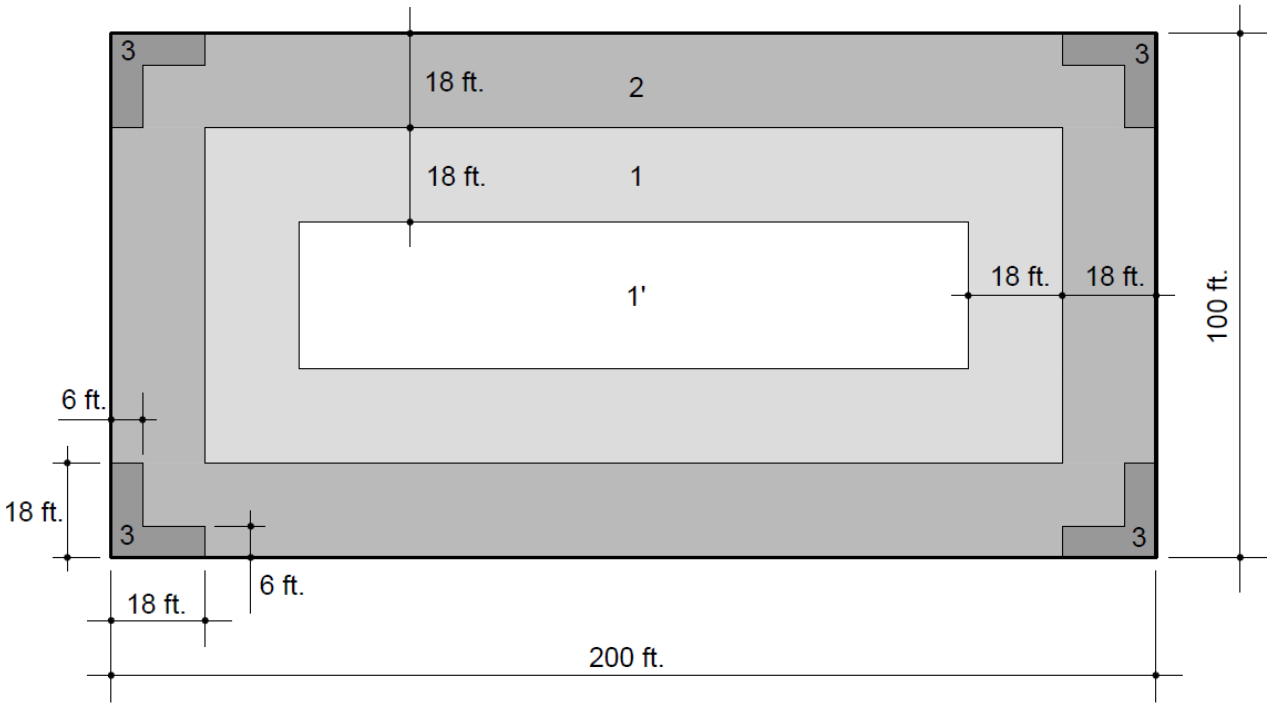
Rectangular Roof Plan Examples

To illustrate how the roof zone layout will vary on a rectangular roof plan with actual dimensions, the following are examples for a 100 ft. by 200 ft. building at heights of 15, 30, 45 and 60 ft.

Example: 15 ft. building
0.6h = 9 ft.
0.2h = 3 ft.



Example: 30 ft. building
0.6h = 18 ft.
0.2h = 6 ft.



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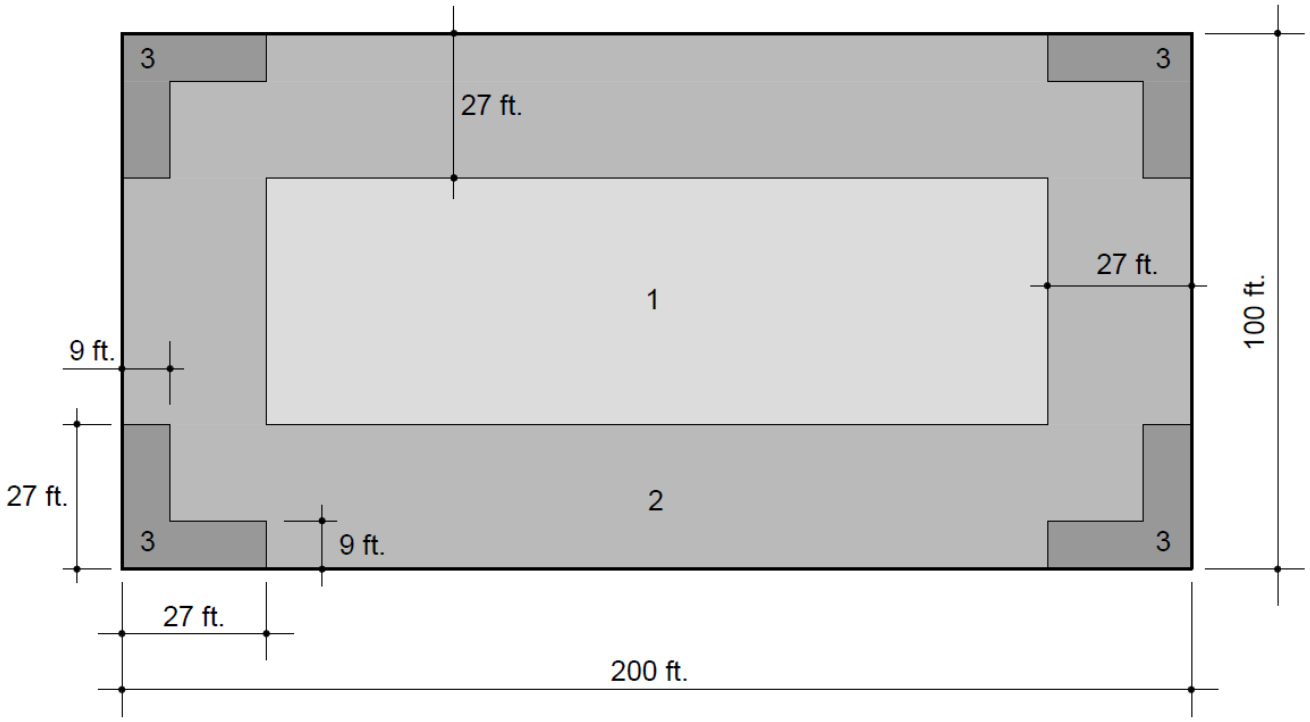
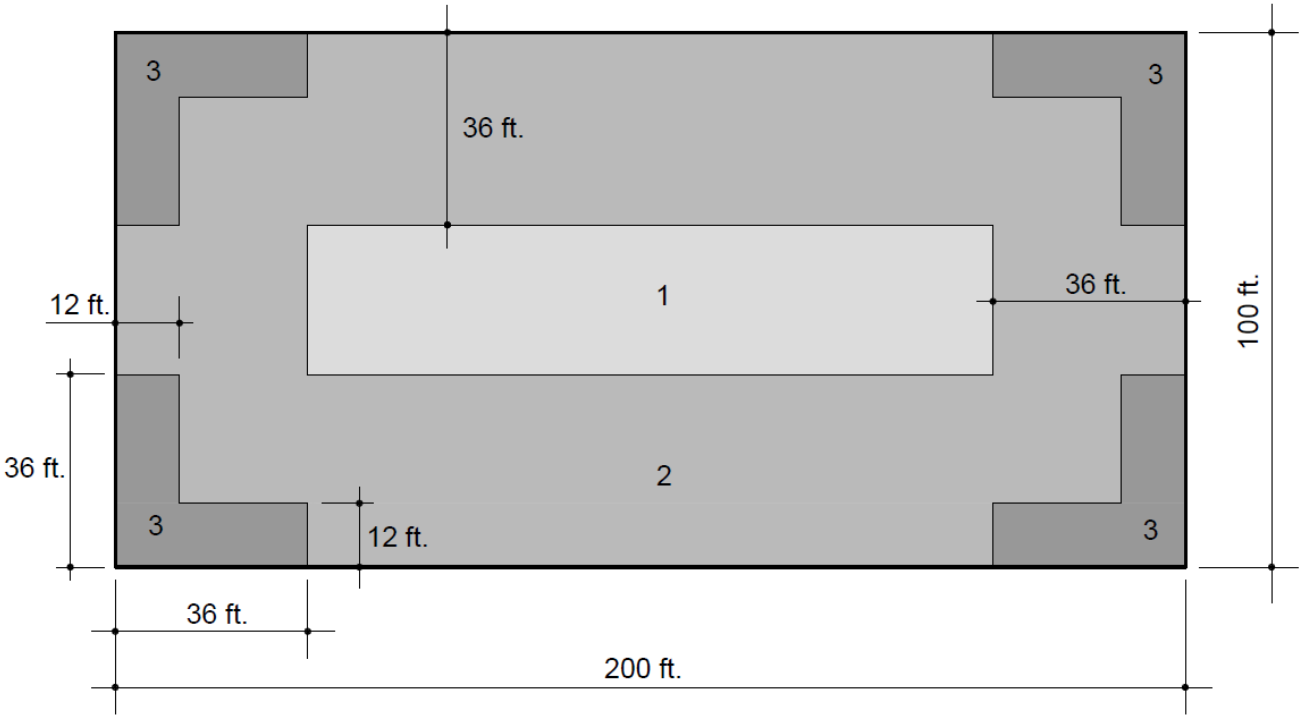
Example: 45 ft. building
0.6h = 27 ft.
0.2h = 9 ft.



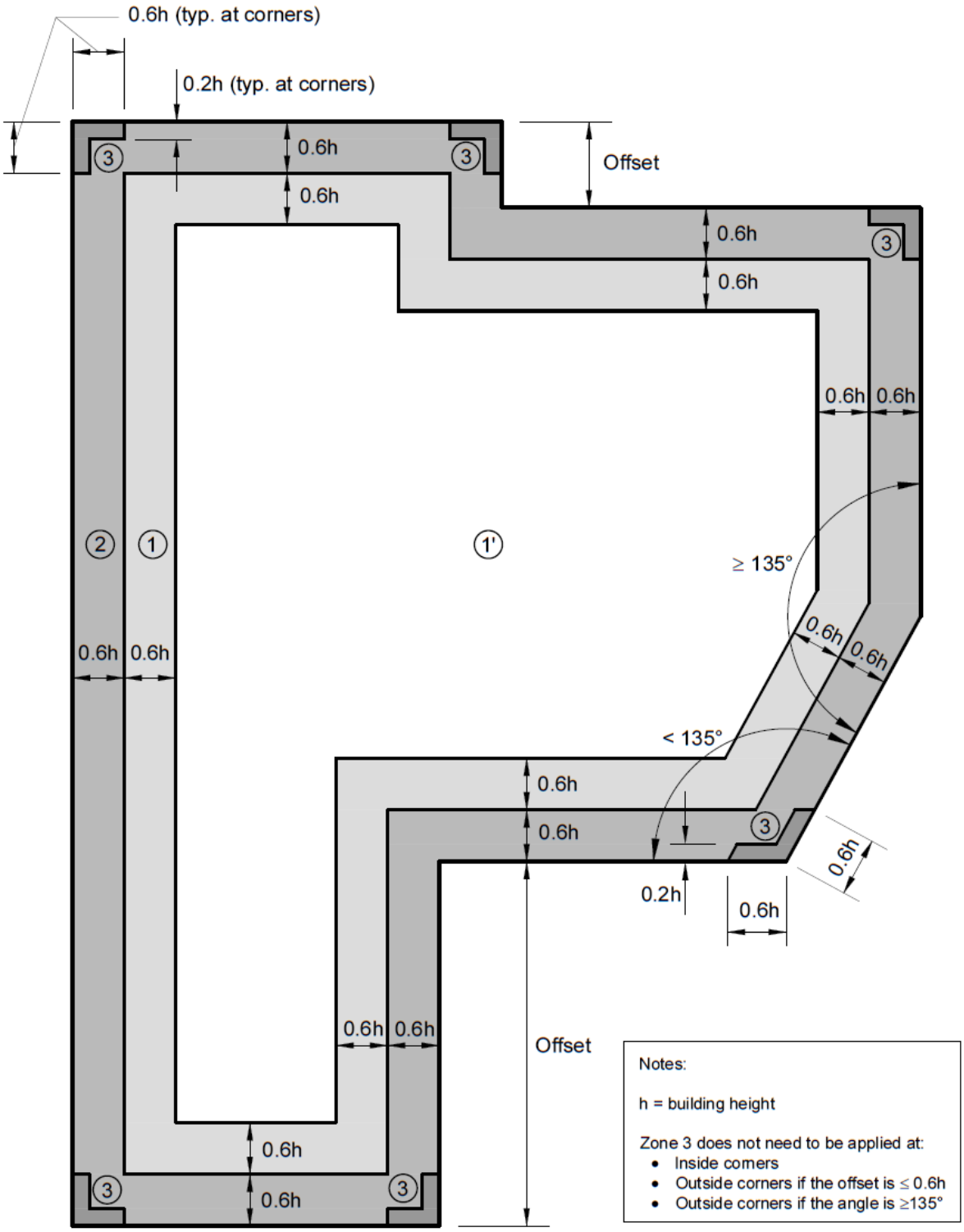
Example: 60 ft. building
0.6h = 36 ft.
0.2h = 12 ft.



Non-rectangular Roof Plan Examples

Many roofs are not simple rectangles. Figure 2 is a roof plan with different corner conditions that may be encountered. Note that Zone 3 does not need to be applied at:

- Inside corners
- Outside corners where there is an offset with a distance ≤ 0.6h
- Outside corners where the angle is ≥ 135°



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Courtyard Example

Perimeter and corner zones are treated the same with courtyards. See Figure 3 for an example of a building with a courtyard.

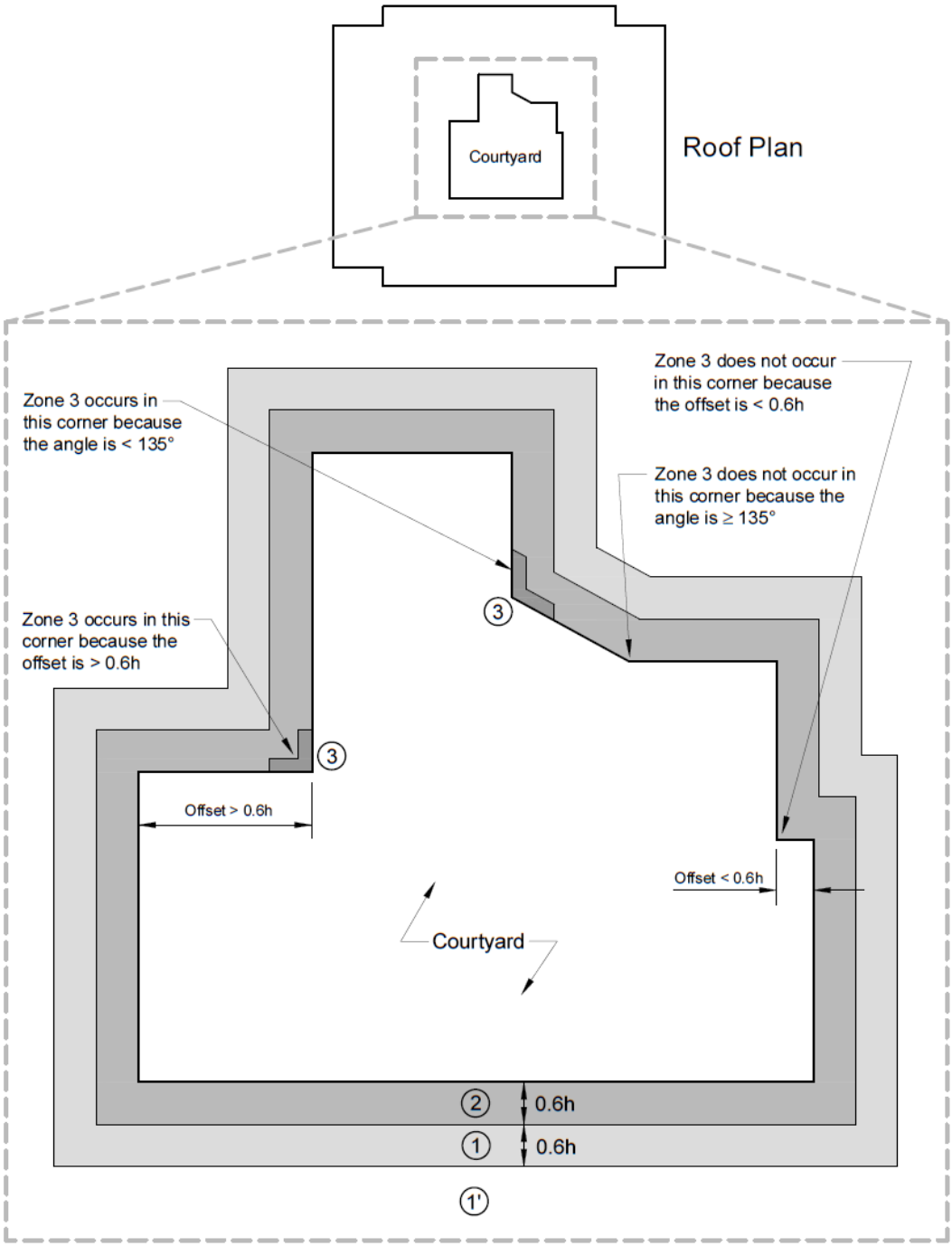


Figure 3: Example of perimeter and corner zones at a courtyard.

Roof Zone 1' (interior field)

Roof Zone 1' is not going to exist on every roof. For example, Figure 4 illustrates how Zone 1' will change—and eventually go away—by altering the height of a 100 ft. by 200 ft. building. Likewise, Figure 5 illustrates how changing the building's width while keeping the height the same, also affects Zone 1'.

If Zone 1' is relatively small, a practical approach is to use the same roofing system attachment as Zone 1 (exterior field). This is acceptable and would be conservative, while simplifying the layout.

Parapets ≥ 3 feet

If a building has a parapet or wall that is 3 ft. or higher and it is provided around the perimeter of a roof zone, Zone 3 (corners) can be treated as Zone 2 (perimeter). See Figure 6 for examples of 100 ft. by 200 ft. building at heights of 15, 30, 45 and 60 ft.

Lookup Tables with 0.6h and 0.2h Calculations

The tables below can be used as an easy reference to determine the 0.6h and 0.2h dimensions for buildings with heights from 15 to 60 ft.

Bldg. height, h (feet)	0.6h (feet)	0.2h (feet)
15	9	3
16	9.6	3.2
17	10.2	3.4
18	10.8	3.6
19	11.4	3.8
20	12	4
21	12.6	4.2
22	13.2	4.4
23	13.8	4.6
24	14.4	4.8
25	15	5
26	15.6	5.2
27	16.2	5.4
28	16.8	5.6
29	17.4	5.8
30	18	6
31	18.6	6.2
32	19.2	6.4
33	19.8	6.6
34	20.4	6.8
35	21	7
36	21.6	7.2
37	22.2	7.4

Bldg. height, h (feet)	0.6h (feet)	0.2h (feet)
38	22.8	7.6
39	23.4	7.8
40	24	8
41	24.6	8.2
42	25.2	8.4
43	25.8	8.6
44	26.4	8.8
45	27	9
46	27.6	9.2
47	28.2	9.4
48	28.8	9.6
49	29.4	9.8
50	30	10
51	30.6	10.2
52	31.2	10.4
53	31.8	10.6
54	32.4	10.8
55	33	11
56	33.6	11.2
57	34.2	11.4
58	34.8	11.6
59	35.4	11.8
60	36	12

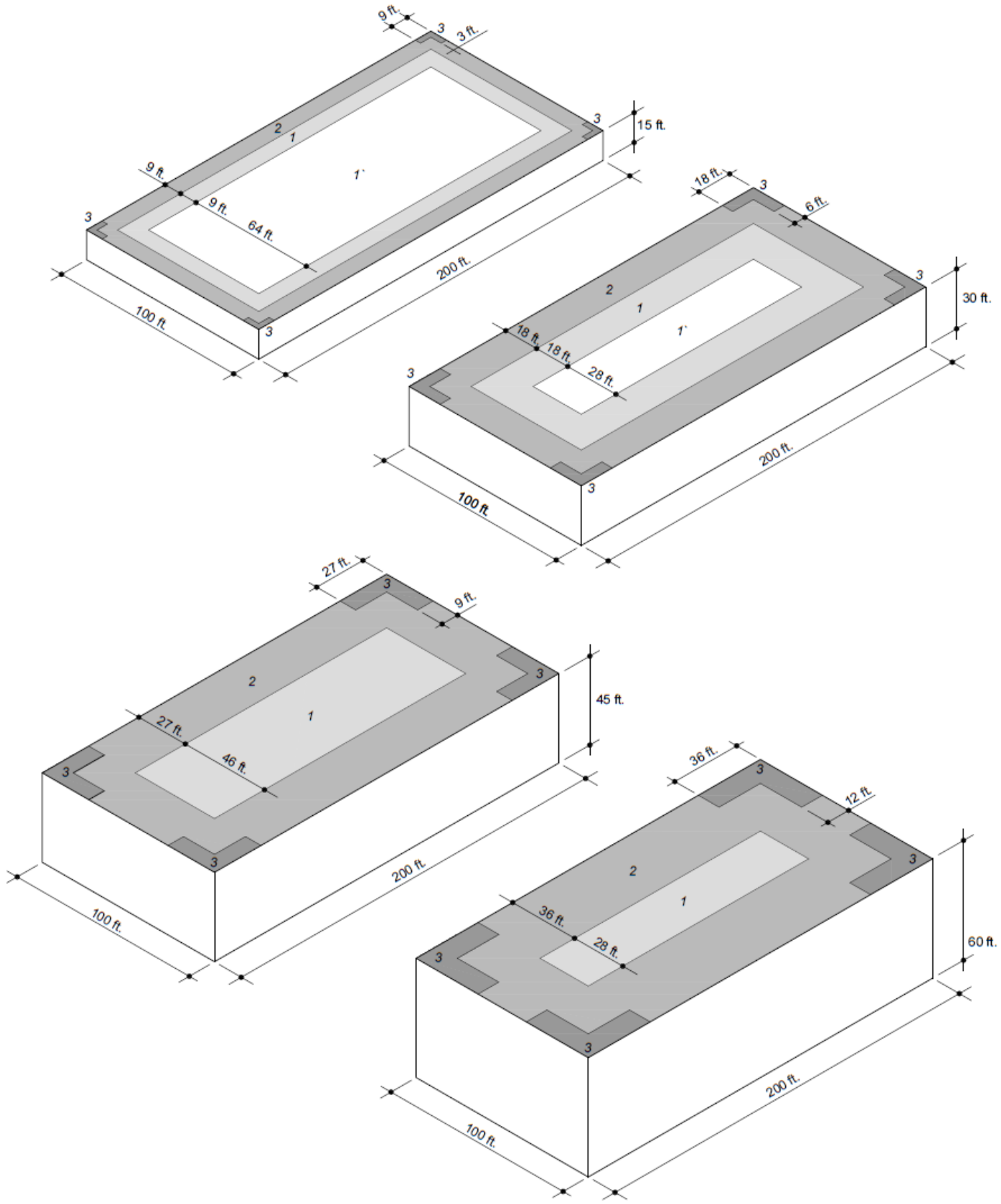


Figure 4: Example of a 100 ft. by 200 ft. building at heights of 15, 30, 45 and 60 ft.

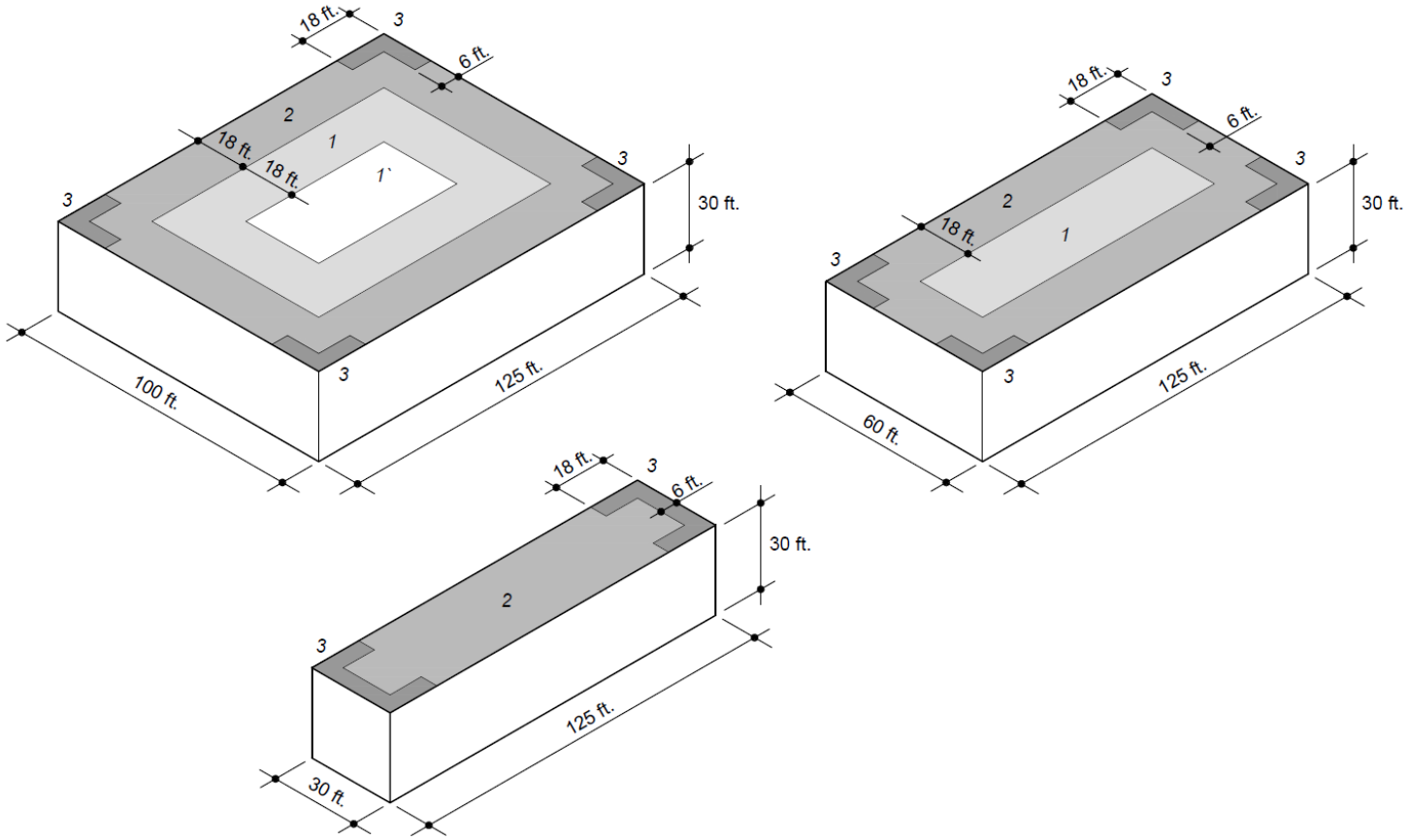


Figure 5: Example of a 30 ft. high building with widths of 100, 60 and 30 ft.

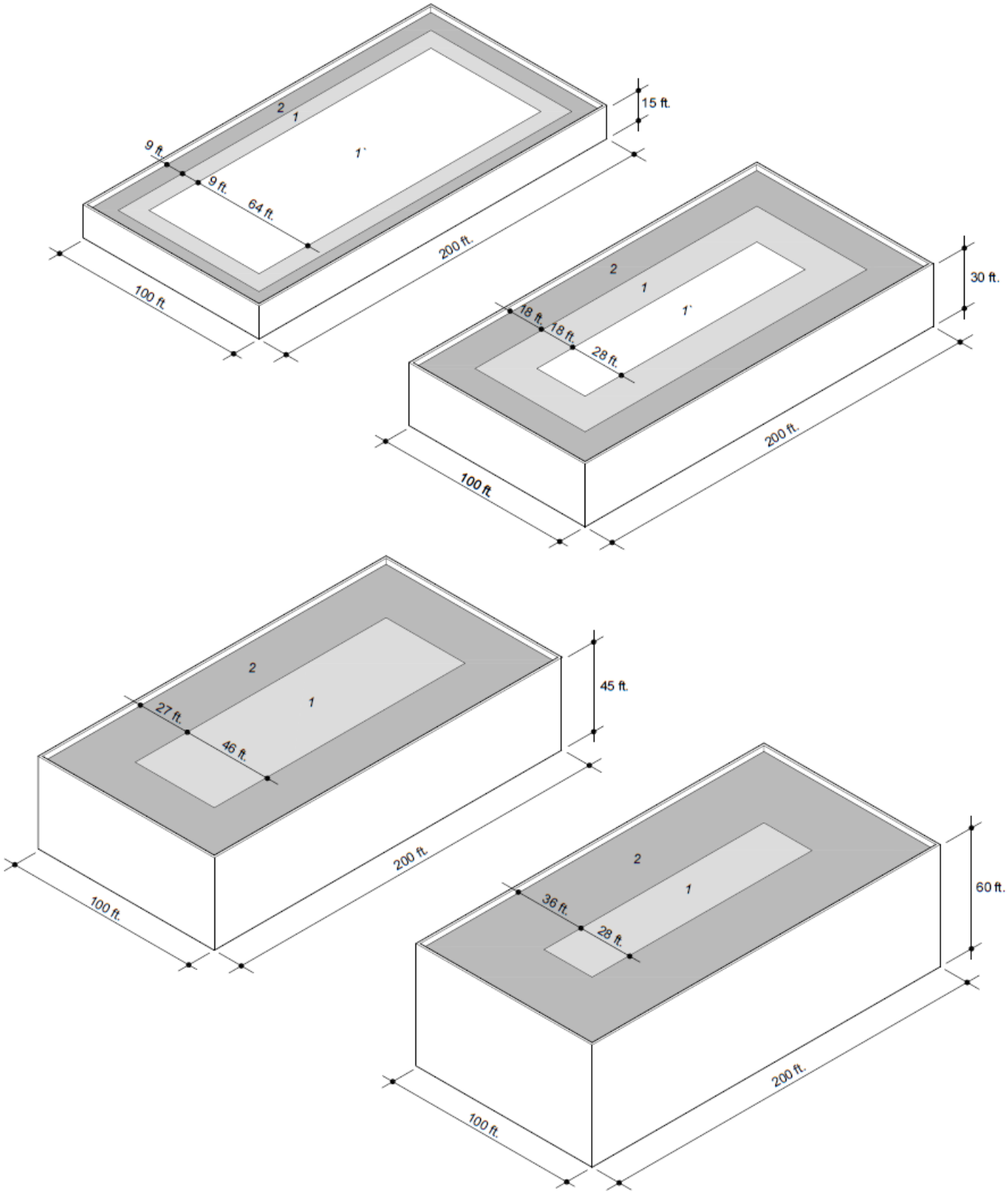


Figure 6: Example of 100 ft. by 200 ft. building with parapets ≥ 3 ft., at heights of 15, 30, 45 and 60 ft.

Application Considerations for Roof Zones 2 and 3

ASCE 7-16 is significantly impacting how roof design has been traditionally done. You will notice that there will be an increase in the amount of adhesive or fasteners used for roofing systems because:

- Design wind uplift pressures have increased for all roof zones.
- The size of perimeter zones are larger than with ASCE 7-05 and ASCE 7-10.

There are two ways to address perimeter (Zone 2) and corner (Zone 3) zones:

- Performance-based
- Prescriptive enhancement

Performance-based

This approach is where you select a roofing system with a wind uplift rating that is applicable for Zones 1', 1, 2 and 3. This is the most reliable method to ensure building code compliance. This approach includes:

- Using a combination of multiple wind ratings that are applicable for the respective roof zone, or
- Using a roof system throughout the entire roof area that has a wind rating adequate for Zone 3 (or Zone 2 if there is a parapet ≥ 3 ft.).

Prescriptive Enhancement

This approach originates from FM Global Property Loss Prevention Data Sheet 1-29, "Roof Deck Securement and Above-Deck Roof Components" (FM 1-29) and is a widely accepted practice. See Appendix B for additional information on FM 1-29.

The Zone 2 and 3 enhancements should be extrapolations **based on Zone 1** and not Zone 1'.

Important note: *It should be verified if the prescriptive enhancement method is acceptable with the authority-having-jurisdiction (AHJ).*

This Guide offers assistance with EverGuard® TPO/PVC Roofing Systems that:

- are conventionally mechanically attached.
- are adhered over insulation boards.
- use Drill-Tec™ RhinoBond® plates and fasteners.

Conventional Mechanically Attached Roofing Systems

The following are **suggested** installation methods to approach perimeter and corner zones with conventional mechanically attached roofing systems for buildings **less than 60 ft. in height**:

- Method A – Standard Picture Framing
- Method B – Modified Picture Framing
- Method C – Full Size and Half Size Sheets with Intermediate Fastener Rows
- Method D – Full Size Sheets with Intermediate Fastener Rows

Important Note!

FM 1-29 was updated in February 2020. The Data Sheet revised the parameters for fastener row spacing used in the perimeter and corner zones. The installation methods shown in the previous edition of this Guide followed the earlier version of FM 1-29.

The changes to FM 1-29 are as follows:

- Perimeters (Zone 2): the distance between fastener rows is no more than 67% of the row spacing needed for the wind uplift resistance rating for Zone 1, or one row of intermediate fasteners.

- Corners (Zone 3): the distance between fastener rows is no more than 50% of the row spacing needed for the wind uplift resistance rating for Zone 1, or one row of intermediate fasteners.

Therefore, the row spacing in the corner zones can be the same as in the perimeter zones for conventional mechanically attached roof systems. The roof layouts in this Guide reflect this change to FM 1-29.

Method A – Standard Picture Framing

Standard picture framing is using the appropriate fastening pattern for **Zone 1** and then applying half sheets around the building's perimeter. Historically, this typically meant one or two rows of half sheets. Due to the changes in ASCE 7-16, a significant increase in the number of half-sheet rows will be noticed with taller buildings.

Installation Considerations:

- For roofing contractors accustomed with picture framing, this doesn't deviate from what they are familiar with.
- This method results in a double-layer of membrane at corner zones which is substantial with taller buildings. **It is suggested that this method be limited to buildings needing only two rows of half sheets.** For example, buildings up to 16 ft. tall when using 10 ft. and 5 ft. sheets and 19 ft. tall when using 12 ft. and 6 ft. sheets.
- For the half sheets installed parallel to steel deck flutes, the fasteners are located along the length of a single flange in the steel deck. It is preferable, or may be required, that the fastener rows run perpendicular to the steel deck flutes.
- Consider treating Zone 1' as Zone 1. This will simplify the roof zone layout by only having one "field" zone.

Important note: *If the project is an FM Global insured building, the requirements must be acceptable to their field engineering staff. See Appendix B for additional information from FM 1-29 regarding mechanically attached roofing systems.*

The following tables summarize the number of rows of half-sheets that may be needed:

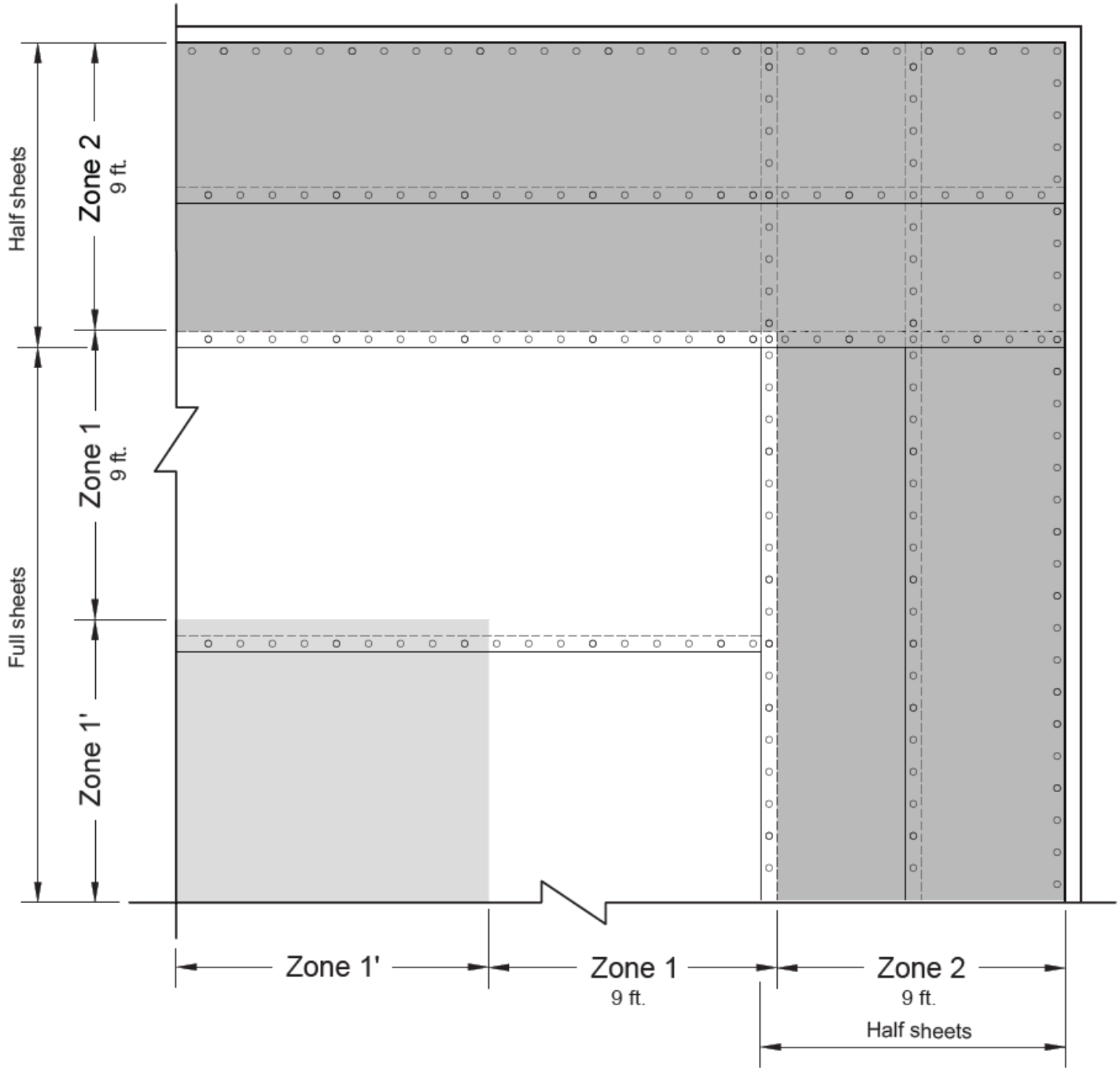
10 ft. wide sheets	
Bldg. height, h	Number of rows 5 ft. wide sheets
15 to 16 ft.	2 rows
17 to 23 ft.	3 rows
24 to 31 ft.	4 rows
32 to 38 ft.	5 rows
39 to 46 ft.	6 rows
47 to 53 ft.	7 rows
54 to 60 ft.	8 rows

12 ft. wide sheets	
Bldg. height, h	Number of rows 6 ft. wide sheets
15 to 19 ft.	2 rows
20 to 29 ft.	3 rows
30 to 46 ft.	4 rows
47 to 55 ft.	5 rows
56 to 60 ft.	6 rows

Following is an example for a 15 ft. tall building using 10 ft. and 5 ft. wide rolls.

Method A – Standard Picture Framing

15 ft. building
0.6h = 9 ft.
10 ft. and 5 ft. sheets



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Method B – Modified Picture Framing

This method is similar to standard picture framing. The appropriate fastening pattern for Zone 1 is used, however, one set of half sheet rows is stopped at the leading edge of the opposing rows of half sheets.

Installation Considerations:

- This method avoids having a double layer of membrane in corner areas.
- For the half sheets installed parallel to steel deck flutes, the fasteners are located along the length of a single flange in the steel deck. **It is preferable, or may be required, that the fastener rows run perpendicular to the steel deck flutes.**
- Consider treating Zone 1' as Zone 1. This will simplify the roof zone layout by only having one "field" zone.

Important note: *If the project is an FM Global insured building, the requirements must be acceptable to their field engineering staff. See Appendix B for additional information from FM 1-29 regarding mechanically attached roofing systems.*

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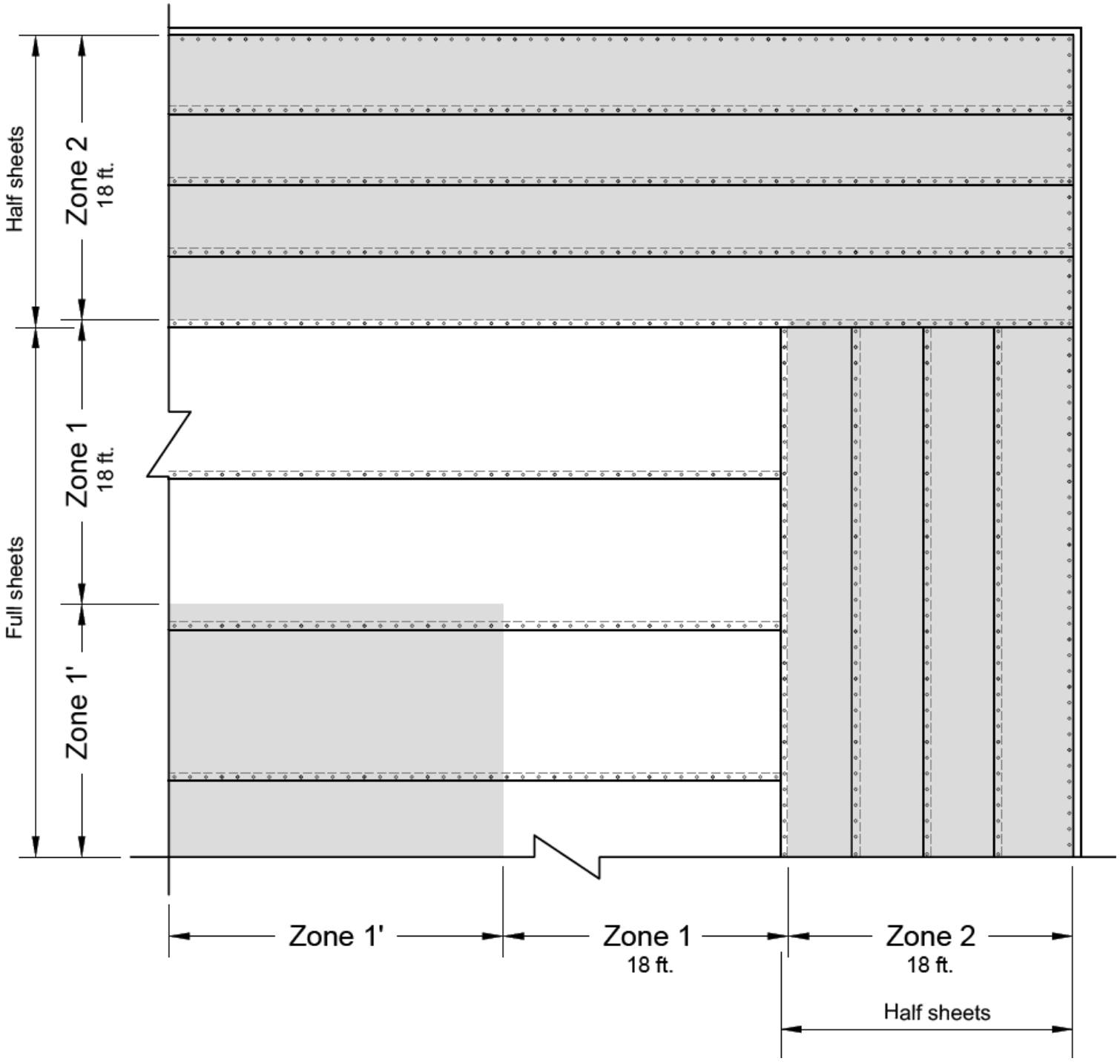
15 to 16 ft.	2 rows
17 to 23 ft.	3 rows
24 to 31 ft.	4 rows
32 to 38 ft.	5 rows
39 to 46 ft.	6 rows
47 to 53 ft.	7 rows
54 to 60 ft.	8 rows

12 ft. wide sheets	
Bldg. height, h	Number of rows 6 ft. wide sheets
15 to 19 ft.	2 rows
20 to 29 ft.	3 rows
30 to 46 ft.	4 rows
47 to 55 ft.	5 rows
56 to 60 ft.	6 rows

Following is an example for a 30 ft. tall building using 10 ft. and 5 ft. wide rolls.

Method B – Modified Picture Framing

30 ft. building
0.6h = 18 ft.
10 ft. and 5 ft. sheets



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Method C – Full Size and Half Size Sheets with Intermediate Fastener Rows

This method is similar to Method B, where the appropriate fastening pattern for Zone 1 is used; except the half sheets are just installed where they are perpendicular to steel deck flutes. In the perimeter zones (Zone 2) without half sheets, intermediate rows of fasteners are used. The intermediate rows may be fasteners that are stripped in (a.k.a., fingers), or Drill-Tec™ RhinoBond® plates and fasteners.

Installation Considerations:

- This method avoids having a double layer of membrane in corner areas.
- This eliminates the placement of fasteners along the length of a single flange in the steel deck.
- Consider treating Zone 1' as Zone 1. This will simplify the roof zone layout by only having one "field" zone.

Important note: *If the project is an FM Global insured building, the requirements must be acceptable to their field engineering staff. See Appendix B for additional information from FM 1-29 regarding mechanically attached roofing systems.*

The following tables summarize the number of rows of half-sheets that may be needed:

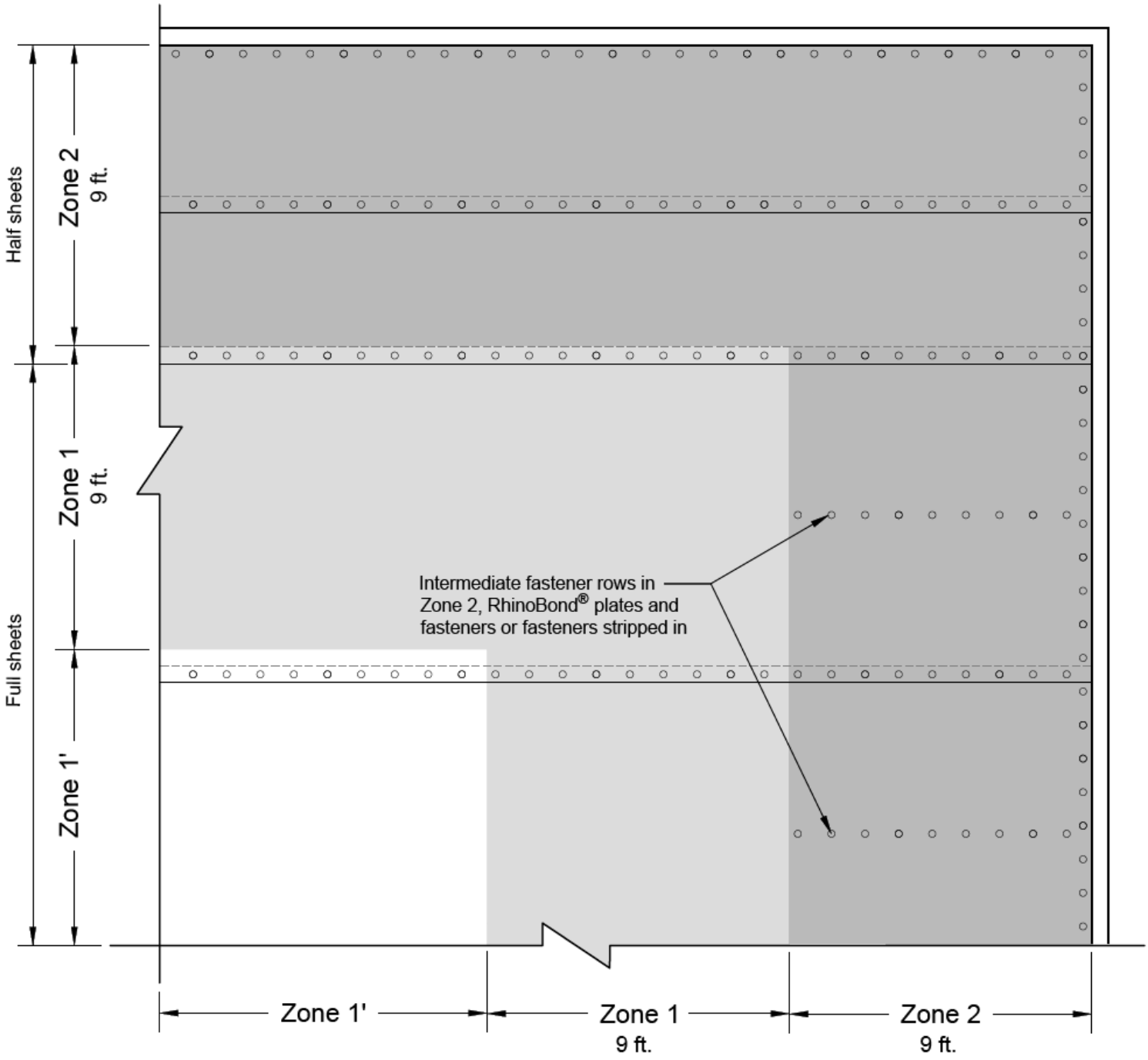
10 ft. wide sheets	
Bldg. height, h	Number of rows 5 ft. wide sheets
15 to 16 ft.	2 rows
17 to 23 ft.	3 rows
24 to 31 ft.	4 rows
32 to 38 ft.	5 rows
39 to 46 ft.	6 rows
47 to 53 ft.	7 rows
54 to 60 ft.	8 rows

12 ft. wide sheets	
Bldg. height, h	Number of rows 6 ft. wide sheets
15 to 19 ft.	2 rows
20 to 29 ft.	3 rows
30 to 46 ft.	4 rows
47 to 55 ft.	5 rows
56 to 60 ft.	6 rows

The examples on the following pages are for 15, 30, 45 and 60 ft. tall buildings using 10 ft. and 5 ft. sheets.

Method C – Full Size and Half Size Sheets with Intermediate Fastener Rows

15 ft. building
0.6h = 9 ft.
10 ft. and 5 ft. sheets



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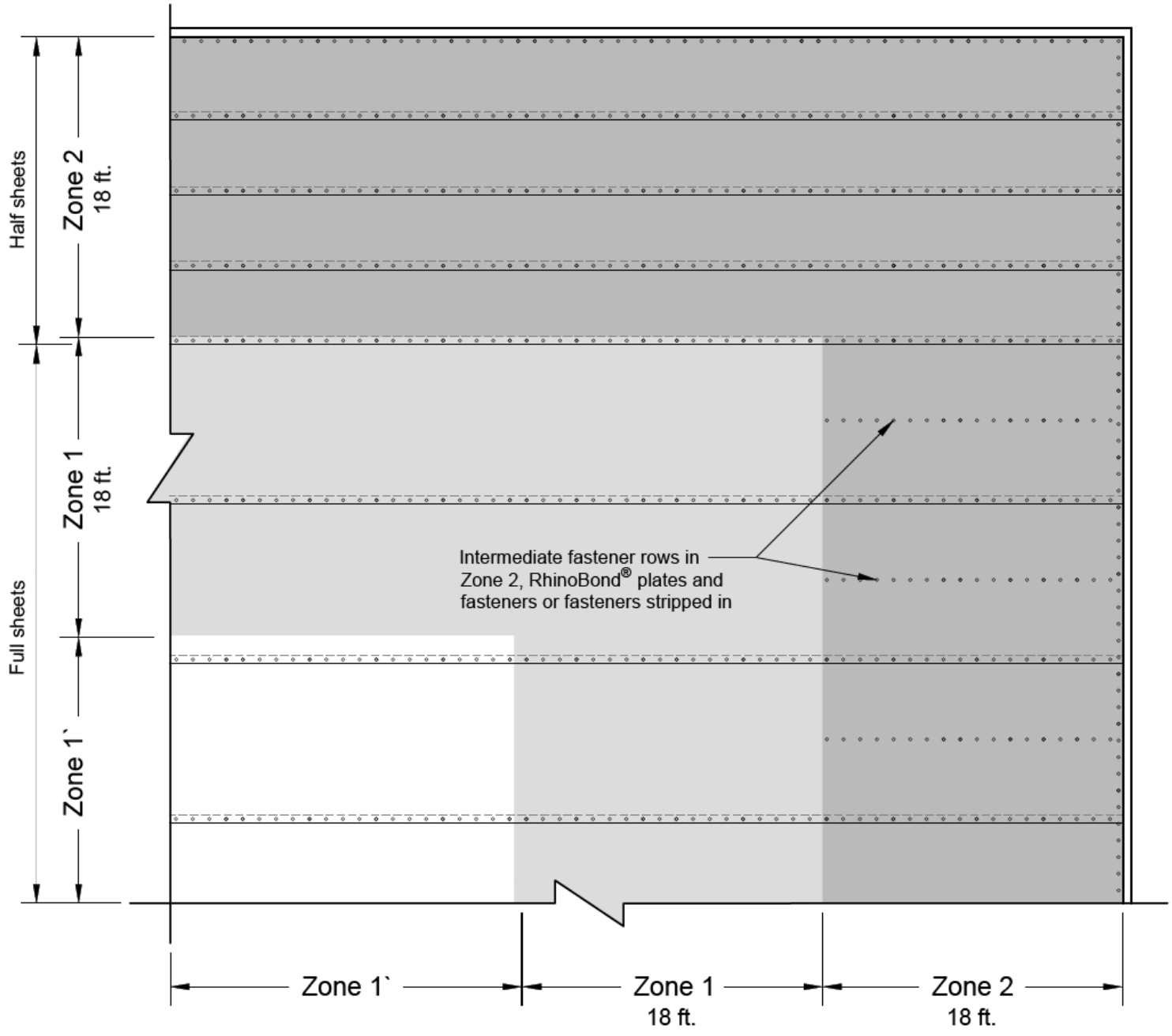
Method C – Full Size and Half Size Sheets with Intermediate Fastener Rows

30 ft. building
0.6h = 18 ft.
10 ft. and 5 ft. sheets



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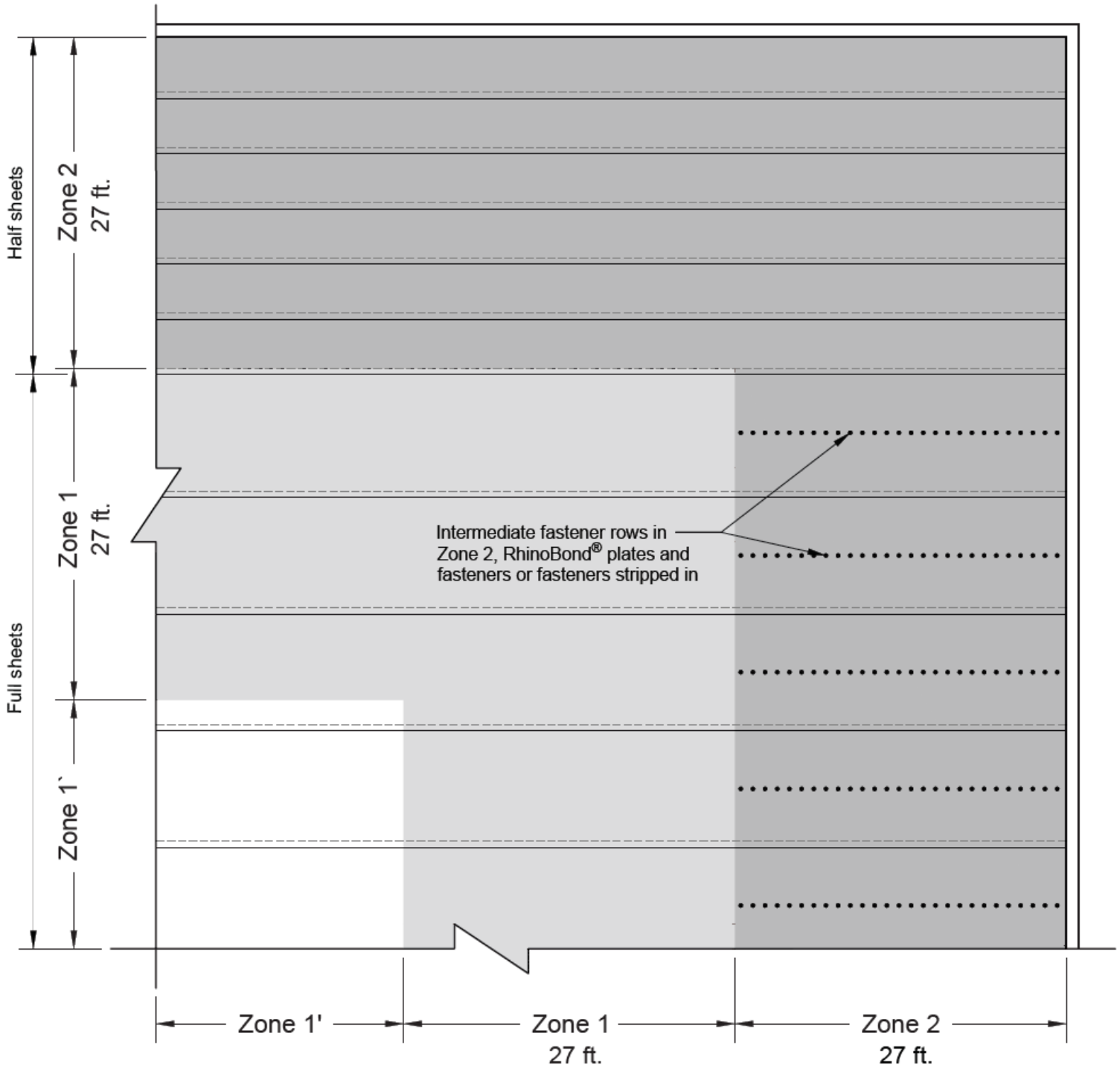
Method C – Full Size and Half Size Sheets with Intermediate Fastener Rows

45 ft. building
0.6h = 27 ft.
10 ft. and 5 ft. sheets



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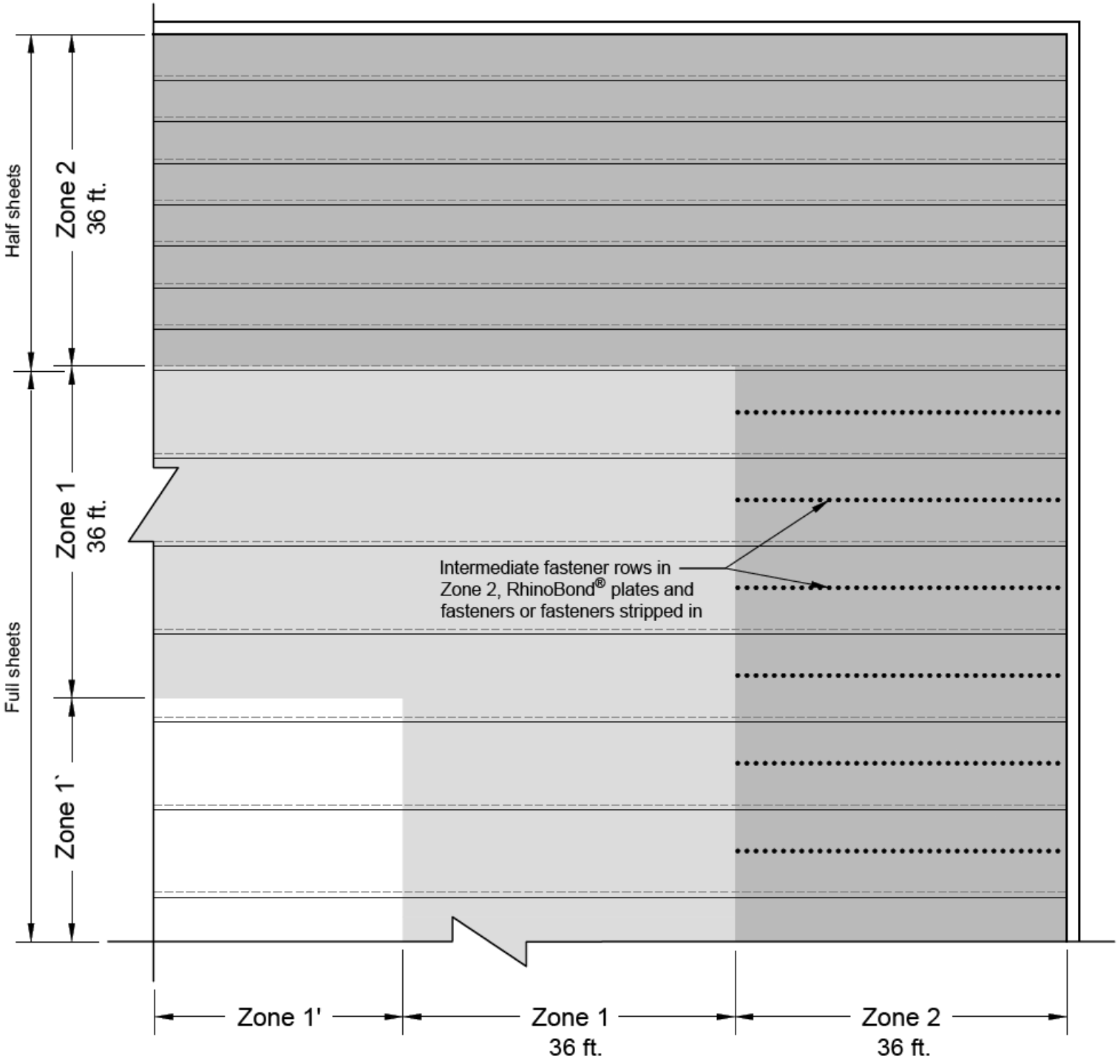
Method C – Full Size and Half Size Sheets with Intermediate Fastener Rows

60 ft. building
0.6h = 36 ft.
10 ft. and 5 ft. sheets



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Method D – Full Size Sheets with Intermediate Fastener Rows

This method uses full size membrane sheets for the entire roof area. The appropriate fastening pattern for Zone 1 is used and intermediate rows of fasteners are used in perimeter zones (Zone 2). The intermediate rows may be fasteners that are stripped in (a.k.a., fingers), or Drill-Tec™ RhinoBond® plates and fasteners.

Installation Considerations:

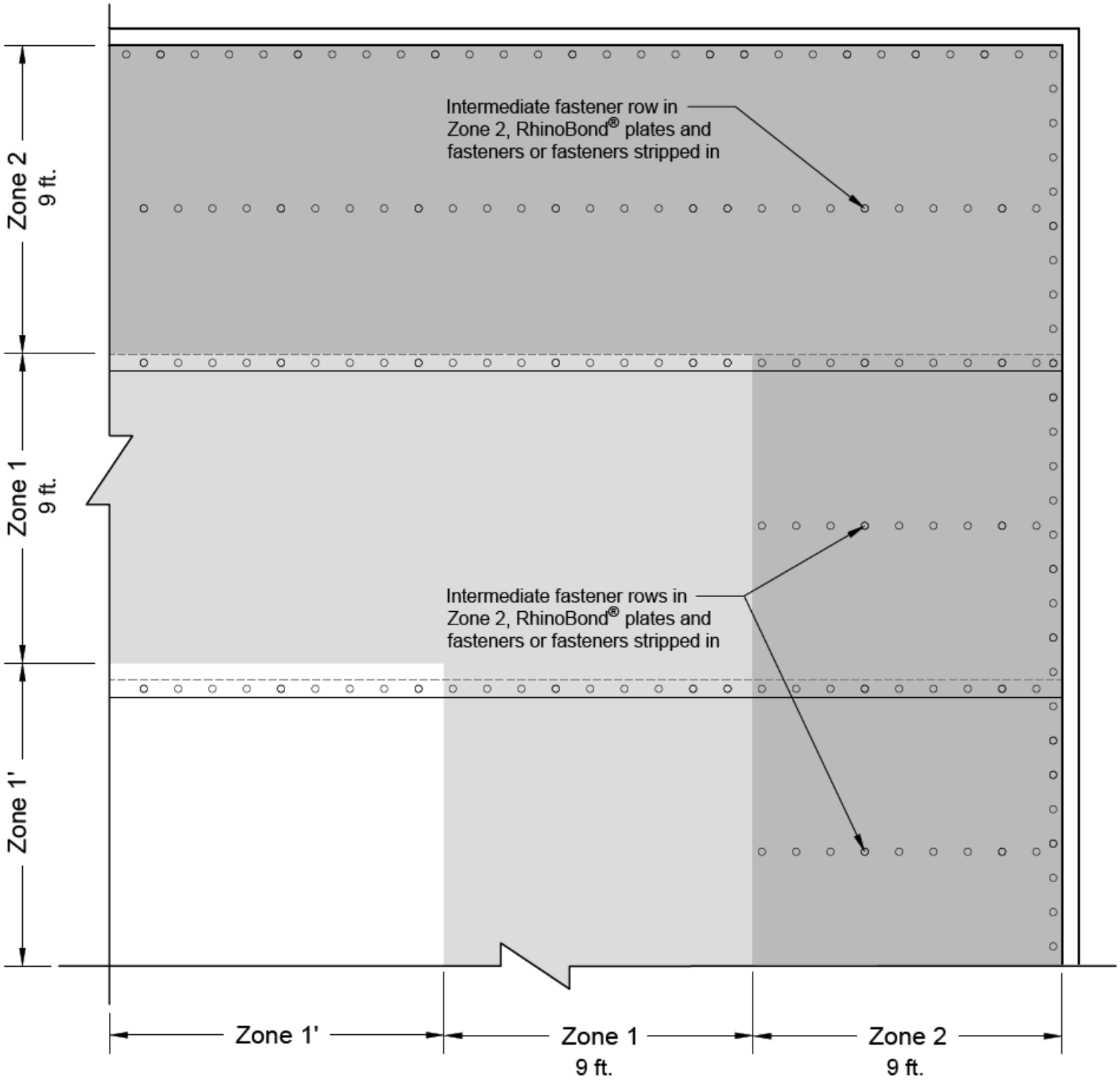
- This method avoids using half sheets.
- This eliminates the placement of fasteners along the length of a single flange in the steel deck.
- Consider treating Zone 1' as Zone 1. This will simplify the roof zone layout by only having one "field" zone.

Important note: *If the project is an FM Global insured building, the requirements must be acceptable to their field engineering staff. See Appendix B for additional information from FM 1-29 regarding mechanically attached roofing systems.*

The examples on the following pages are for 15, 30, 45 and 60 ft. tall buildings using 10 ft. sheets.

Method D – Full Size Sheets with Intermediate Fastener Rows

15 ft. building
0.6h = 9 ft.
10 ft. sheets



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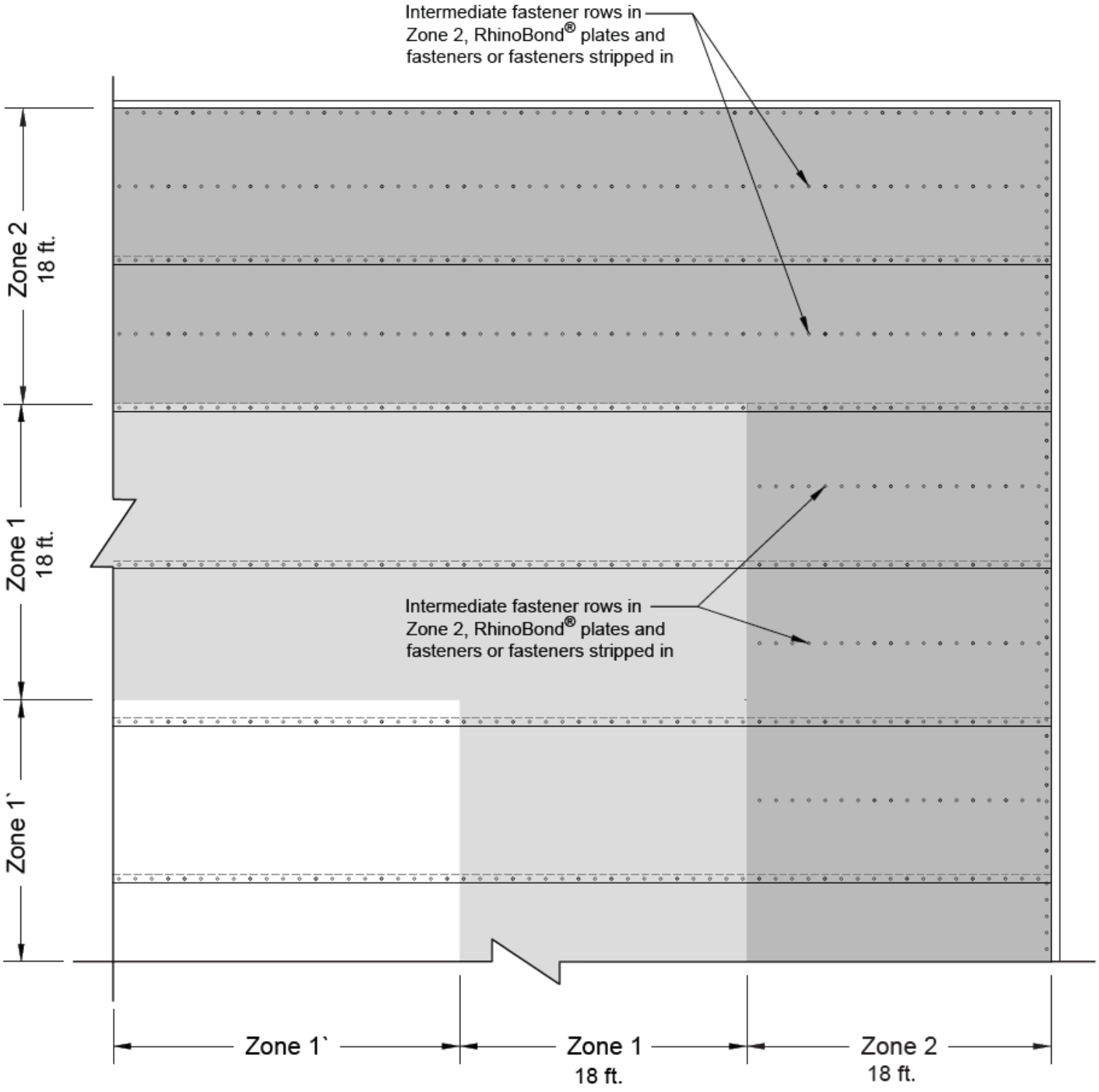
Method D – Full Size Sheets with Intermediate Fastener Rows

30 ft. building
0.6h = 18 ft.
10 ft. sheets



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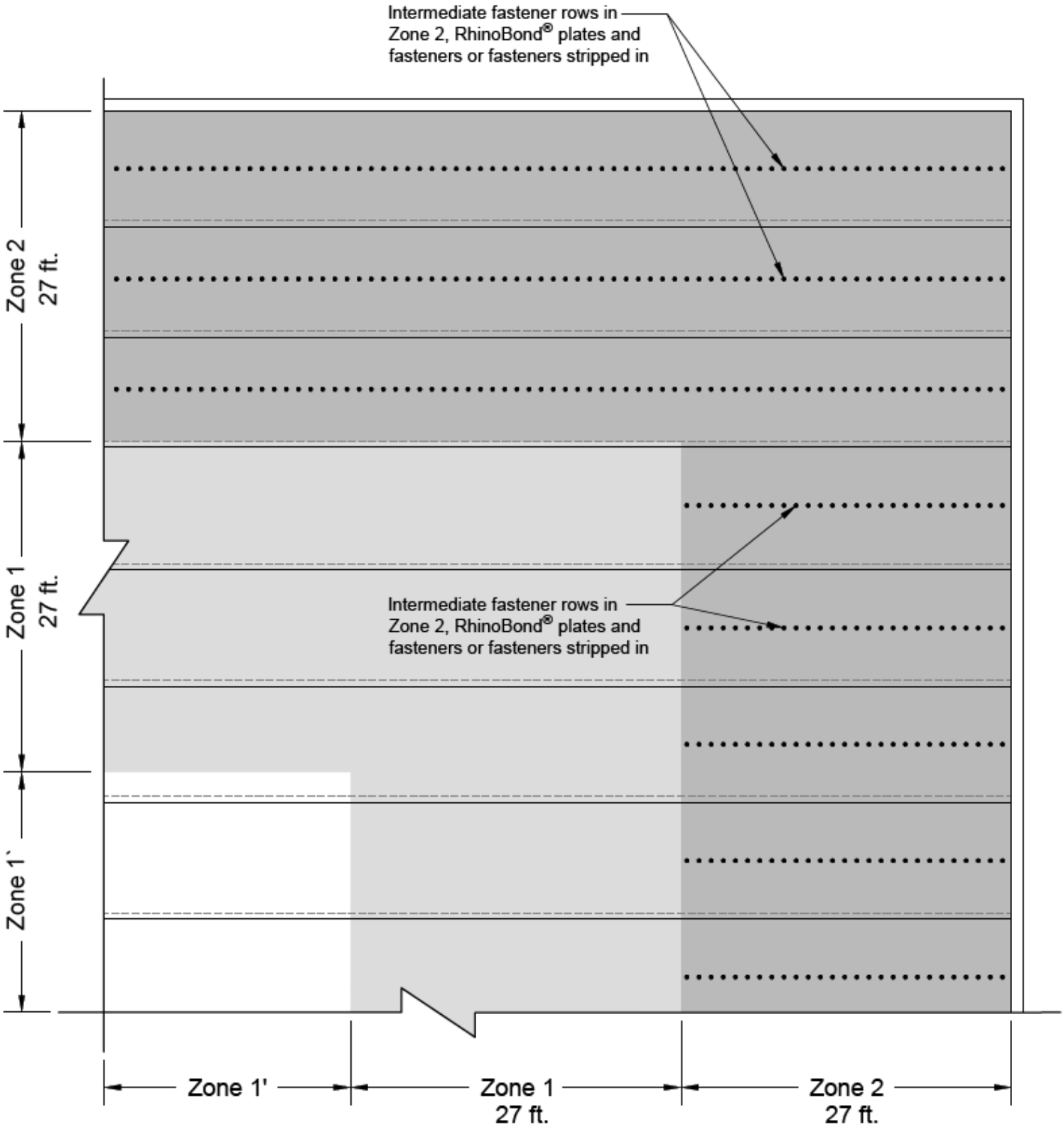
Method D – Full Size Sheets with Intermediate Fastener Rows

45 ft. building
0.6h = 27 ft.
10 ft. sheets



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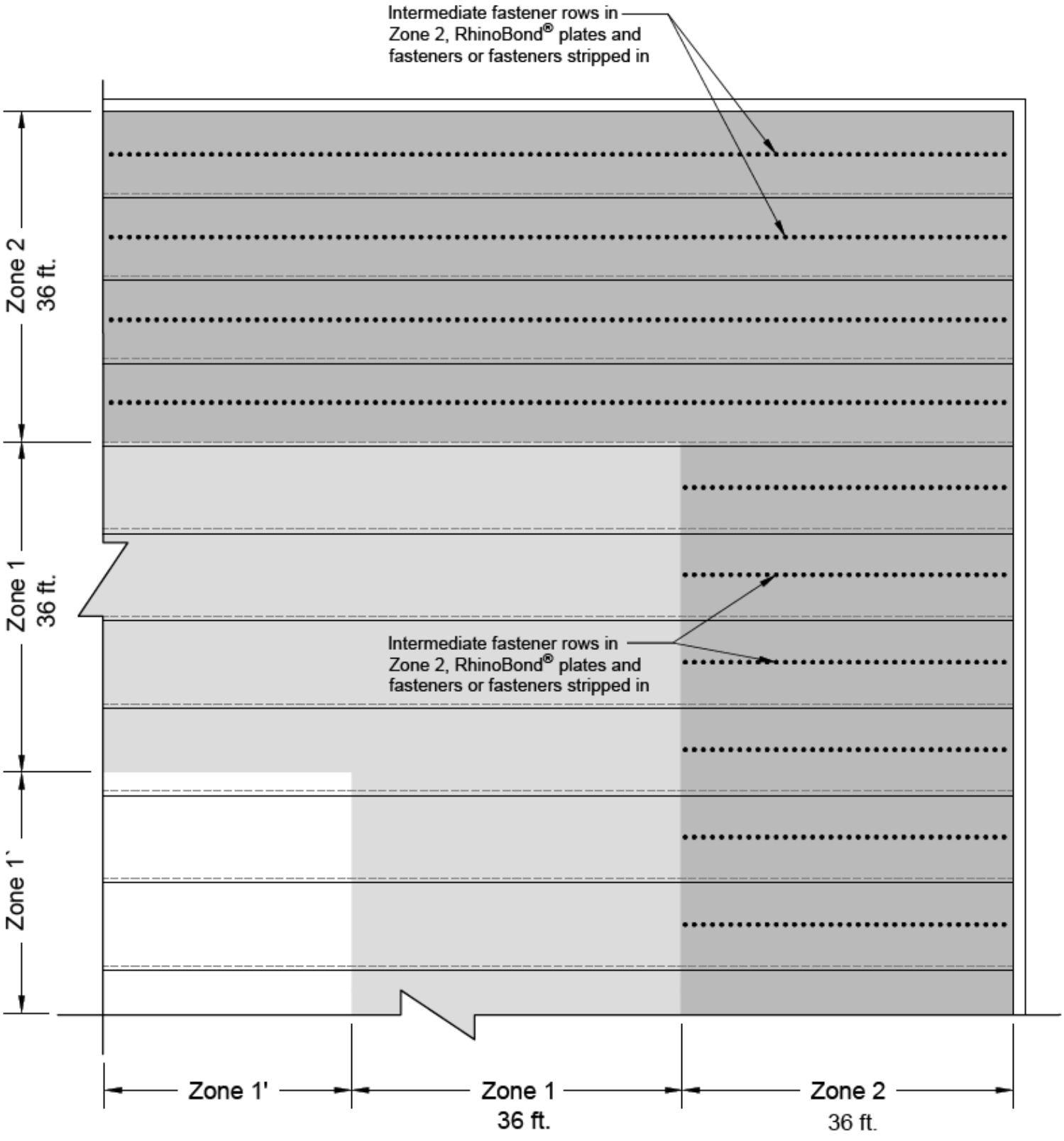
Method D – Full Size Sheets with Intermediate Fastener Rows

60 ft. building
0.6h = 36 ft.
10 ft. sheets



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Adhered Roof Membranes Installed Over Insulation Boards

For relatively low wind-pressure designs, prescriptive enhancements may be used with adhered roof membranes. This approach has limitations, but is acceptable where one of the following conditions is met:

- The NEEDED wind rating in Zone 1 is 90 psf or less.
- The roof is in a non-tropical cyclone-prone region where the design wind speed does not exceed 90 mph and the roof height does not exceed 75 ft. in Surface Roughness Exposure (SRE) B or C. For partially enclosed buildings in SRE D, roof height is limited to 30 ft.

Installation Considerations:

- If a portion of an insulation board extends into another zone, it must use the higher fastening pattern.
- Consider treating Zone 1' as Zone 1. This will simplify the roof zone layout by only having one "field" zone.

Important note: *If the project is an FM Global insured building, the requirements must be acceptable to their field engineering staff. See Appendix B for additional information from FM 1-29 regarding adhered roofing systems.*

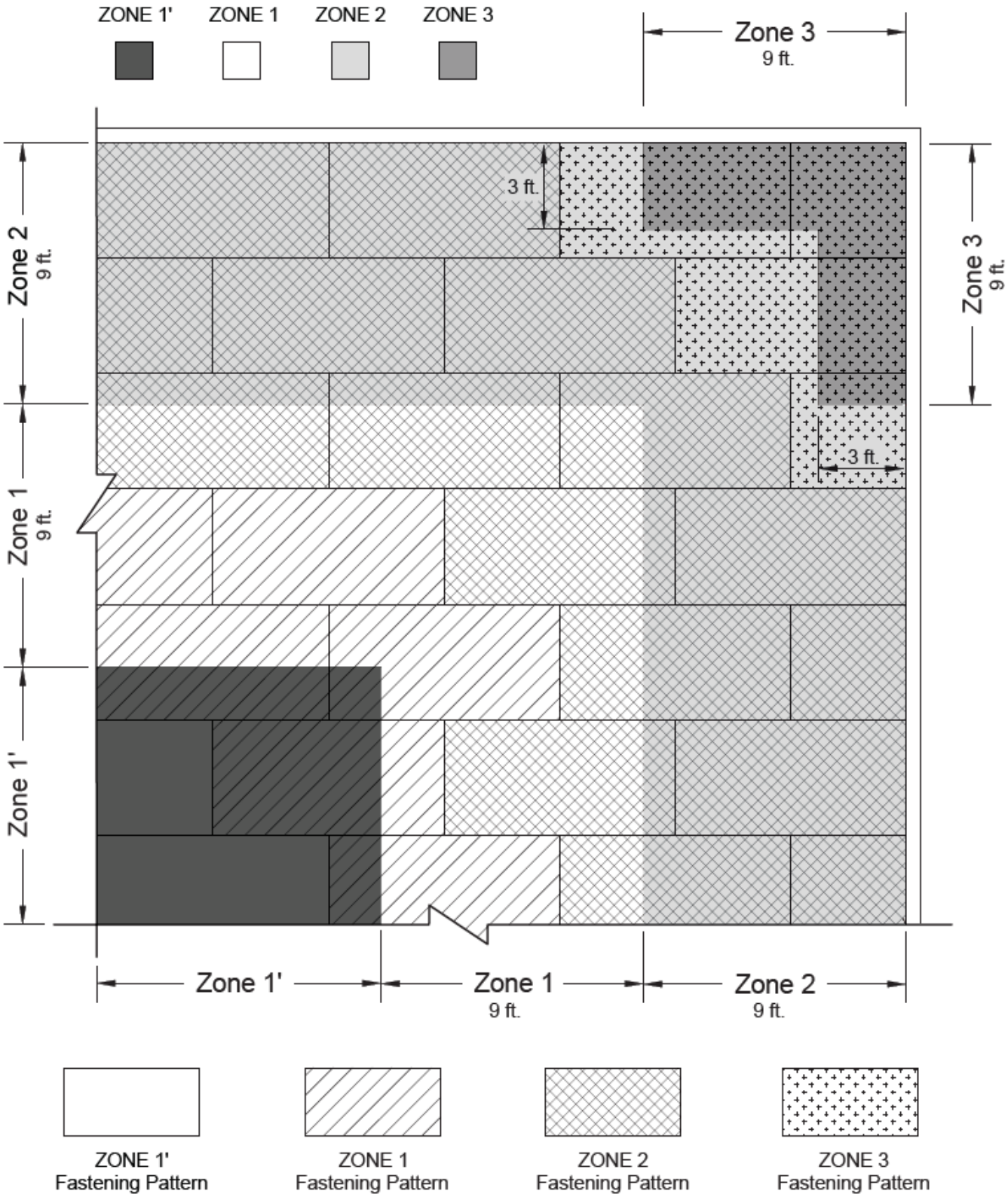
The following are **suggested** methods to approach perimeter and corner zones with the following insulation board sizes for buildings **less than 60 ft. in height**:

- 4 ft. x 8 ft. Boards
- 4 ft. x 4 ft. Boards

The examples on the following pages are for 15, 30, 45 and 60 ft. tall buildings.

4 ft. x 8 ft. Boards

15 ft. building
0.6h = 9 ft.
0.2h = 3 ft.



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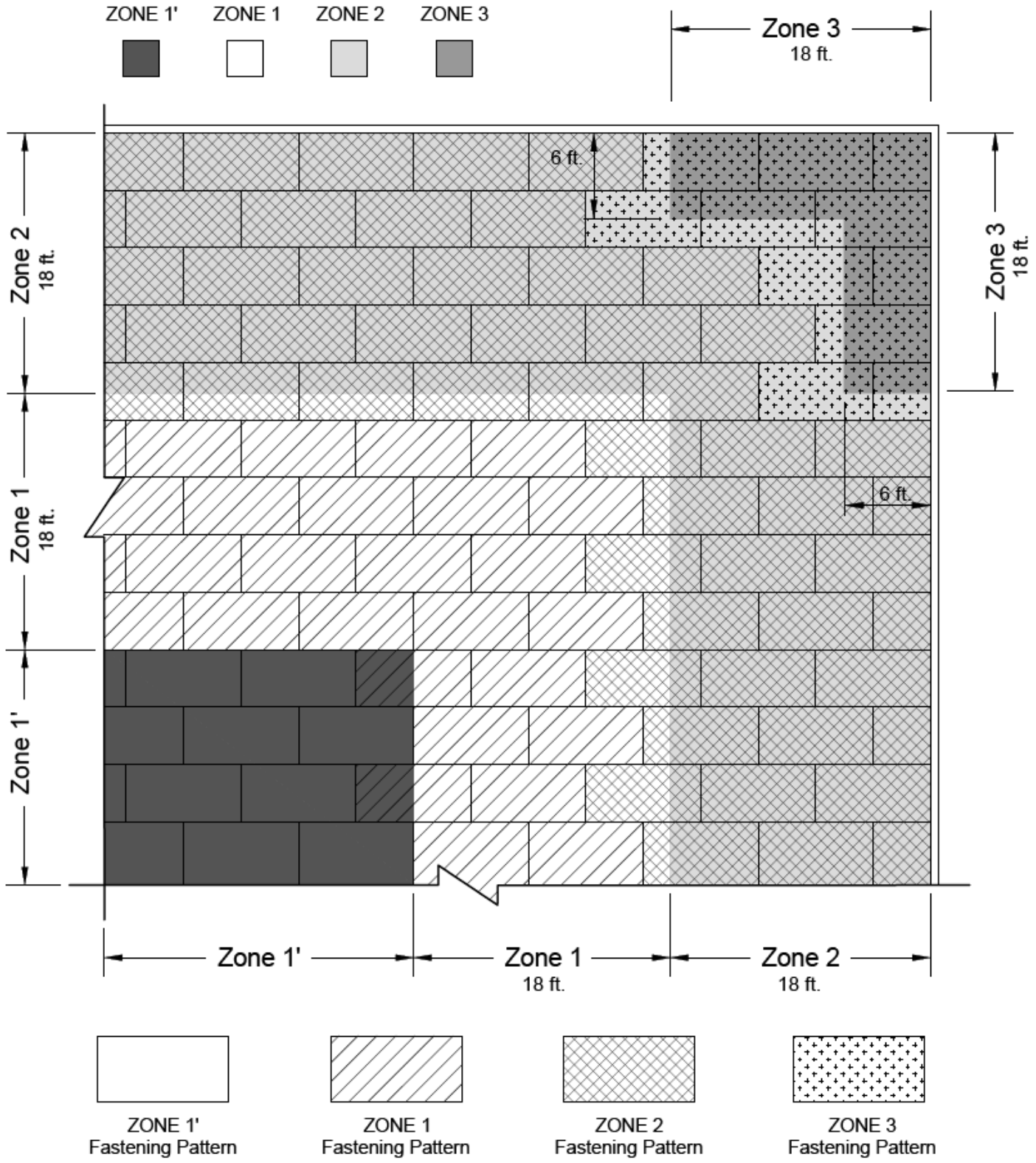
4 ft. x 8 ft. Boards

30 ft. building
0.6h = 18 ft.
0.2h = 6 ft.



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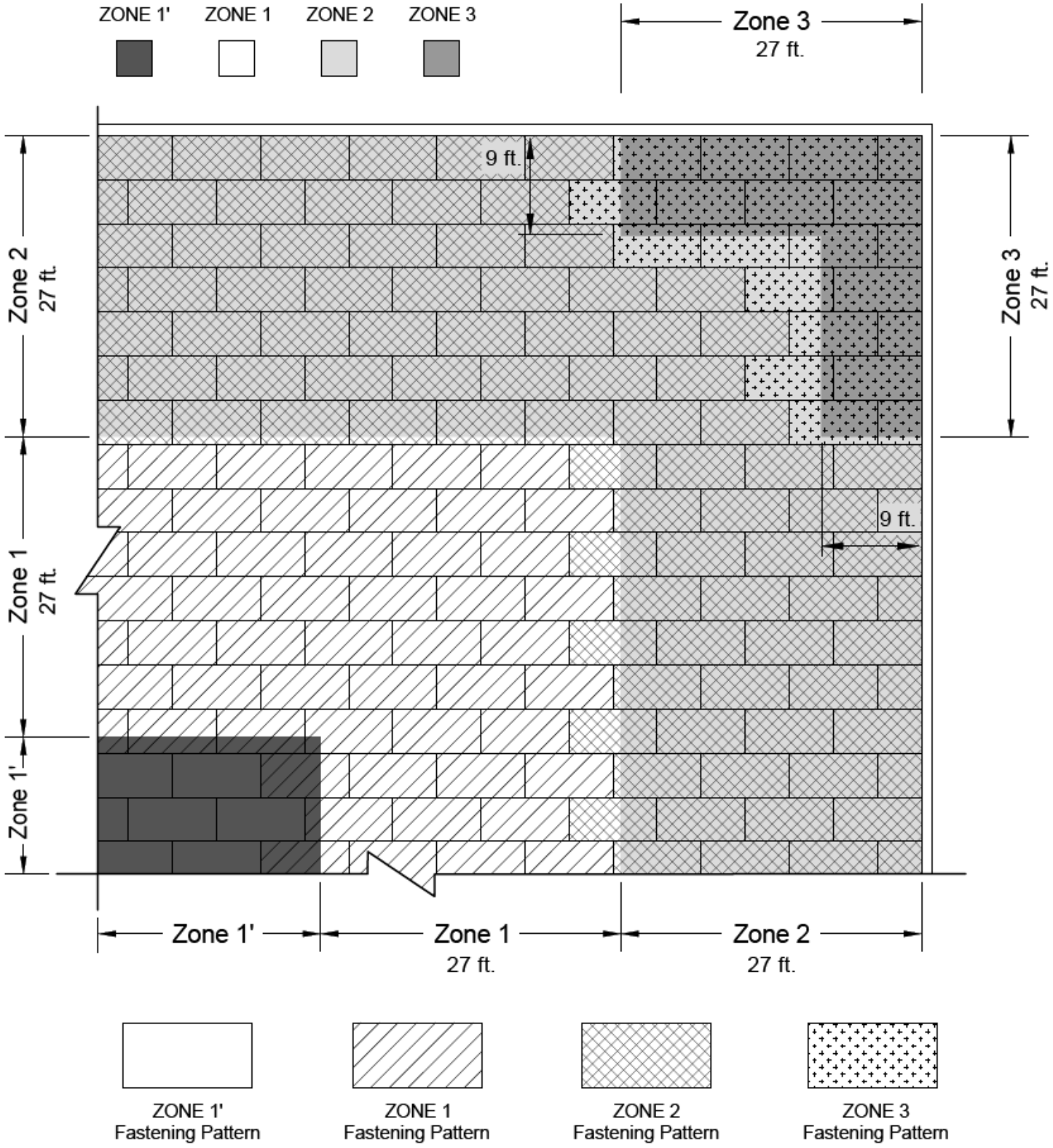
4 ft. x 8 ft. Boards

45 ft. building
0.6h = 27 ft.
0.2h = 9 ft.



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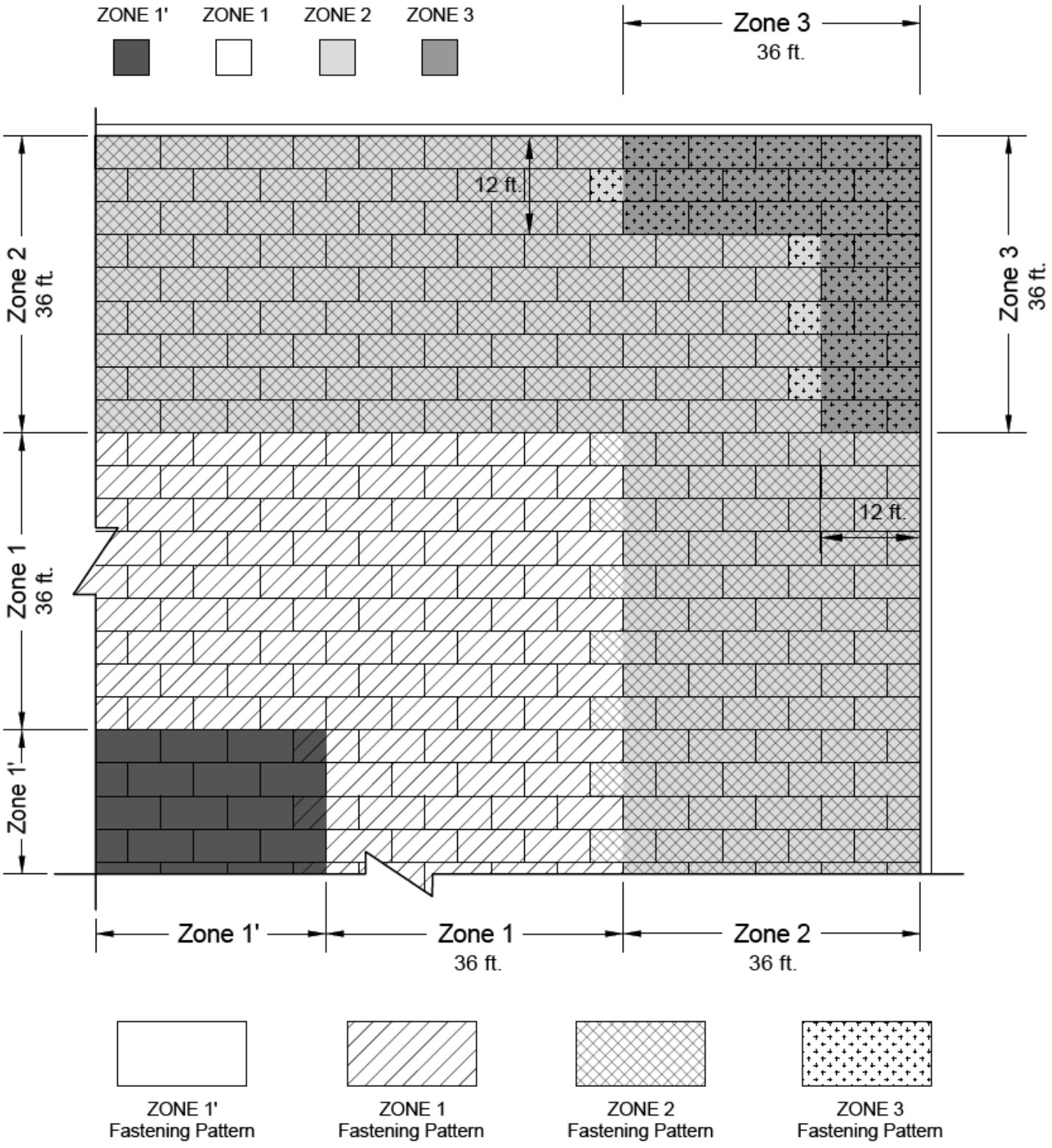
4 ft. x 8 ft. Boards

60 ft. building
0.6h = 36 ft.
0.2h = 12 ft.



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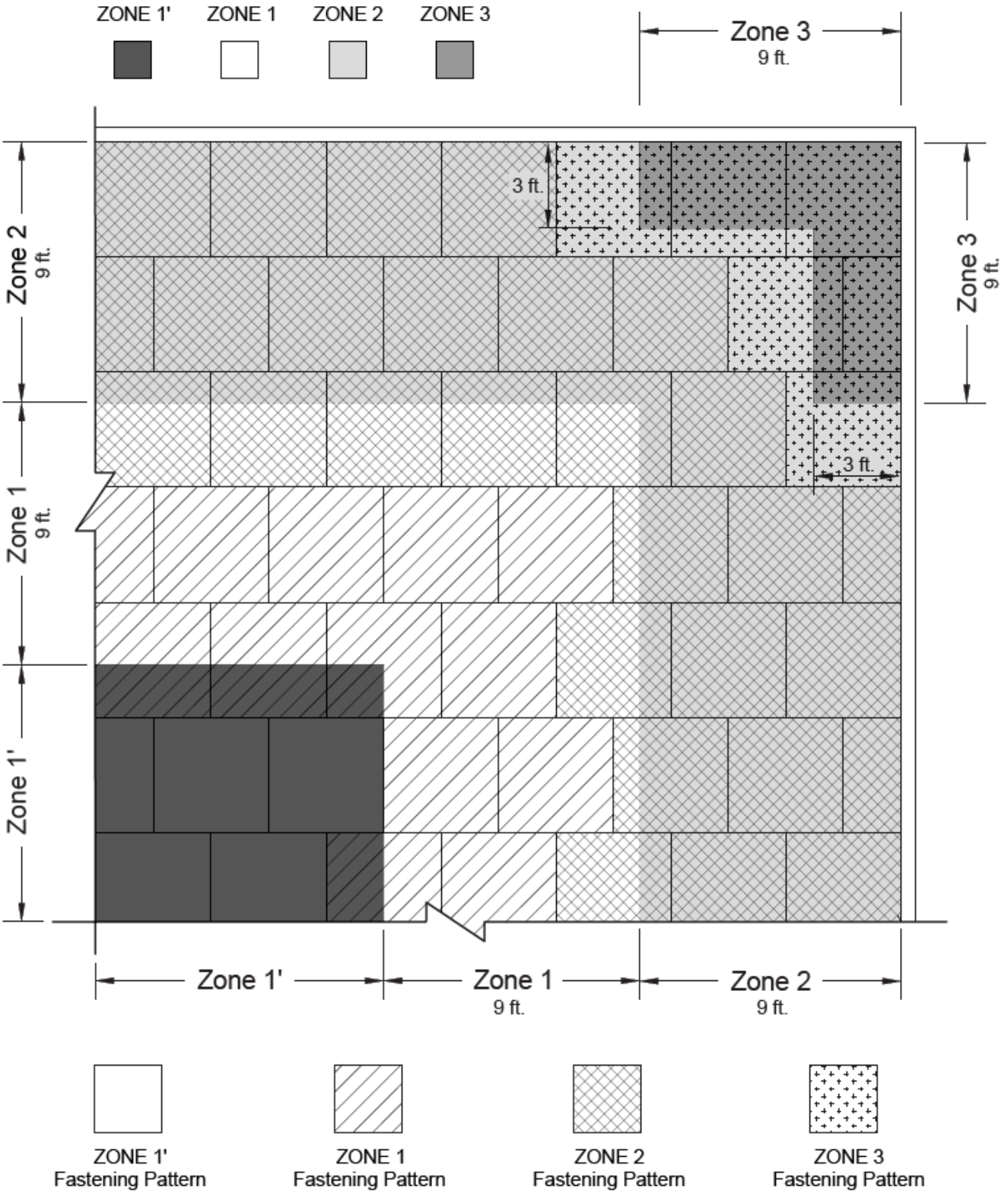
4 ft. x 4 ft. Boards

15 ft. building
0.6h = 9 ft.
0.2h = 3 ft.



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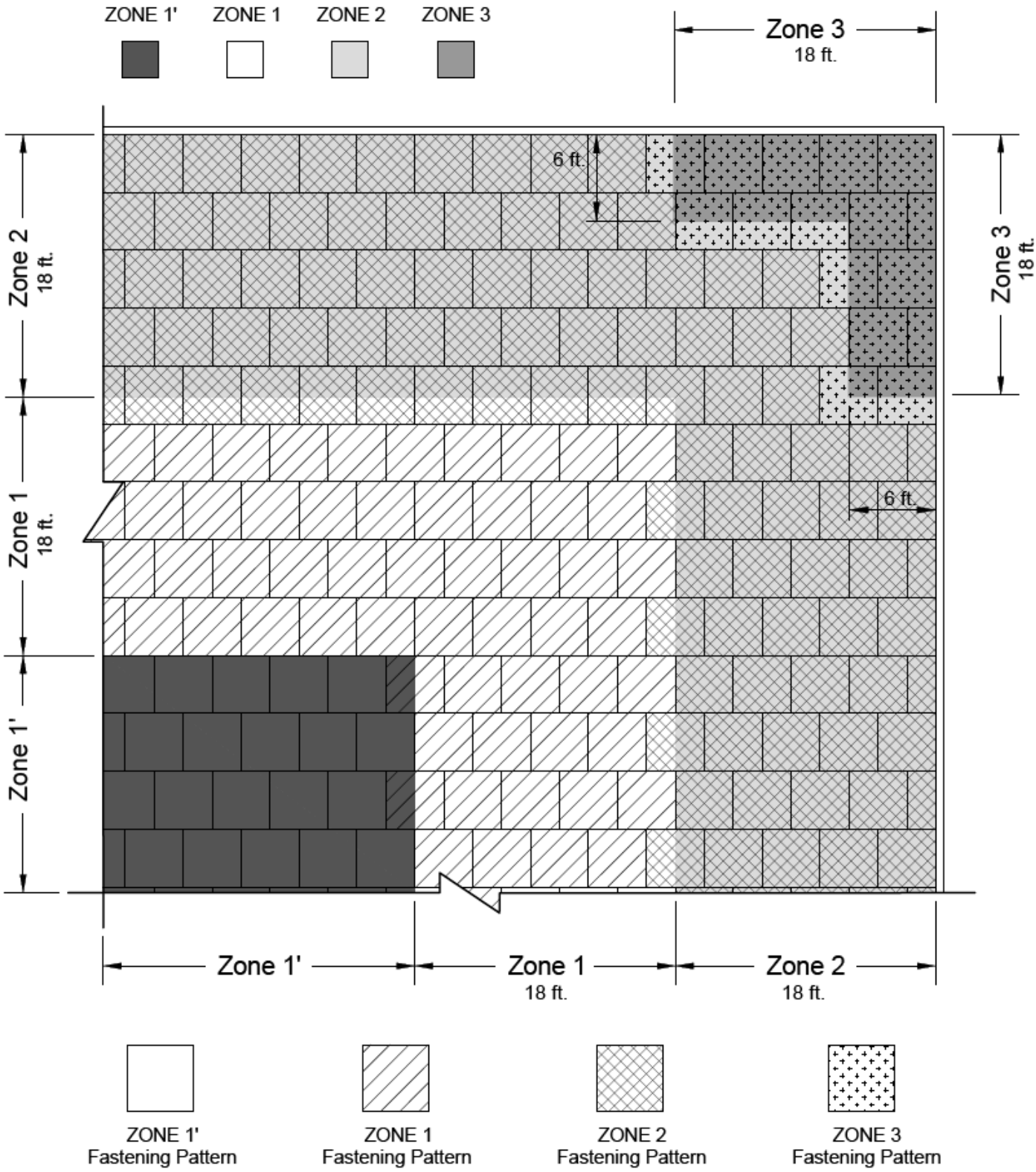
4 ft. x 4 ft. Boards

30 ft. building
0.6h = 18 ft.
0.2h = 6 ft.



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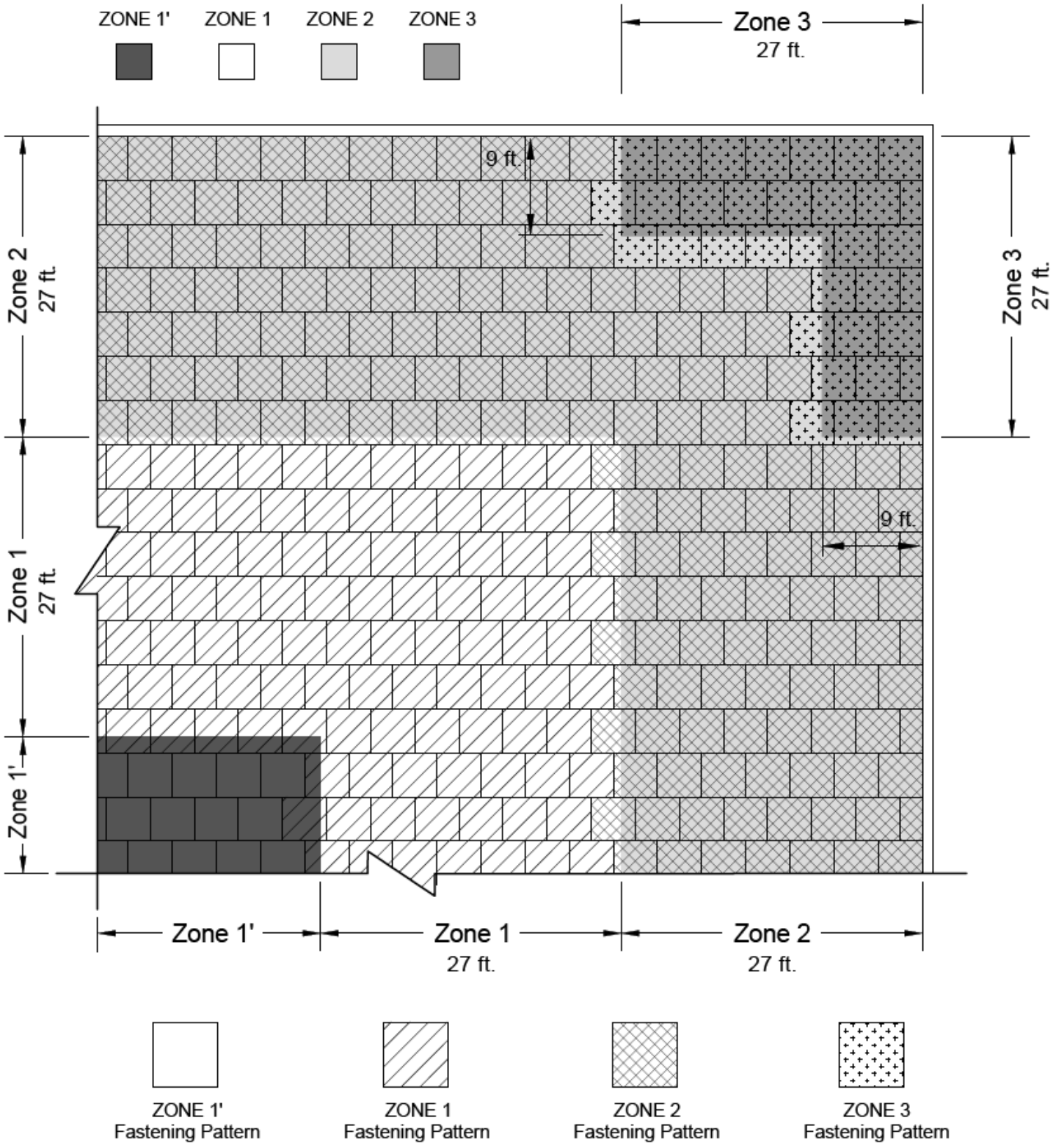
4 ft. x 4 ft. Boards

45 ft. building
0.6h = 27 ft.
0.2h = 9 ft.



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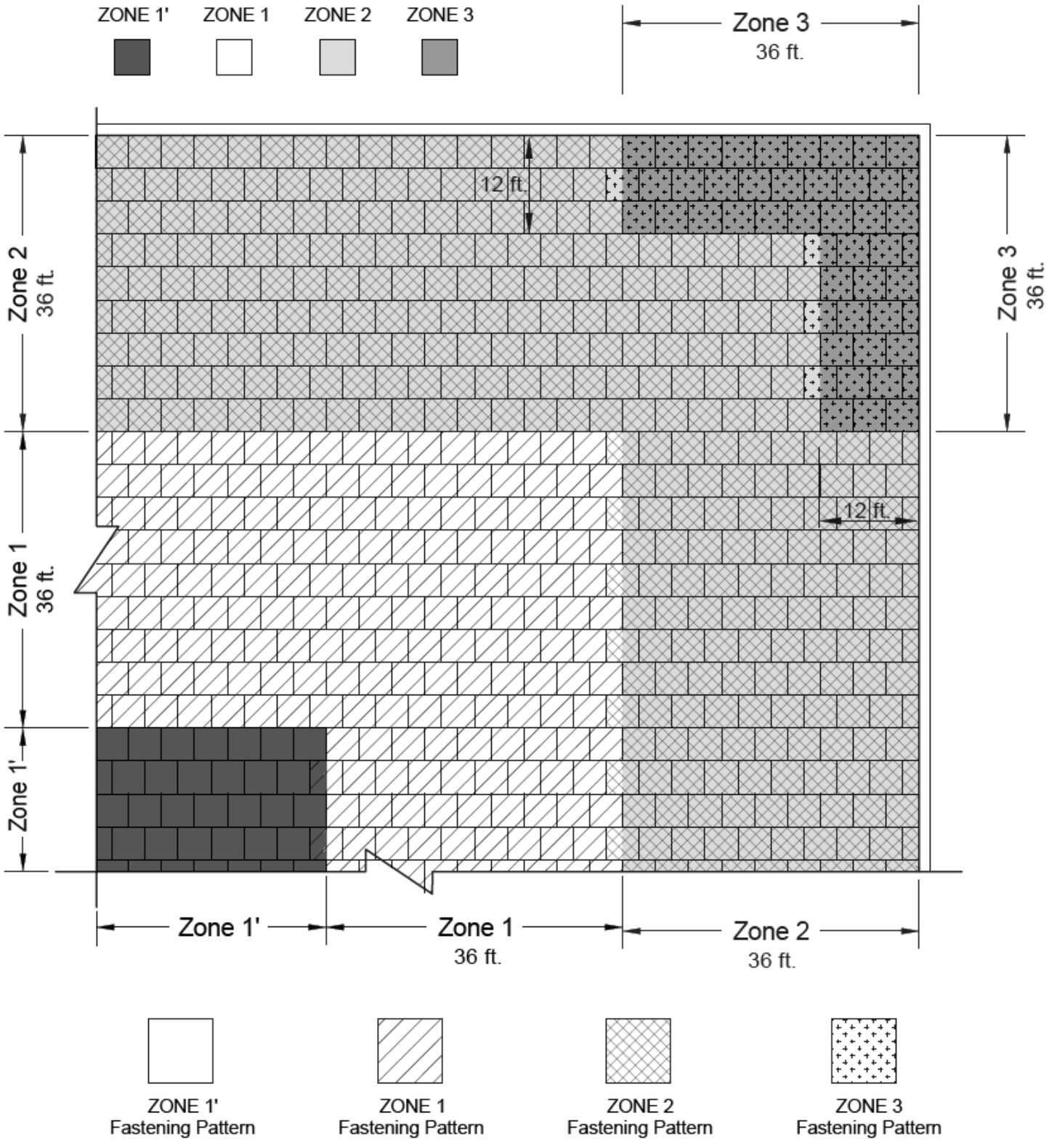
4 ft. x 4 ft. Boards

60 ft. building
0.6h = 36 ft.
0.2h = 12 ft.



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Drill-Tec™ RhinoBond® Attachment Roofing Systems

For Drill-Tec™ RhinoBond® roofing systems, corner and perimeter zones will be treated in the same manner as with adhered roof membranes installed over insulation boards.

Follow the fastening patterns found in the Drill-Tec™ RhinoBond® Attachment System Overview & General Requirements Manual. **Make sure to use Zone 1—not Zone 1'—as the basis for the field zone.**

Installation Considerations:

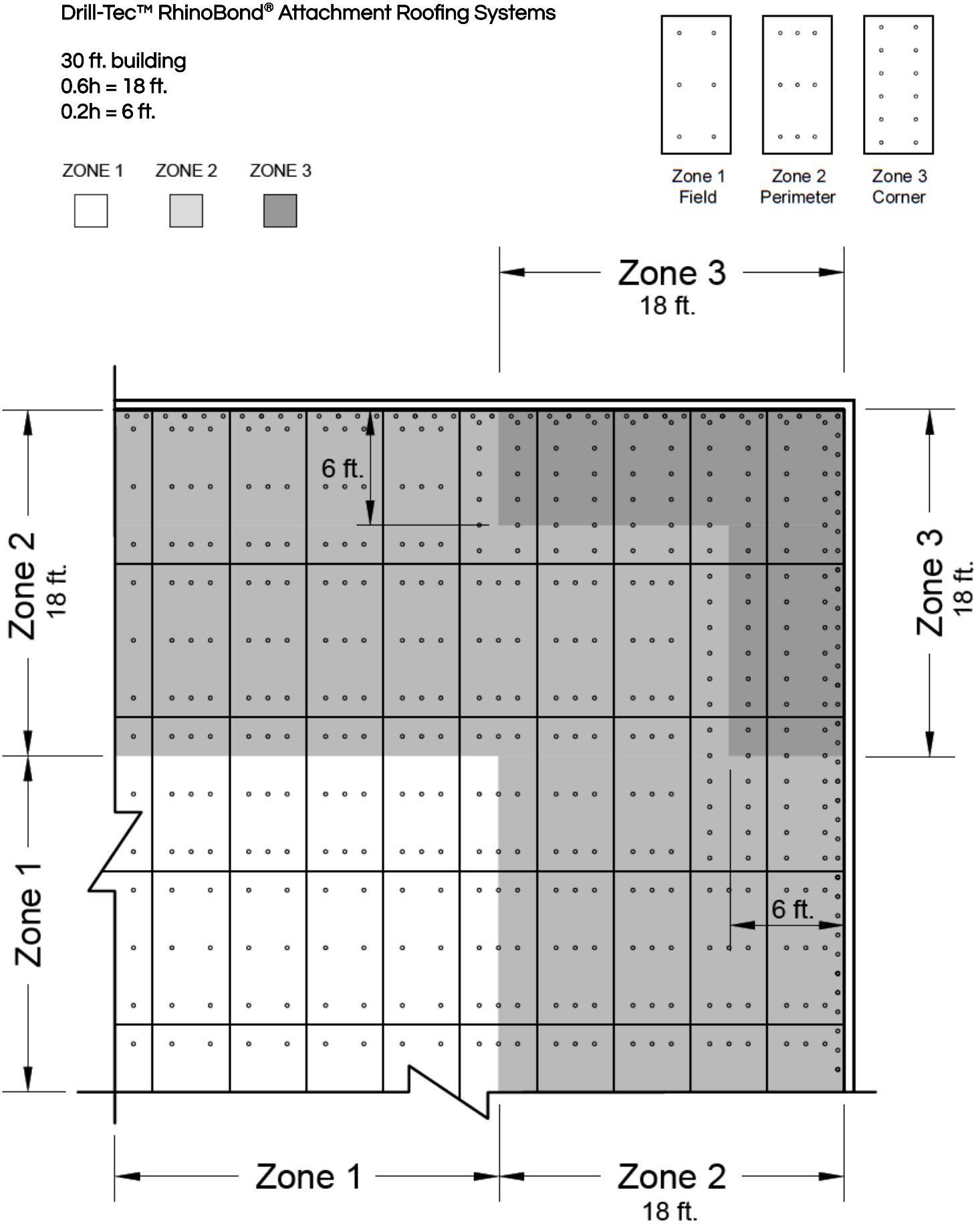
- With this method, **the L-shaped corner zones (Zone 3) should be followed.** This is because the fastening pattern is based on fasteners per board and not fastener row spacing.
- If a portion of an insulation board extends into another zone, it must use the higher fastening pattern.
- Consider treating Zone 1' as Zone 1. This will simplify the roof zone layout by only having one "field" zone.

Important note: *If the project is an FM Global insured building, the requirements must be acceptable to their field engineering staff. See Appendix B for additional information from FM 1-29 regarding adhered roofing systems.*

Following is an example for a 30 ft. tall building using Drill-Tec™ RhinoBond® attachment system.

Drill-Tec™ RhinoBond® Attachment Roofing Systems

30 ft. building
0.6h = 18 ft.
0.2h = 6 ft.



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Appendix A: ASCE 7 Comparison

There are some noteworthy differences between the three ASCE 7 editions and they include: the wind speed maps, roof zones, enclosure classifications, external pressure coefficients, and the equation to calculate velocity pressures.

Wind Speed Maps

	ASCE 7-05	ASCE 7-10	ASCE 7-16
Maps	One map for contiguous US and Alaska	Three maps for contiguous US and Alaska: • Category I buildings • Category II buildings • Category III and IV buildings	Four maps for contiguous US and Alaska: • Category I buildings • Category II buildings • Category III buildings • Category IV buildings Additional wind speed maps for Hawaii.
Design Method	Wind speeds based on determining ASD pressures.	Wind speeds based on determining Ultimate (Strength) Design pressures.	Wind speeds based on determining Ultimate (Strength) Design pressures.

Roof Zones

ASCE 7-05 and ASCE 7-10 have three roof zones: field, perimeter and corner. ASCE 7-16 added another zone and it presents the potential to have four roof zones: interior, field, perimeter and corner. The calculations to determine the zone dimensions also changed, see table below:

ASCE Edition	Zones	Zone Dimensions
ASCE 7-05 and ASCE 7-10	Zone 1 (field) Zone 2 (perimeter) Zone 3 (corner)	Zones 2 and 3: The smaller of 10% of least horizontal dimension or 0.4h; but not less than 4% of least horizontal dimension; or 3 feet.
ASCE 7-16	Zone 1' (interior) Zone 1 (field) Zone 2 (perimeter) Zone 3 (corner)	Zones 1 and 2: Width is 60% of building height. Zone 3: "L-shaped" with the width being 20% of building height and length is 60% of building height.

Variables used to Determine Wind Uplift Pressures

The formula to determine design wind uplift pressures (p) is:

$p = q_h [(GC_p) – (GC_{pi})]$

where:

q_h = velocity pressure
GC_p = external pressure coefficient
GC_{pi} = internal pressure coefficient

Comparing ASCE 7-05, ASCE 7-10 and ASCE 7-16, there are differences to the three variables and they are explained below.

Velocity pressure (q_h): This is determined by an equation which has changed slightly with each edition of ASCE 7.

ASCE 7-05 Velocity Pressure Equation

$$q_h = 0.00256 (K_z)(K_{zt}) (K_d) (V^2)(I)$$

Where:
q_h = velocity pressure at mean roof height
K_z = exposure coefficient based on exposure and height
K_{zt} = topography factor
K_d = wind directionality factor
V = basic wind speed for the location
I = Importance Factor (based on Occupancy Category)

ASCE 7-10 Velocity Pressure Equation

$$q_h = 0.00256 (K_z)(K_{zt}) (K_d) (V^2)$$

The Importance Factor (I) was removed from the equation because the three wind maps in ASCE 7-10 take into account the Risk Category. Therefore, what was considered the "Importance Factor" is addressed by the wind speeds in each map.

ASCE 7-16 Velocity Pressure Equation

$$q_h = 0.00256 (K_z)(K_{zt}) (K_d) (K_e) (V^2)$$

A ground elevation factor (K_e) was added to adjust for air density at higher elevations. It is permitted by ASCE 7-16 to be 1.0 for all locations. Using 1.0 is most conservative.

External Pressure Coefficient (GC_p): The external pressure coefficient values are based on roof zones and the appropriate "effective wind area." Effective wind area is the tributary area for the element being considered, and 10 sq. ft. is typically used for roof systems.

The external pressure coefficients values were the same in 2005 and 2010, but were increased in ASCE 7-16, see table below:

Zone	ASCE 7-05 and ASCE 7-10	ASCE 7-16
Zone 1' (interior field)	n/a	-0.9
Zone 1 (exterior field)	-1.0	-1.7
Zone 2 (perimeter)	-1.8	-2.3
Zone 3 (corner)	-2.3	-3.2

Internal Pressure Coefficient (GC_{pi}): The internal pressure coefficient value is determined by the "Enclosure Classification" of a building. This factor relates to the possibility that a building will become internally pressurized during a wind event.

The enclosure classifications were the same in 2005 and 2010, but ASCE 7-16 added a "Partially Open" category. See table below:

Enclosure Classification	ASCE 7-05 and ASCE 7-10	ASCE 7-16
Enclosed	- 0.18	- 0.18
Partially Enclosed	- 0.55	- 0.55
Open	0.0	0.0
Partially Open	n/a	- 0.18

Appendix B: FM 1-29 Prescriptive Enhancements for Perimeters and Corners

This appendix contains excerpts from FM Global Property Loss Prevention Data Sheet 1-29, "Roof Deck Securement and Above-Deck Roof Components" (FM 1-29) on their prescriptive enhancements for Zones 2 and 3 regarding:

- Mechanically attached and Drill-Tec™ RhinoBond® attached single-ply roof membranes
- Adhered roof membranes installed over insulation boards

Mechanically Attached and Drill-Tec™ RhinoBond® Single-ply Roof Membranes

The information below is limited to **mechanically attached single-ply roof membranes** installed over **cementitious panel, wood and steel decks**. Please refer to FM 1-29 for additional requirements and information.

FM 1-29 has the following parameters for permitting prescriptive enhancement:

- The rows of roof cover fasteners should run perpendicular to the steel deck ribs, and the deck should be designed to resist the design wind pressure applied at the roof cover fastener row spacing.
- The Zone 2 and 3 enhancements should be extrapolations based on Zone 1 and not Zone 1'.

The following section from FM 1-29 is specific to conventional mechanically attached and Drill-Tec™ RhinoBond® attached (point-attached) single-ply membranes:

> *"2.2.10.11 Mechanically Fastened Single-Ply (MFSP) Membrane Covers: Design Recommendations*
>
> *This section is applicable to both in-seam and point-attached single-ply roof membranes.*
>
> *2.2.10.11.1 Install a roof system in Zone 2 and Zone 3 using one of the following options:*
>
> A. *Enhance FM Approved MFSP roof covers in Zone 2 and Zone 3 in a performance-based manner as follows:*
>
> 1. *Reduce the distance between rows of roof cover fasteners and stress plates or batten bars in Zone 2 and Zone 3 by dividing by the ratio of the required rating for the respective zone to Zone 1. […]*
>
> B. *Prescriptively enhance FM Approved MFSP roof covers in Zone 2 and Zone 3 by reducing the distance between rows of roof cover fasteners and stress plates or batten bars using one of the following options, as applicable:*
>
> 1. *Zone 2: For single-plies fastened in rows, ensure the distance between rows is no more than 67% of the FM Approved spacing for the needed wind uplift resistance rating, or one row of intermediate fasteners is provided in between (See Example 2.)*

2. *Zone 3: For single-plies fastened in rows, the distance between rows is no more than 50% of the FM Approved spacing for the needed wind uplift resistance rating, or one row of intermediate fasteners is provided in between.*

   NOTE: *Intermediate securement for single-plies fastened in rows may be provided by installing intermediate fastener rows over the roof cover and providing a seal strip over it, or by pre-fastening an FM Approved intermediate bonding strip in its center and adhering the underside of the roof cover to the top of both sides of the bonding strip.*

3. *Zone 2: For point-attached single-plies, decrease the spacing between fastener points in one or both directions. Ensure total tributary area to each fastener is no more than 67% of the FM Approved spacing. (See Example 3.)*

4. *Zone 3: For point-attached single-plies, decrease the spacing between fastener points in one or both directions. Ensure total tributary area to each fastener is no more than 50% of the FM Approved spacing. (See Example 3.)*

Increased fastening density for single-ply membranes is obtained by using narrower sheets, underside securement methods, or through-fastening covered by seal strips. Fastening increase is not obtained by increasing the number of fasteners along each row, unless substantiated by FM Approval. Increased securement by reducing the distance between rows is recommended as it also reduces deck bending stress and provides better load distribution to the deck securement."

Adhered Single-ply Roof Membranes Installed Over Insulation Boards

The following excerpts are taken from FM 1-29 and are applicable for above-deck roof components used in adhered membrane roofing systems, over all roof decks except lightweight insulating concrete (LWIC) decks:

"2.2.10.1 Wind Uplift Resistance

2.2.10.1.1 Provide one of the following options to secure Zones 2 and 3:

A. *Use a roof system with an FM Approval wind uplift rating that is acceptable for Zones 1', 1, 2, and 3 per the Ratings Calculator of RoofNav or DS 1-28. That could entail using a system throughout the entire roof that had a wind rating adequate for Zone 3, or using a system that has a varied fastener spacing and multiple wind ratings that are adequate for the respective roof zone.*

B. *Use the appropriate prescriptive recommendation noted in Section 2.2.10.1.2.*

In either case, ensure any whole or partial insulation board or roof cover/base sheet width (when the roll is parallel to the building edge) that falls within the calculated Zone 1, Zone 2, or Zone 3 area has the increased securement applied over the entire board or roof cover/base sheet width.

2.2.10.1.2 Use prescriptive enhancements for Zone 2 and Zone 3 (for all deck types) where roof covers are adhered to some combination of insulation or cover board as long as one of the following conditions applies:

A. *The recommended Zone 1 rating needed per DS 1-28 in any location does not exceed Class 1-90 (3.6 kPa), or*

B. *The building is in a non-tropical cyclone-prone region (see Appendix A) and the recommended Zone 1 rating per DS 1-28 does not exceed Class 1-105 (4.3 kPa).*

2.2.10.1.2.1 For either of the above conditions, increase the securement over the FM Approved Zone 1 rating as follows:

A. *For assemblies using insulation fasteners, enhance the fastening as follows:*

1. *Increase the number of fasteners per board by 50% minimum in Zone 2, but at least one fastener per 2 ft^2 (1 per 0.19 m^2). It is not necessary to install fasteners closer than one per 1 ft^2 (1 per 0.09 m^2).*

2. *Install one fastener per 1 ft^2 (1 per 0.09 m^2) in Zone 3.*

3. *Round up to the next whole number of fasteners, if necessary*

B. *For components adhered with adhesives applied in ribbons, spots, etc., reduce the spacing between ribbons or spots over the FM Approved spacing for the given wind rating as noted below (round down to a dimension that is practical with respect to board sizes, applicators, etc.):*

1. *In Zone 2, not more than 67% of the Zone 1 spacing between rows, or area.*

2. *In Zone 3, not more than 50% of the Zone 1 spacing between rows, or area.*

Note: If the FM Approval wind rating already meets the higher criteria for Zone 2 or Zone 3, no further reduction is needed in those areas."

The following is applicable to multi-ply roof covers with mechanically attached base sheets:

"2.2.10.14 Multi-Ply Roof Covers with Mechanically Attached Base Sheets: Fastener Installation Recommendations

2.2.10.14.1 Enhance the securement for FM Approved base sheets using one of the following methods:

A. *Use an assembly that has a wind rating that is FM Approved for the required Zone 3 rating, or FM Approved systems that have adequate wind ratings for the respective Zones.*

B. *Reduce the spacing between rows of fasteners by using one intermediate row in Zone 2 and Zone 3.*

C. *Reduce the area per fastener to no more than 67% of the FM Approved spacing in Zone 2, and no more than 50% of the FM Approved spacing in Zone 3.*

2.2.10.14.2 Install fasteners that engage lightweight insulating concrete (LWIC) no closer than 4 in. (100 mm) on center to avoid cracking the LWIC.

2.2.10.14.4 The above-deck portion of FM Approved roof assemblies may be used for the securement of mechanically fastened base sheets over non-FM Approved roof decks, such

as wood, if the deck span and securement is adequate and the fastener pullout resistance from the deck is adequate for the rated pressure and area proposed…"

The following is from Section 3.1.6-Wind Uplift and also applies to adhered roof covers installed over insulation boards:

"The 2019 revision of Data Sheet 1-28 and 1-29 introduced a new interior roof zone, Zone 1', and altered the shape of the former perimeter and corner, now referred to as Zone 2 and Zone 3. Refer to Data Sheet 1-28, Section 3.2.2 for a visual representations of roof zones.

Zone 1':

Roof Zone 1' is not present on all buildings. It is located on buildings within stated parameters of roof slope, building size, and orientation as specified within Data Sheet 1-28. For buildings that do not include Zone 1', the entire roof area inboard of Zone 2 and Zone 3 is Zone 1. For buildings that include Zone 1', Zone 1' is the inboard roof area of a narrow, rectangular, perimeter strip-shaped Zone 1, where Zone 1 is located immediately inboard of Zone 2 and Zone 3. Due to significant differences in the required wind uplift pressures resistance between Zone 1' and other roof zones, there are limited options with regard to roof deck securement and above-deck roof components in Zone 1' relative to other Zones. It is acceptable to use the same construction in Zone 1' as used in Zone 1. This is a conservative approach regarding wind uplift resistance. The other option for Zone 1' is to treat it completely separately from the other roof zones. In this scenario, the wind uplift pressure for Zone 1' is determined from Data Sheet 1-28 and guidance is followed for Zone 1 from Data Sheet 1-29 using the wind uplift pressure for Zone 1' within the location of Zone 1' on the roof only. (For example, if a wind rating of 60 psf is required for Zone 1', follow all guidance in the data sheets stated for Zone 1 at a rating of 60 psf for roof deck securement and above-deck roof components in the Zone 1' area of the roof. Then, for Zones 1, 2 and 3 of the roof, follow guidance as stated at the appropriate pressures for the respective zone.) NOTE: There is no relationship between Zone 1' and other zones for prescriptive enhancement recommendations. Subsequently, for roof deck securement and above deck roof components in Zones 1, 2 and 3, guidance should be followed as stated in those areas.

Zone 2 and Zone 3:

To compensate for increased pressures in Zone 2 and Zone 3, special roof deck and above-deck component fastening is recommended. To provide adequate resistance for these higher wind pressure areas, one of the following can be done:

A. *A roof system that is wind rated for Zones 1', 1, 2, and 3 may be used. This could consist of the same system throughout, or a higher-rated system requiring more fasteners could be provided for Zone 2 and Zone 3. There are many FM Approved assemblies for use on concrete deck, and some assemblies for use on steel deck (with mechanically fastened covers or roofs adhered to dense cover boards), that are rated for several hundred psf.*

B. *A mechanically fastened cover may be used, with a reduced fastener row spacing in Zone 2 and Zone 3.*

C. *For relatively low wind-pressure designs, prescriptive enhancements may be used, consisting of providing additional insulation fasteners in Zone 2 and Zone 3 for adhered roof covers. This approach has limitations (described below), but is acceptable where one of the following conditions is met:*

1. *The NEEDED wind rating in Zone 1 is 90 psf (4.3 kPa) or less.*

2. *The roof is in a non-tropical cyclone-prone region where the design wind speed does not exceed 90 mph (40 m/s) and the roof height does not exceed 75 ft (23 m) in Surface Roughness Exposure (SRE) B or C. For partially enclosed buildings in SRE D, roof height is limited to 30 ft (9.1 m).*

Except where otherwise noted, it is not necessary to actually calculate the increased pressure. The increased fastening recommended for these areas is sufficient to resist these forces.

Prescriptive enhancements, such as providing additional insulation fasteners for adhered roof covers, will usually increase wind resistance. However, there is a practical limit to the additional wind resistance that can be achieved, as well as the reduction in area per fastener. Insulation fastener spacing less than 1 ft^2 (1 per 0.1 m^2) becomes impractical and yields diminishing returns on wind uplift resistance because ultimately the roof cover may peel off the insulation, the roof insulation facer may delaminate, or the insulation or cover board itself may delaminate.

Even with a fastener spacing equal to or slightly greater than 1 ft^2 (1 per 0.1 m^2), the maximum wind resistance rating may be between 150 and 195 psf (7.2 and 9.3 kPa), depending on the type of roof cover and insulation or topping board it is adhered to. Where higher wind ratings are needed for steel deck roofs in Zone 2 and Zone 3, higher wind uplift resistance can be achieved by using mechanically attached base plies or mechanically attached single-ply membranes because they are dependent on the resistance of the interaction of the fastener stress plate and the membrane, or the pullout of the screw from the deck, not the insulation board."

Appendix C: Roof Zone Layout Examples for a Non-rectangular Roof Plan

This appendix contains examples of roof zone layouts for a non-rectangular roof plan using:

- Conventional mechanically attached roofing systems
- Adhered roof membranes over insulation boards and Drill-Tec™ RhinoBond® roofing systems

Conventional Mechanically Attached Roofing Systems

As previously mentioned in this guide, corner zones (Zone 3), may be treated as perimeter zones (Zone 2) when it comes to fastener row spacing in conventional mechanically attached roof systems. This treatment is based on changes to FM Global Property Loss Prevention Data Sheet 1-29, "Roof Deck Securement and Above-Deck Roof Components" (FM 1-29). FM 1-29 was updated in February 2020. The Data Sheet includes revised parameters for fastener row spacing used in perimeter and corner zones.

For corners (Zone 3), the February update specifies that the distance between fastener rows be no more than 50% of the row spacing needed for the wind uplift resistance rating for Zone 1, or one row of intermediate fasteners. **Therefore, the row spacing in the corner zones can be the same as in the perimeter zones.**

Accordingly, the roof zone layouts for conventional mechanically attached roofing systems do not show corner zones (Zone 3).

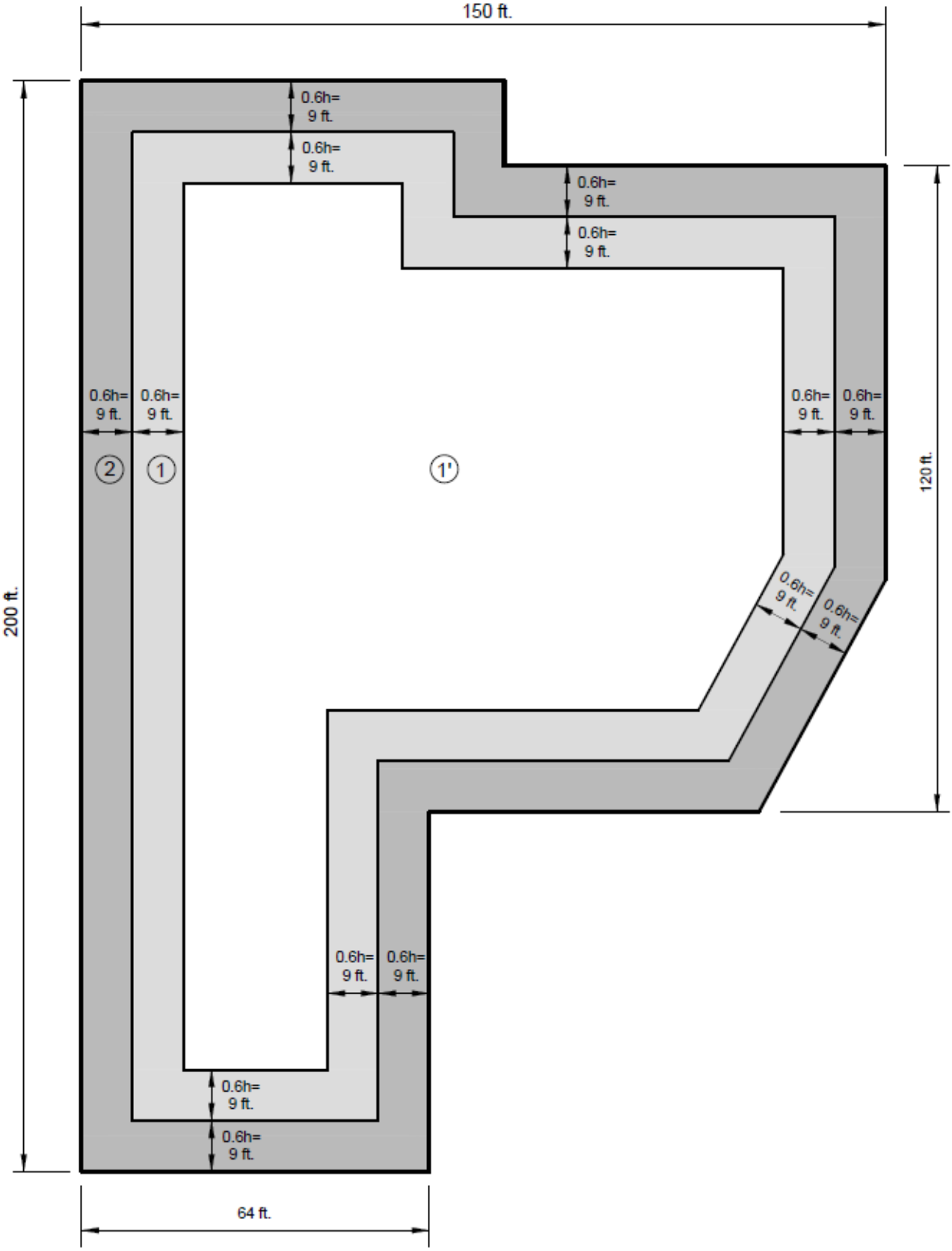
Adhered and Drill-Tec™ RhinoBond® Roofing Systems

However, roof zone layout is different for adhered roof membranes over insulation boards and Drill-Tec™ RhinoBond® roofing systems, because the fastening pattern is based on the number of fasteners per insulation board, not fastener row spacing. For these roof systems, the corner zones (Zone 3) are shown in the roof zone layouts.

The examples on the following pages are for 15, 30, 45 and 60 ft. tall buildings illustrating the roof zone layouts for:

- conventional mechanically attached roofing systems
- adhered roof membranes over insulation boards and Drill-Tec™ RhinoBond® roofing systems

Conventional mechanically attached roof systems
Example: 15 ft. building
0.6h = 9 ft.



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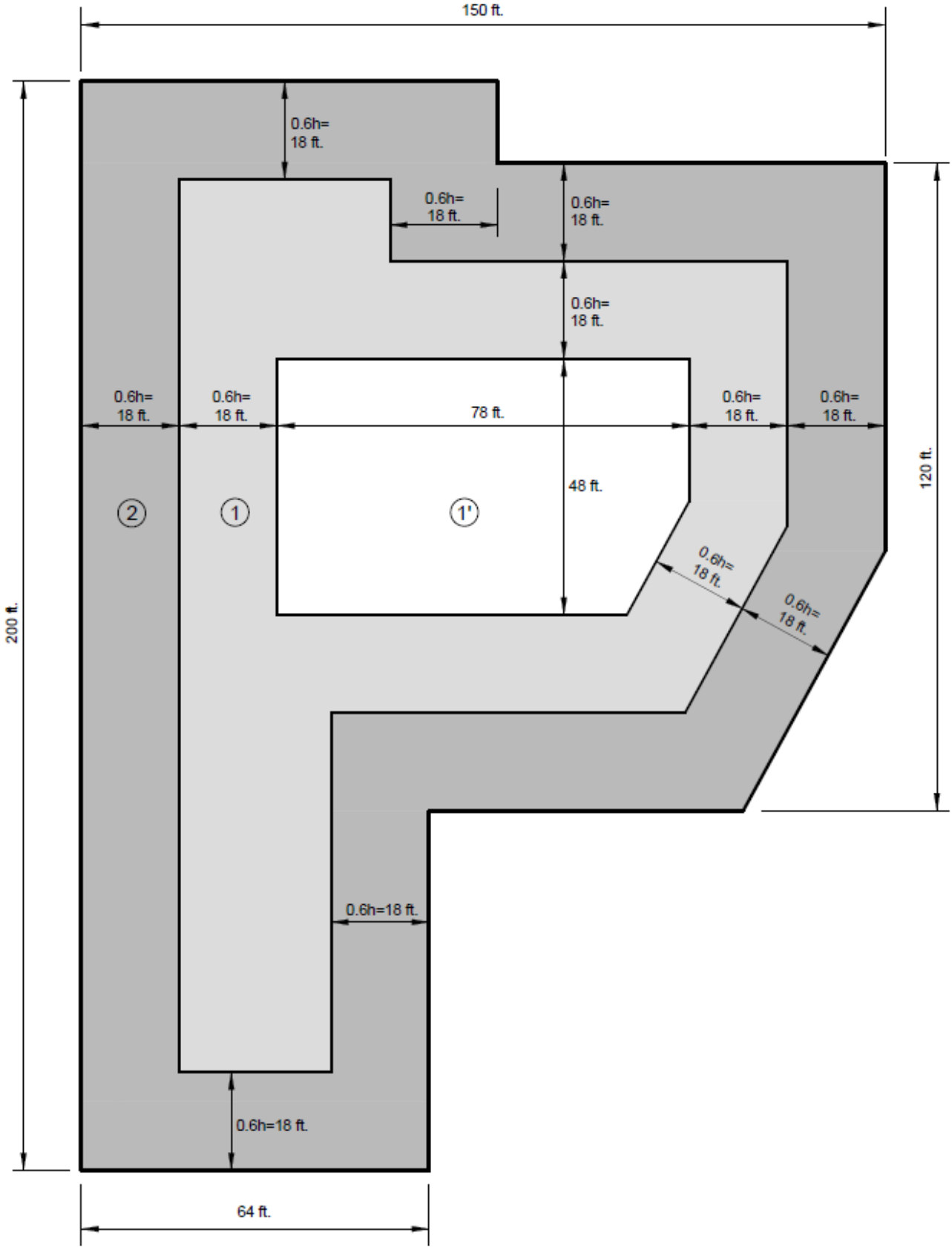
Conventional mechanically attached roof systems
Example: 30 ft. building
0.6h = 18 ft.



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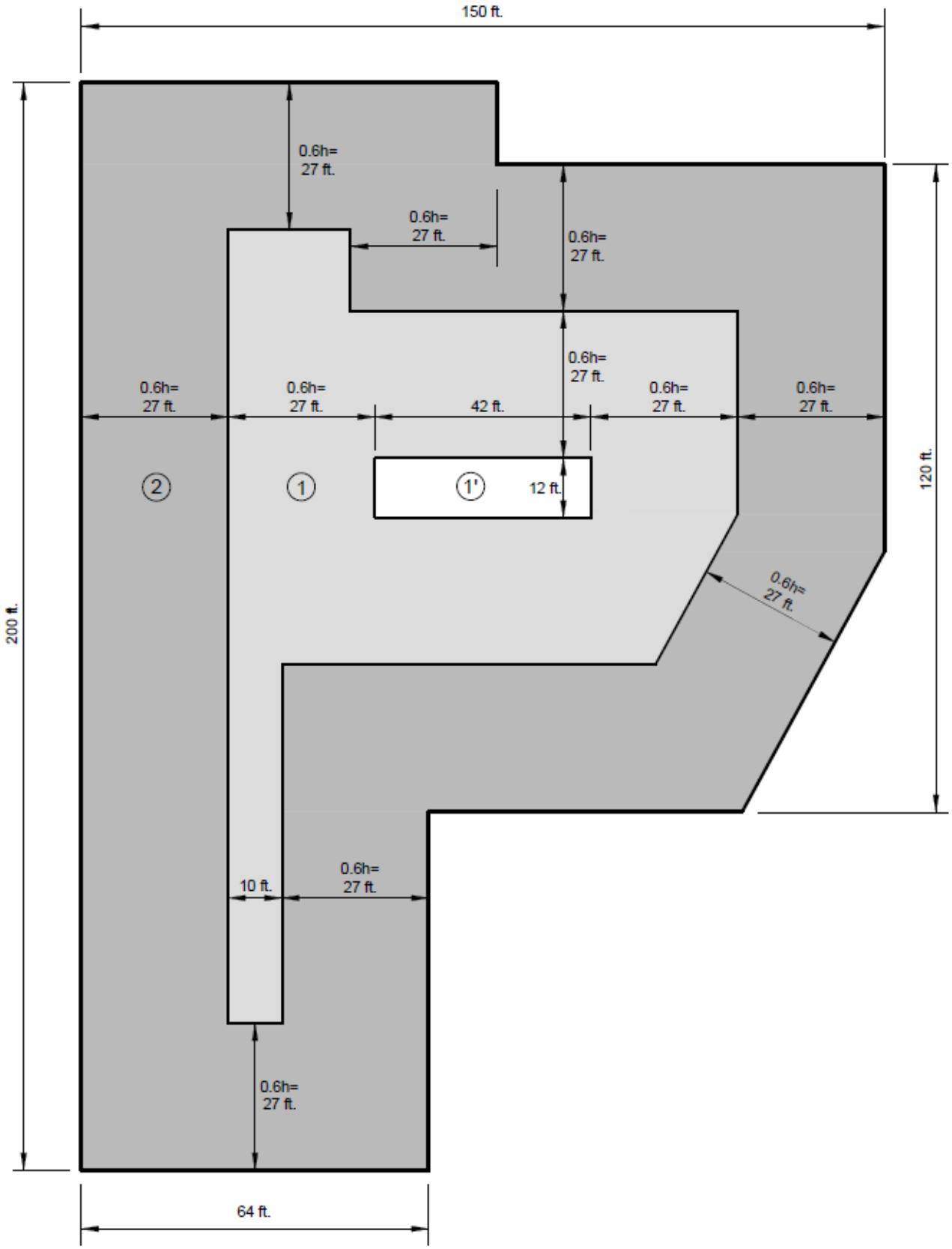
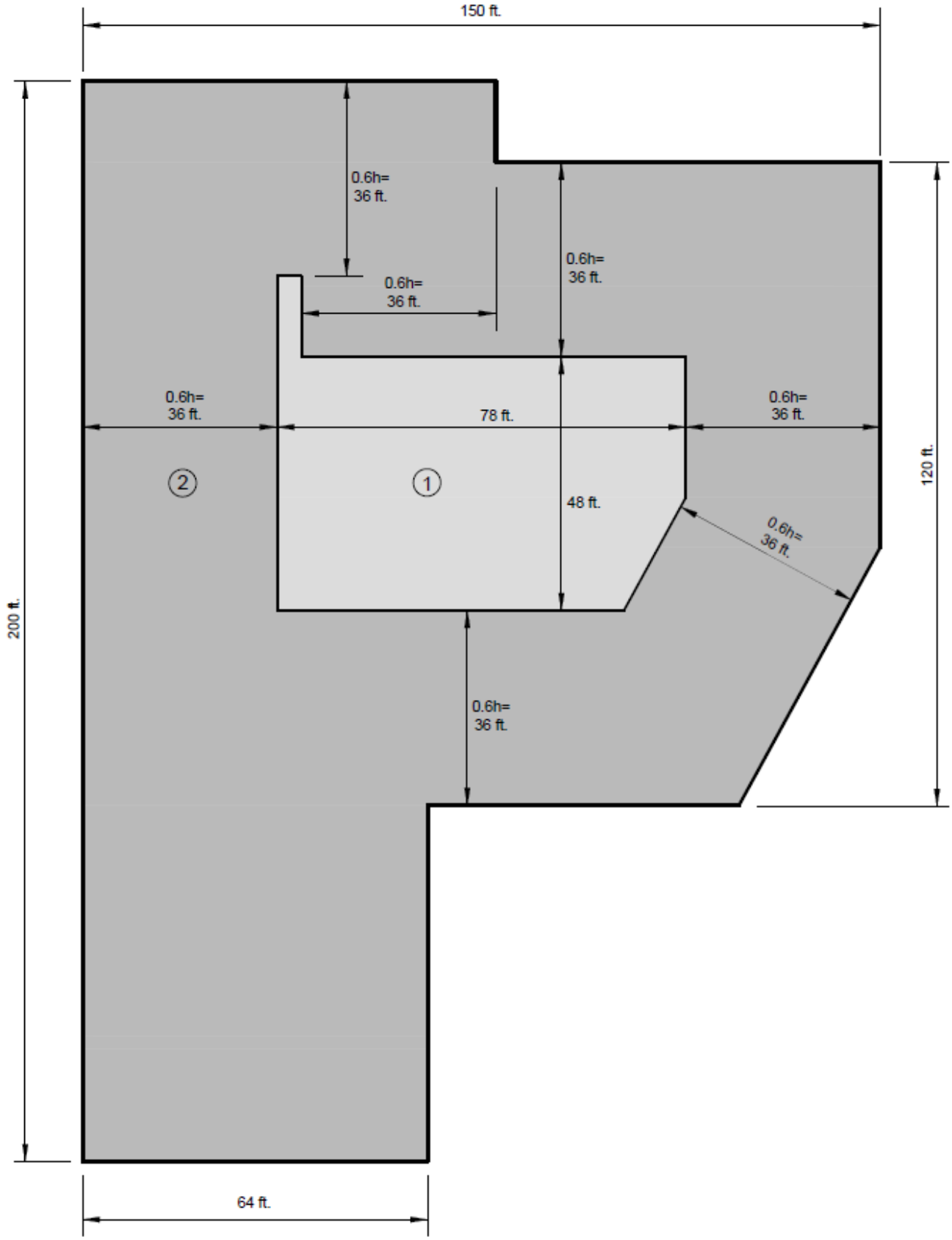
Conventional mechanically attached roof systems
Example: 45 ft. building
0.6h = 27 ft.



Conventional mechanically attached roof systems
Example: 60 ft. building
0.6h = 36 ft.



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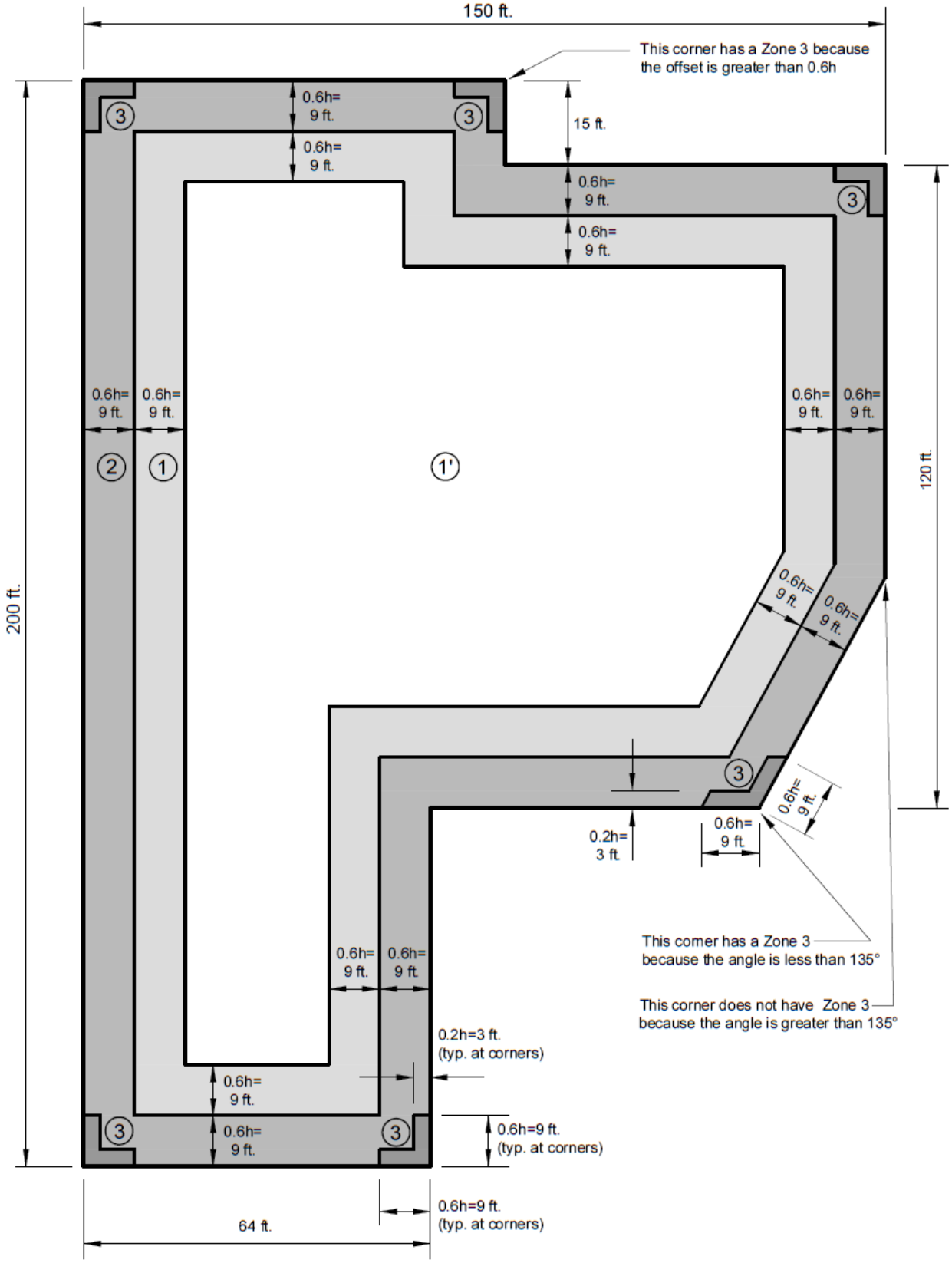
Example: 15 ft. building

0.6h = 9 ft.

0.2h = 3 ft.



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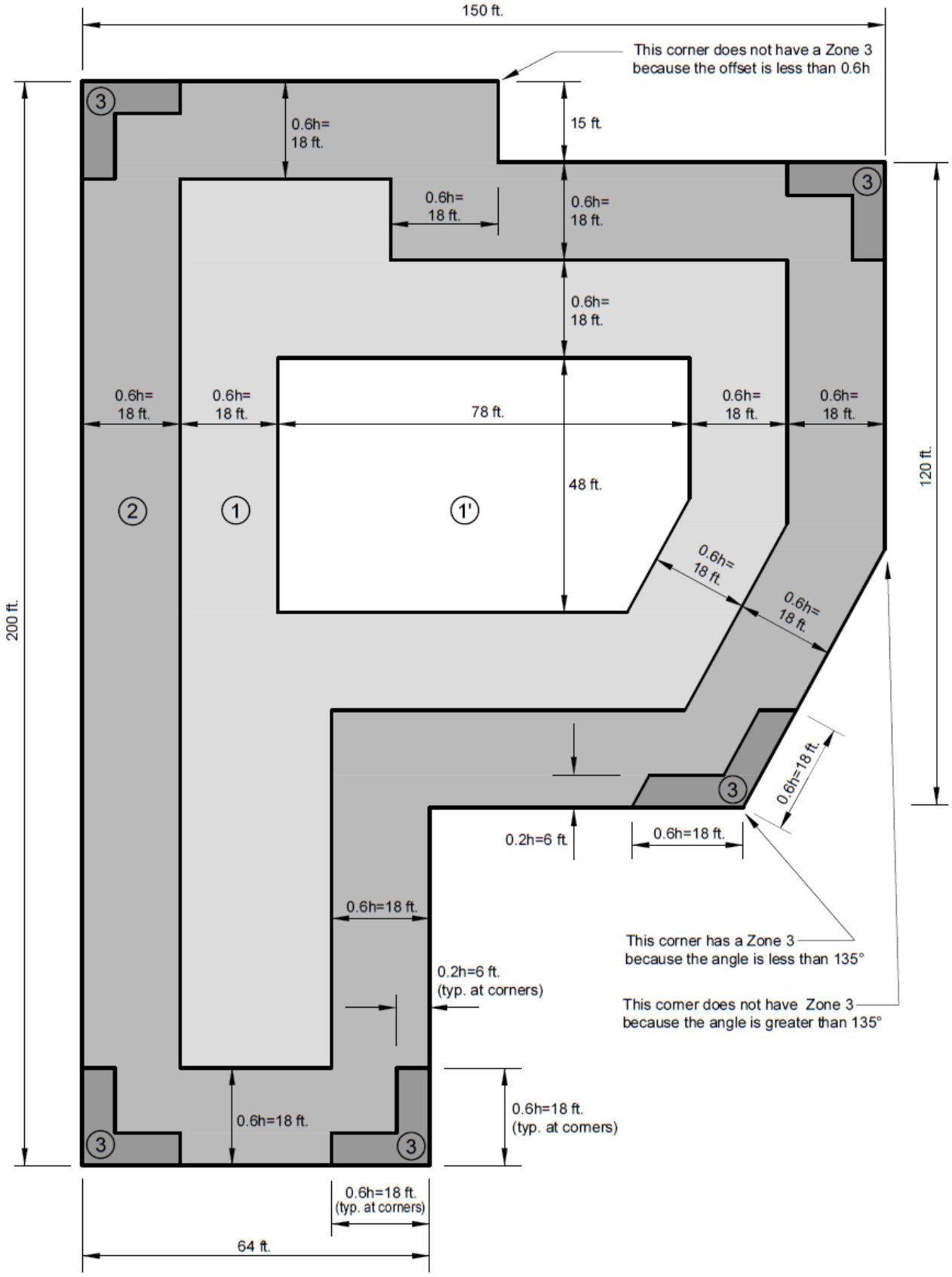
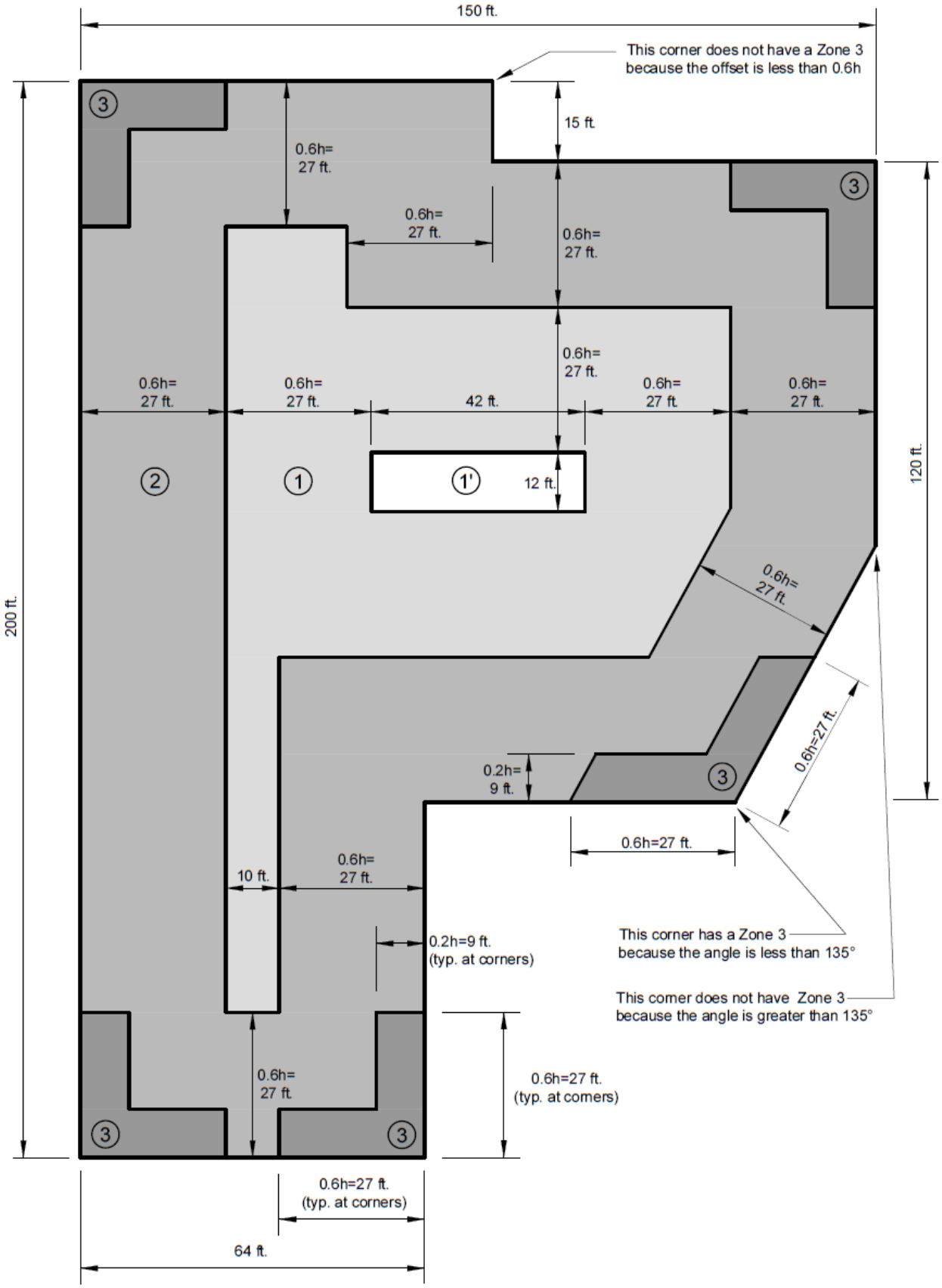
Example: 30 ft. building

0.6h = 18 ft.

0.2h = 6 ft.



Example: 45 ft. building
0.6h = 27 ft.
0.2h = 9 ft.



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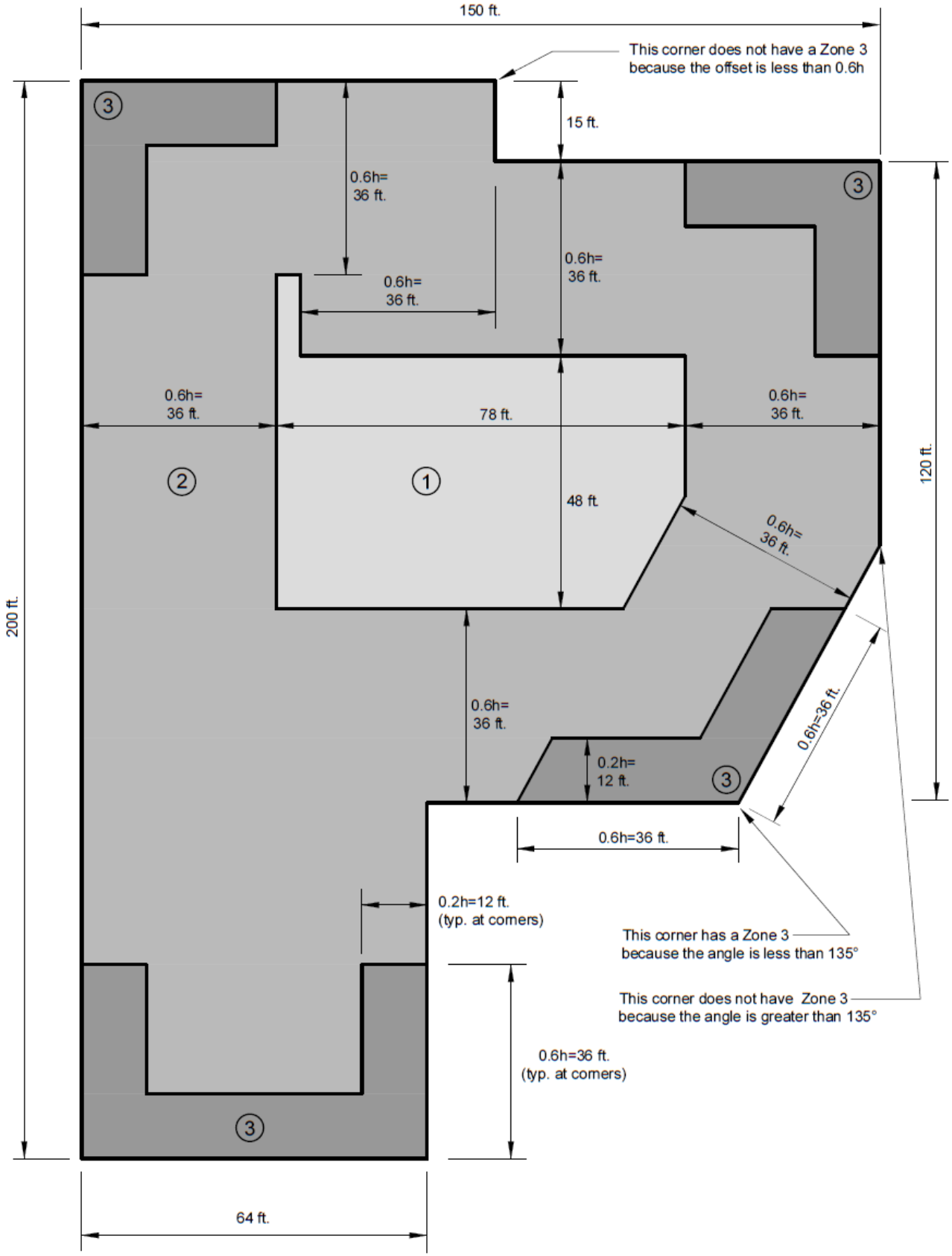
Adhered and Drill-Tec™ RhinoBond® Roofing Systems
Example: 60 ft. building
0.6h = 36 ft.
0.2h = 12 ft.