Tech Solutions 510.0

Ballast Design Guide for PMR Systems – for Wind-Uplift to 80 mph

INTRODUCTION

This document has been developed for those who design, specify or install protected membrane roof (PMR) systems to assist in the selection of job-specific stone and/or paver ballast design. PMR assemblies place **DuPont™ Styrofoam™ Brand Extruded Polystyrene Insulation** above the roofing membrane, protecting it from UV degradation, physical abuse, freeze-thaw cycling and the stress of temperature extremes. The application of roof ballast in accordance with this guide will protect the underlying filter fabric and insulation from displacement during wind and rainstorms. PMR systems should be installed in accordance with the recommendations of this guide, those of DuPont's Protected Membrane Roofing Installation Guidelines and good roofing practice. The recommendations in this Guide have been derived from an extensive series of wind tunnel tests of ballasted roofing systems at the National Research Council of Canada and from relevant sections of ANSI/SPRI RP-4 "Wind Design Standard for Ballasted Single-Ply Roofing Systems". This document first presents General Design Considerations, then a series of tables from which the proper ballast design can be selected. The final section describes the requirements for the four recommended ballast designs. It is the responsibility of the design professional and/or the installer to ensure that the PMR system is appropriately designed for each building.

General Design Considerations:
The following factors should be considered when designing a ballasted PMR system:

Roof Structure
The building structure must be appropriately designed to support all anticipated present and future loads on the roof.

Slope
The roof slope shall not exceed 2-inch vertical rise per horizontal foot (2:12)

Wind Speed
Determination of the factored design wind speed for buildings in Canada should reference Figure 1 (mph) or from the Authority Having Jurisdiction (AHJ). The 3-sec gust wind speed should be determined by applying a multiplying factor of 1.32 to the Figure 1 map speeds.

Determination of factored design wind speed for buildings in the USA will depend on the Exposure and Risk Category assigned to the project building and on the version of ASCE-7 wind map selected by the designer or mandated by the AHJ. It is imperative that the designer confirm the factored design wind speed in order to determine the correct ballast system. Figures 2 through 5 depict ASCE-7 Exposure C, Risk Categories I to IV Ultimate wind speeds for the USA and are shown for reference only. If the building is specified as Exposure B the designer must refer to the appropriate Exposure B ultimate design wind speed maps in ASCE 7-16. In any Risk or Exposure the map ultimate wind speeds need to be factored down by 0.774 to the working load.

Roof Height
A building may include numerous roof sections of different elevations. The height of each roof section is defined as the distance between ground level for that building section and the top of the ballast for that roof assembly.

Parapet Height
For the purpose of determining the appropriate ballast design, the parapet height shall be defined as the distance from the top of the ballast to the top of the parapet. If the height varies, the shortest parapet height should be used. For special cases, contact the DuPont Contact Center at 1-866-583-2583.

Gravel Stop
If a gravel stop is used at the building perimeter, its height above the ballast should be a minimum of 2" (50 mm) to contain the ballast.

Roof Areas Requiring Extra Ballast
Roof perimeters, corner areas, and large roof penetrations require additional ballast to reduce potential displacement of ballast and/or insulation during high wind loads or intense rainfalls. The weight and dimensions of those increased ballast zones are specific to the type of Ballast System recommended. Tables A and B shall be used to determine the required Ballast System. The specifications for each Ballast System are outlined further in this document.

Building Exposure

The surrounding terrain has an effect on the overall wind exposure of the building. The exposure categories used for PMR systems are defined pursuant to ASCE-7 criteria; as either B or C. Buildings in a "B" exposure are typically in urban areas with numerous, closely spaced obstructions having the size of a single-family dwelling or larger. Buildings in a C exposure are situated in an open terrain with scattered obstructions, including surface undulations or other irregularities having heights generally less than 30 ft. This category includes flat open country, grasslands and all water surfaces in hurricane prone regions.

When the building's location qualifies it as an Exposure D it is considered a special wind region. Thus, when determining ASCE 7-22 pressure calculations note the higher multiplier for that exposure.

Insulation selection

Thickness of insulation is based on thermal resistance required for the assembly while the type is based on the expected total dead and live load on it from rooftop equipment supported on sleepers or pedestals, rooftop planters and heavy pavers supported on pavers. STYROFOAM™ brand insulation is a thermoplastic material and long-term compressive loading may lead to compressive creep deformation. The transmitted stress to the surface of the insulation from dead and live loads must be kept at or below the recommended maximum loads of Table 1 below.

TABLE 1: Insulation Selection Table to Prevent Compressive Creep

DuPont™ Styrofoam™	Nominal Compressive Strength psi (kPa)	Maximum Loading*** psi (kPa)
Roofmate™	40 (275) *	13 (92)
Plazamate™ and Plazamate™ XR	60 (415) *	20 (140)
Highload 40	40 (275) **	13 (92)
Highload 60	60 (415) **	20 (140)

* Compressive strength measured at 10% deflection or yield whichever occurs first Concrete Pavers.

** Compressive strength measured at 5% deflection or yield whichever occurs first.

*** Maximum compressive load on insulation to limit compressive creep to < 2% after 50 years of service.

Concrete Pavers

Concrete pavers shall be manufactured from minimum 3,000 psi (20 MPa) air entrained concrete whose minimum weight shall be determined by the Requirements of PMR Ballast Designs listed further in this document.

Paver Venting

If paver ballast is to be used and will cover over 10 percent of the insulated area paver venting is needed. This may be provided with paver pedestals, a 1" (25mm) layer of clean pea gravel, rubber tabs, ribbed or footed concrete pavers or top surface ribbed insulation. In locations with HDD (heating degree day) values less than 3000 ºF-days (1670 °C-days), paver venting is not required.

Paver Strapping

Strapping of pavers should be accomplished with minimum 22 gauge, 3" wide x 12' long galvanized or stainless steel straps. Strapping shall be mechanically fastened to each paver with minimum 1/4" x 1-1/4" corrosion-resistant metal anchors, installed in predrilled holes. Zamac Nailin #2814 by Powers Fasteners, Inc. and TRUFAST Zamac Nailin by TRUFAST Corporation or similar fasteners are acceptable.

Filter Fabric

Stone ballast shall be installed over an approved filter fabric. Fabric prevents the migration of fine particles to the membrane level and prevents dislodgement of insulation boards in the event of roof flooding and floatation. The use of a filter fabric under paver ballast is optional.

Some acceptable fabrics include:

- American Hydrotech Incorporated - System Filter Fabric
- International Paper Company - Confil 689 H
- Phillips Fibers - Rufon P3B
- Thrace Linq GTF 200S
- Fabrene Spunbond PP Landscape Fabric

For more information on filter fabrics contact the DuPont Contact Center at 866-583-2583.

Controlled-Flow Drain Systems and Blue Roof (Water Retention) Designs

Blue Roof Systems and Control Flow Drain Roof Systems are roofing system designs that restrict the drainage of rainwater, slowing its release rate into sewer systems and mitigating the impact of water runoff. Depending on the intensity of rainfall, roof slope, drain flow characteristics, insulation thickness and ballast weight, the insulation may float once a threshold depth of water above the membrane is reached. As a guide, Table 1 shows the ballast required to prevent the insulation from floating when the ballast is not submerged or when it is fully submerged. The latter results in loss in effective ballast because of water's buoyancy effect on the submerged stone ballast. The recommended ballast takes this into account. For water retention roof design assistance please contact DuPont Contact Center at 1-866-583-2583.

CAUTION: The additional load from heavy ballast and/or deep water retention over the roof structure needs to be taken into account at the structural design stage. Water retention roofs and control flow drain systems should be designed to allow evacuation of retained water within 48 hours of maximum accumulation. Contact your DuPont representative for recommendations in cases of water retention assemblies.

TABLE 2: Ballast Requirement to Prevent Flotation

Insulation thickness inches (mm)	Ballast (non-submerged) lb/ft² (kg/m²)	Ballast (fully submerged) lb/ft² (kg/m²)
2.0 (50)	12 (59)	15 (88)
3.0 (75)	15 (74)	23 (110)
3.5 (90)	18 (86)	26 (129)
4.0 (100)	20 (98)	30 (147)
4.5 (115)	23 (110)	34 (165)
5.0 (125)	25 (123)	38 (184)
5.5 (140)	28 (135)	41 (202)
6.0 (150)	30 (147)	45 (221)
7.0 (175)	35 (172)	53 (257)
8.0 (200)	40 (196)	60 (294)
9 (225)	45 (221)	68 (331)
10.0 (250)	50 (246)	75 (368)

Options

Selection of the Proper PMR Ballast Design:
A designer of PMR systems has four ballast designs to choose from: Standard, #1, #2 and #3. The appropriate design is a function of building height, parapet height, membrane attachment and city's wind speed. Tables A and B show the recommended ballast designs for PMRs installed over Adhered Membranes and Loose-Laid Ballasted/Mechanically Fastened Membranes, respectively. These tables are organized by building and parapet height and list the ballast design that is required for each roof condition.
The recommended ballast design can be determined by using the appropriate Table A or B and considering to the following factors:

1. Building height
2. City's design wind speed
3. Parapet height
4. Building site exposure

If paver ballast is to be used and will cover over 10 percent of the insulated area, paver venting is needed. This may be provided with paver pedestals, a 1" (25mm) layer of clean pea gravel, rubber tabs, ribbed or footed concrete pavers or top surface ribbed insulation. In locations with HDD (heating degree day) values less than 3000 °F-days (1670 °C-days), paver venting is not required.

Technical Solutions 510.0 provides guidance and installation recommendations for DuPont's Protected Membrane Roof assemblies. This document does not provide information for compliance verification with building codes, project specifications, Factory Mutual or other agency requirement which are the sole responsibility of the design professional. As a supplier of material only, DuPont does not assume responsibility for error in design and/or engineering.

This document contains proprietary information generated by DuPont and is only intended to be used in conjunction with Styrofoam™ Brand Insulation in Protected Membrane Roofing Systems

Fire Resistance of PMR Assemblies

Protected Membrane Roofing assemblies meet the current Class A requirements of ASTM E108 Test Methods for Fire Test of Roof Coverings and UL790 Standard Test Methods for Fire Tests of Roof Coverings provided the ballast over the insulation is comprised of:

- Stone ballast applied at a minimum rate of 9 psf (44 kg/m²),
- Concrete pavers installed with a maximum paver separation gap of ¼" (6mm),
- Concrete pavers on pedestals with minimum 5/8" gap required for ventilation [1]
- Insulation with an integral covering of 3/8" (9 mm) latex modified mortar

Note 1 – UL listing TGFU.R3573

Warranties

Limited thermal and/or system warranty is available for approved project registered with DuPont and issued project specific warranty. Please contact your sales representative to determine if warranties apply in your region.

Table A: Ballast System for Adhered Membranes

A1 – Roof Heights: 12′ (3.7m) to 45′ (13.7m)

Parapet heights 2″ (.05m) gravel stops to 36″ (0.90m) high parapets					
Design Wind Speed (Figure 1)	Canada - Wind Speed on 50 yr. return period – 3-sec gust – mph (m/s)				
	90 (40)	100 (45)	110 (49)	120 (54)	130 & 140 (58 & 63)
Design Wind Speed (Figures 2 - 5)	USA - Wind Speeds based on 700 yr. return period – 3-sec gust - mph (m/s)				
	115 (51)	130 (58)	140 63	155 (69)	270 & 290 (120 & 129)
Site Exposure	C&B	C&B	C&B	C&B	C&B
Ballast design	Standard	1	1	1	2
Parapet heights > 36″ (0.9m)					
Design Wind Speed (Figure 1)	Canada - Wind Speed on 50 yr. return period – 3-sec gust – mph (m/s)				
	90 (40)	100 (45)	110 (49)	120 (54)	130 & 140 (58 & 63)
Design Wind Speed (Figutres 2 - 5)	USA - Wind Speeds based on 700 yr. return period – 3-sec gust - mph (m/s)				
	115 (51)	130 (58)	140 (63)	155 (69)	270 & 290 (120 & 129)
Site Exposure	C&B	C&B	C&B	C&B	C&B
Ballast design	Standard	Standard	Standard	Standard	1

A2 – Roof Heights: 45′ (13.7m) to 70′ (21.3m)

Parapet heights 6″ (.15m) gravel stops to 36″ (0.90m) parapet heights					
Design Wind Speed (Figure 1)	Canada - Wind Speed on 50 yr. return period – 3-sec gust – mph (m/s)				
	90 (40)	100 (45)	110 (49)	120 (54)	130 & 140 (58 & 63)
Design Wind Speed (Figures 2 - 5)	Equivalent ASCE 7-10 Basic Wind Speeds based on 700 yr. return period – 3-sec gust - mph (m/s)				
	115 (51)	130 (58)	140 63	155 (69)	270 & 290 (120 & 129))
Site Exposure	C&B	C&B	C&B	C&B	C&B
Ballast design	Standard	1	1	1	2
Parapet heights > 36″ (0.9m)					
Design Wind Speed (Figure 1)	Canada - Wind Speed on 50 yr. return period – 3-sec gust – mph (m/s)				
	90 (40)	100 (45)	110 (49)	120 (54)	130 & 140 (58 & 63)
Design Wind Speed (Figures 2 to 5)	USA - Wind Speeds based on 700 yr. return period – 3-sec gust - mph (m/s)				
	115 (51)	130 (58)	140 63	155 (69)	270 & 290 (120 & 129)
Site Exposure	C&B	C&B	C&B	C&B	C&B
Ballast design	Standard	Standard	Standard	Standard	Standard

A3 – Roof Heights: 70′ (21.3m) to 500′ (152.5m)

Parapets heights 18" (.416 m) to 36" (.91m) * 16″ parapet height allowed					
Design Wind Speed (Figure 1)	Canada - Wind Speed on 50 yr. return period – 3-sec gust – mph (m/s)				
	90 (40)	100 (45)	110 (48)	120 (54)	130 & 140 (58 & 63)
Design Wind Speed (Figures 2 - 5)	USA - Wind Speeds based on 700 yr. return period – 3-sec gust - mph (m/s)				
	115 (51)	130 (58)	140 63	155 (69)	270 & 290 (120 & 129)
Site Exposure	C&B	C&B	C&B	C&B	C&B
Ballast design, feet (m)					
> 70′ – 100 ft′ (> 21.3m – 31m)	1*	1	2*	2	2
> 100′ - 200′ (31m - 61m)	1	2*	2*	2	3
>200′ - 300′ (> 61m - 92m)	1	2*	2	3	3a
> 300′ - 400′ (> 92m - 122m)	2	2	2	3	3a
> 400′ - 500′ (> 122m - 152m)	2	2	3	3	3b

NOTE: Roofs above 500 ft (152 m) contact DuPont at 1-866-583-2583 NR = Not Recommended **3a** = 2′ x 2′ x 2″ Hanover Guardian Pavers (not to exceed -81 psf design) **3b** = 2′ x 2′ x 3″ Hanover or Guardian Pavers (not to exceed -91 psf design) or other lockdown pavers approved by DuPont.

A4 – Roof Heights: 70′ (21.3m) to 500′ (152.5m)

Parapet heights > 36″ (0.9m)

Design Wind Speed (Figure 1)	Canada - Wind Speed on 50 yr. return period – 3-sec gust – mph (m/s)				
	90 (40)	100 (45)	110 (49)	120 (54)	130 & 140 (58 & 63)
Design Wind Speed (Figures 2 - 5)	USA - Wind Speeds based on 700 yr. return period – 3-sec gust - mph (m/s)				
	115 (51)	130 (58)	140 63	155 (69)	270 & 290 (120 & 129)
Site Exposure	C&B	C&B	C&B	C&B	C&B
Ballast design, feet (m)					
> 70′ – 100 ft′ (> 21.3m – 31m)	Standard	1	1	1	1
> 100′ - 200′ (31m - 61m)	Standard	1	1	1	2
>200′ - 300′ (> 61m - 92m)	1	1	1	1	2
> 300′ - 400′ (> 92m - 122m)	1	1	1	2	2
> 400′ - 500′ (> 122m - 152m)	1	1	2	2	3

Table B: Ballast System for Loose-Laid Ballasted or Mechanically Attached Membranes
Roof Heights: Up to150 ft (46 m) max

Parapet heights (.05m) gravel stops to 5.9″ (0.15m)

Design Wind Speed (Figure 1)	Canada - Wind Speed on 50 yr. return period – 3-sec gust – mph (m/s)					
	90 (40)	100 (45)	110 (48)	120 (54)	130 (58)	140 (63)
Design Wind Speed (Figures 2 - 5)	USA - Wind Speeds based on 700 yr. return period – 3-sec gust - mph (m/s)					
	115 (51)	130 (58)	140 63	155 (69)	270 (120)	290 (129)
Site Exposure	C B	C B	C B	C B	C B	C B
Ballast design, feet (m)						
0 – 15 (0 – 4.6)	S S	1 S	1 1	1 1	2 2	NR 3
>15 – 30 (>4.6 – 9.1)	S S	1 S	1 1	1 1	2 2	NR 3
>30 – 60 (>9.1 – 18.3)	1 1	1 1	2 2	2 2	3 3	NR NR
>60 – 90 (>8.3 – 27.4)	2 2	2 2	2 2	3 3	NR NR	NR NR
>90 – 120 (>27.4 – 36.6)	2 2	2 2	3 3	NR NR	NR NR	NR NR
>120 – 150 (>36.6 – 46)	2 2	2 2	3 3	NR NR	NR NR	NR NR

Parapet heights from 6″ (0.015 m) to 11.9″ (0.30 m)

Design Wind Speed (Figure 1)	Canada - Wind Speed on 50 yr. return period – 3-sec gust – mph (m/s)					
	90 (40)	100 (45)	110 (48)	120 (54)	130 (58)	140 (63)
Design Wind Speed (Figures 2 - 5)	USA - Wind Speeds based on 700 yr. return period – 3-sec gust - mph (m/s)					
	115 (51)	130 (58)	140 63	155 (69)	270 (120)	290 (129)
Site Exposure	C B	C B	C B	C B	C B	C B
Ballast design, feet (m)						
0 – 15 (0 – 4.6)	S S	1 S	1 1	1 1	2 2	3 3
>15 – 30 (>4.6 – 9.1)	S S	1 S	1 1	1 1	2 2	3 3
>30 – 60 (>9.1 – 18.3)	1 1	1 1	1 1	2 2	3 3	NR 3
>60 – 90 (>8.3 – 27.4)	2 2	2 2	2 2	3 3	NR NR	NR NR
>90 – 120 (>27.4 – 36.6)	2 2	2 2	3 3	NR NR	NR NR	NR NR
>120 – 150 (>36.6 – 46)	2 2	2 2	3 3	NR NR	NR NR	NR NR

NOTE: For roofs above 500 ft (152 m) contact DuPont at 1-866-583-2583
NR = Not Recommended

Parapet heights from 12" (0.30 m) to 17.9" (0.45 m)

Design Wind Speed (Figure 1)	Canada - Wind Speed on 50 yr. return period – 3-sec gust – mph (m/s)											
	90 (40)		100 (45)		110 (48)		120 (54)		130 (58)		140 (63)	
Design Wind Speed (Figures 2 - 5)	USA - Wind Speeds based on 700 yr. return period – 3-sec gust - mph (m/s)											
	115 (51)		130 (58)		140 63		155 (69)		270 (120)		290 (129)	
Site Exposure	C	B	C	B	C	B	C	B	C	B	C	B
Ballast design, feet (m)												
0 – 15 (0 – 4.6)	S	S	1	S	1	1	1	1	2	2	3	3
>15 – 30 (>4.6 – 9.1)	S	S	1	S	1	1	1	1	2	2	3	3
>30 – 60 (>9.1 – 18.3)	1	1	1	1	1	1	2	2	3	3	NR	3
>60 – 90 (>8.3 – 27.4)	2	2	2	2	2	2	3	3	NR	NR	NR	NR
>90 – 120 (>27.4 – 36.6)	2	2	2	2	3	3	NR	NR	NR	NR	NR	NR
>120 – 150 (>36.6 – 46)	2	2	2	2	3	3	NR	NR	NR	NR	NR	NR

Parapet heights from 18" (0.45 m) to 23.9" (0.60 m)

Design Wind Speed (Figure 1)	Canada - Wind Speed on 50 yr. return period – 3-sec gust – mph (m/s)											
	90 (40)		100 (45)		110 (48)		120 (54)		130 (58)		140 (63)	
Design Wind Speed (Figures 2 - 5)	USA - Wind Speeds based on 700 yr. return period – 3-sec gust - mph (m/s)											
	115 (51)		130 (58)		140 63		155 (69)		270 (120)		290 (129)	
Site Exposure	C	B	C	B	C	B	C	B	C	B	C	B
Ballast design, feet (m)												
0 – 15 (0 – 4.6)	S	S	S	S	S	S	1	1	3	3	3	3
>15 – 30 (>4.6 – 9.1)	S	S	S	S	S	S	1	1	3	3	3	3
>30 – 60 (>9.1 – 18.3)	1	S	1	1	1	1	2	2	3	3	3	3
>60 – 90 (>8.3 – 27.4)	1	1	1	1	1	1	3	3	NR	3	NR	NR
>90 – 120 (>27.4 – 36.6)	1	1	2	2	2	2	NR	NR	NR	NR	NR	NR
>120 – 150 (>36.6 – 46)	2	2	2	2	3	3	NR	NR	NR	NR	NR	NR

Parapet heights from 24" (0.60 m) t0 35.9" (0.91 m)

Design Wind Speed (Figure 1)	Canada - Wind Speed on 50 yr. return period – 3-sec gust – mph (m/s)											
	90 (40)		100 (45)		110 (48)		120 (54)		130 (58)		140 (63)	
Design Wind Speed (Figures 2 - 5)	USA - Wind Speeds based on 700 yr. return period – 3-sec gust - mph (m/s)											
	115 (51)		130 (58)		140 63		155 (69)		270 (120)		290 (129)	
Site Exposure	C	B	C	B	C	B	C	B	C	B	C	B
Ballast design, feet (m)												
0 – 15 (0 – 4.6)	S	S	S	S	S	S	1	1	3	3	3	3
>15 – 30 (>4.6 – 9.1)	S	S	S	S	S	S	1	1	3	3	3	3
>30 – 60 (>9.1 – 18.3)	1	S	1	S	1	S	1	1	3	3	3	3
>60 – 90 (>8.3 – 27.4)	1	1	1	1	1	1	2	2	3	3	3	3
>90 – 120 (>27.4 – 36.6)	1	1	1	1	2	2	3	3	3	3	3	3
>120 – 150 (>36.6 – 46)	2	2	2	1	3	3	3	3	3	3	NR	NR

NOTE: For roofs above 150 ft (46 m) contact DuPont at 1-866-583-2583
NR = Not Recommended

Parapet heights from 36" (0.91 m) to 71.9" (1.83 m)												
Design Wind Speed (Figure 1)	Canada - Wind Speed on 50 yr. return period – 3-sec gust – mph (m/s)											
	90 (40)		100 (45)		110 (48)		120 (54)		130 (58)		140 (63)	
Design Wind Speed (Figures 2 - 5)	USA - Wind Speeds based on 700 yr. return period – 3-sec gust - mph (m/s)											
	115 (51)		130 (58)		140 (63)		155 (69)		270 (120)		290 (129)	
Site Exposure	C	B	C	B	C	B	C	B	C	B	C	B
Ballast design, feet (m)												
0 – 15 (0 – 4.6)	S	S	S	S	S	S	1	1	3	3	3	3
>15 – 30 (>4.6 – 9.1)	S	S	S	S	S	S	1	1	3	3	3	3
>30 – 60 (>9.1 – 18.3)	S	S	1	S	1	S	1	1	3	3	3	3
>60 – 90 (>8.3 – 27.4)	S	S	1	1	1	1	1	1	3	3	3	3
>90 – 120 (>27.4 – 36.6)	1	1	1	1	1	2	1	1	3	3	3	3
>120 – 150 (>36.6 – 46)	1	1	2	1	2	1	3	3	3	3	NR	3

Parapet heights from 72" (1.83 m) to 96" (2.44 m)												
Design Wind Speed (Figure 1)	Canada - Wind Speed on 50 yr. return period – 3-sec gust – mph (m/s)											
	90 (40)		100 (45)		110 (48)		120 (54)		130 (58)		140 (63)	
Design Wind Speed (Figures 2 - 5)	USA - Wind Speeds based on 700 yr. return period – 3-sec gust - mph (m/s)											
	115 (51)		130 (58)		140 (63)		155 (69)		270 (120)		290 (129)	
Site Exposure	C	B	C	B	C	B	C	B	C	B	C	B
Ballast design, feet (m)												
0 – 15 (0 – 4.6)	S	S	S	S	S	S	1	1	3	3	3	3
>15 – 30 (>4.6 – 9.1)	S	S	S	S	S	S	1	1	3	3	3	3
>30 – 60 (>9.1 – 18.3)	S	S	1	S	1	S	1	1	3	3	3	3
>60 – 90 (>8.3 – 27.4)	S	S	1	1	1	1	1	1	3	3	3	3
>90 – 120 (>27.4 – 36.6)	1	1	1	1	1	1	1	1	3	3	3	3
>120 – 150 (>36.6 – 46)	1	1	2	2	2	2	2	2	3	3	3	3

NR -= Not Recommended

NOTES:

- For roofs above 150' (46m) contact at 1-866-583-BLUE (2583) or 1-800-363-6210 (French)
- Table B assumes that proper provisions have been specified for sealing off openings in the roof deck and any perimeter blocking, to prevent air intrusion immediately below the roofing membrane and exerting "billowing" forces on the membrane.

Requirements of PMR Ballast Designs

Stone Ballast

All references to stone ballast herein are references to ASTM D448. Nominal ballast sizes, numbers, and associated sieve analyses are outlined below:

ASTM D448: Standard Size of Coarse Aggregate

Weight Percent Finer Than Sieve Openings								
Aggregate Size / #	3"	2-1/2"	2"	1-1/2"	1"	3/4"	1/2"	3/8"
(1.5" – 2-1/2") / # 2	100	90 to 100	35 to 70	0 to 10	–	0 to 5	–	–
(3/4" - 1-1/2") / # 4		–	100	90 to 100	20 to 55	0 to 15	–	0 to 5
(1/2" - 1") / # 5	–	–	–	100	90 - to 00	20 to 55	0 to 10	0 to 5

The following describe the requirements for each of the four PMR ballast designs identified in Tables A and B, including alternate designs and the corner paver array. Roof penetrations, perimeters, and corners requiring additional ballast are defined as follows:

Corner Zone: The corner zone is defined as the corner roof section where the perimeter zones intersect at a minimum dimension of 8 feet x 8 feet.

Field Zone: The field zone is defined as the portion of the roof which is not included in the corner, perimeter or penetration zones.

Perimeter Zone: The perimeter zone is defined as the roof section parallel to the exterior roof edge with a minimum width of 8 feet.

Penetrations: Penetrations are defined as any object projecting above the horizontal roof plane such as, but not limited, to skylights, curbs, equipment platforms, and expansion joints that measure 4-feet or more on any side. The enhanced ballast area shall extend a minimum of 4-feet from all sides of the penetration, inclusive of any side that may not have a 4-foot dimension.

PMR Ballast Design: Standard Figure 6

Field	Install 10 lb/ft² of #5 aggregate (1" stone). It may be crushed stone or rounded river bottom stone.
Perimeter	Install 15 lb/ft2 of #5 aggregate. If the Styrofoam™ Brand insulation is 3 or more in thickness, install 20 lb/ft2 for the 8' perimeter. Alternatively or a combination of 2'x2'x2" concrete pavers or 15 or 25 lb/ft2 of #5 stone for the 8' perimeter is acceptable
Penetrations	Install 15 lb/ft² of #5 aggregate. If the Styrofoam™ Brand insulation is 3" or more in thickness, install 20 lb/ft². Alternately you may install 2'x2'x2" pavers for ballast around penetrations. The ballast must be installed inbound 4 feet of the penetration.
Corners	An 8'x8' area of 15 lb/ft² of #5 stone (20 lbs/ft² if insulation Is 3" or more in thickness), or pavers (18 lb/ft² min pavers)
Options to above	A minimum of 18 lb/ft² of concrete pavers may be installed over the entire roof. **OR** A minimum of 11 lb/ft² of proprietary interlocking concrete pavers (warranted by others) may be installed over the entire roof pursuant to the paver manufacturer's specifications.

PMR Ballast Design: #1 Figure 7

Field	Install 12 lb/ft² of #4 aggregate (1-1/2" stone). It may be crushed stone or rounded river bottom stone.
Perimeter	Install 15 lb/ft2 of #4 aggregate. If the Styrofoam™ Brand insulation is 3" or more in thickness, install 20 lb/ft2 for the 8' perimeter. Alternatively or a combination of 2'x2'x2" concrete pavers or 15 or 25 lb/ft2 of #4 stone for the 8' perimeter is acceptable
Penetrations	Install 15 lb/ft² of #4 aggregate. If the Styrofoam™ Brand insulation is 3" or more in thickness, install 20 lb/ft². Alternately you may install 2'x2'x2" pavers for ballast around penetrations 4 feet inboard.
Corners	An 8'x8' area of 15 lb/ft² of #4 stone (20 lbs/ft² if insulation Is 3" or more in thickness), or pavers (22 lb/ft² min pavers)
Options to above	A minimum of 22 lb/ft² of concrete pavers may be installed over the entire roof. **OR** A minimum of 11 lb/ft² of proprietary interlocking concrete pavers (warranted by others) may be installed over the entire roof pursuant to the paver manufacturer's specifications.

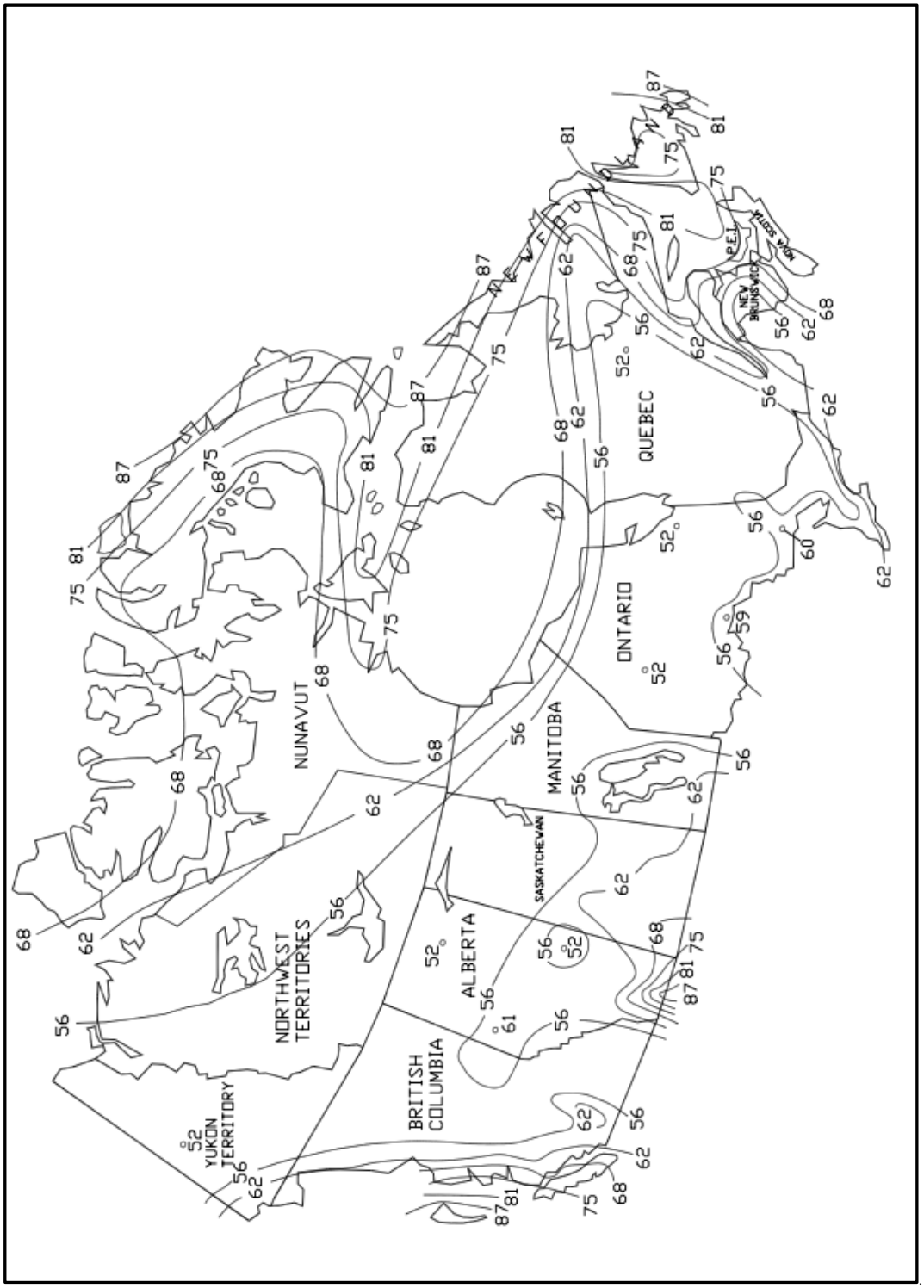
* Any ballast, stone, pavers or otherwise must be installed on a DuPont-approved filter fabric (fabric is optional under pavers). For a list of acceptable fabrics please contact your DuPont Sales representative.

PMR Ballast Design: #2 Figure 8

Field	Install 13 lb/ft² of #2 aggregate (2-1/2" stone). It may be crushed stone or rounded river bottom stone.
Perimeter	Install 15 lb/ft2 of #2 aggregate. If the Styrofoam™ Brand insulation is 3" or more in thickness, install 20 lb/ft2 for an 8' width. As an alternate to either the 15 or 20 lb/ft2 of stone ballast, 4 rows of 2'x2'x2" concrete pavers may be installed along the perimeter with the first row of perimeter edge pavers strapped with straps running parallel to the parapet wall. See Figure 8 for combination of pavers and stone
Penetrations	Install 15 lb/ft² of #2 aggregate. If the Styrofoam™ Brand insulation is 3" or more in thickness, install 20 lb/ft². Alternately you may install 2'x2'x2" pavers for ballast around penetration. The ballast must be installed inbound 4 feet of the penetration.
Corners	8'x8' area of pavers with first row strapped (Figure 8). Pavers are 2'x2'x2" of minimum 22 lb/ft²
Options to above	A minimum of 22 lb/ft² of concrete pavers may be installed over the entire roof, with the first row of perimeter edge pavers strapped together, straps running parallel to the parapets. **OR** A minimum of 11 lb/ft² of proprietary interlocking concrete pavers (warranted by others) may be installed over the entire roof pursuant to the paver manufacturer's specifications.

PMR Ballast Design: #3 Figure 9

Field	Install 13 lb/ft² of #2 aggregate (2-1/2" stone) It may be crushed stone or rounded river bottom stone.
Perimeter	If applicable, adhere the membrane to the roof deck 4' from the parapets. Install four rows of 2'x2'x2" (8') concrete pavers along the perimeter edge of the insulation and strap the first two rows together, straps running parallel to the parapets.
Penetrations	Install 15 lb/ft² of #2 aggregate. If the Styrofoam™ Brand insulation is 3" or more in thickness, install 20 lb/ft². Alternately you may install 2'x2'x2" pavers for ballast around penetrations 4 feet inboard.
Corners	8'x8' area of pavers with first 2 rows strapped. (Figure 8). Pavers are 2'x2'x2" of minimum 22 lb/ft²
Options to above	Minimum of 22 lb/ft² of concrete pavers may be installed over the entire roof, with the two rows of pavers nearest the parapets strapped together, straps running parallel to the parapets. **OR** 3a – 2' x 2' x 2" Hanover Guardian Pavers (not to exceed -81 psf design) or 2' x 2' x 2" Wausau Lock Down Pavers (Not to exceed -65 psf design) or 3b – 2' x 2' x 3" Hanover Guardian Pavers (not to exceed -91 psf design)



Source: CSA Standard C22.3 No. 1-01
The values shown are hourly mean wind speeds in mph at 10 m (32.8') above ground for terrain roughness category B.
Mean 3-sec gust wind speeds can be obtained by multiplying hourly mean wind speed by 1.32.

Figure 1: Canada - Wind Speed on 50 yr. return period – 3-sec gust – mph (m/s)

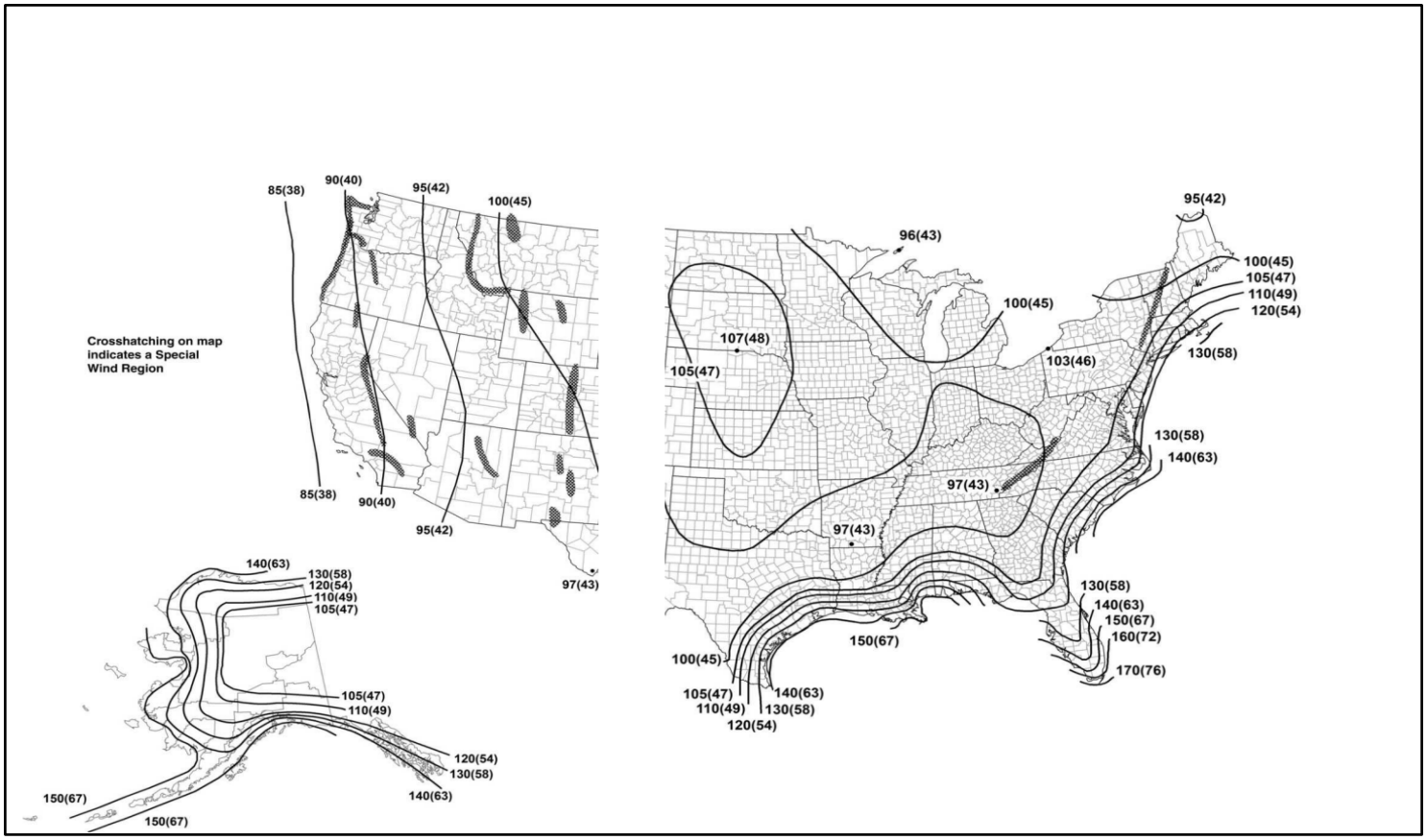


Figure 2: Basic Wind Speeds for Risk Category I Buildings and Other Structures

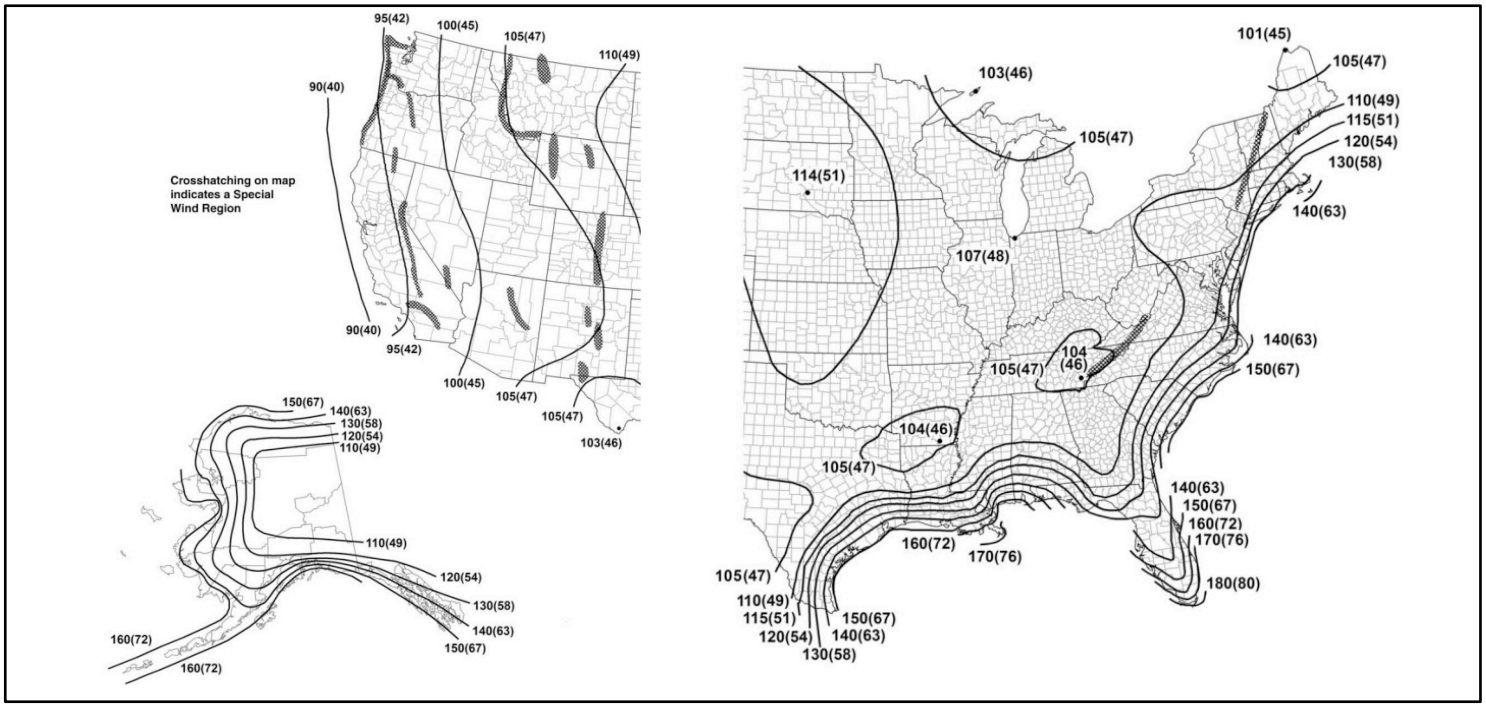


Figure 3: Basic Wind Speeds for Risk Category II Buildings and Other Structures

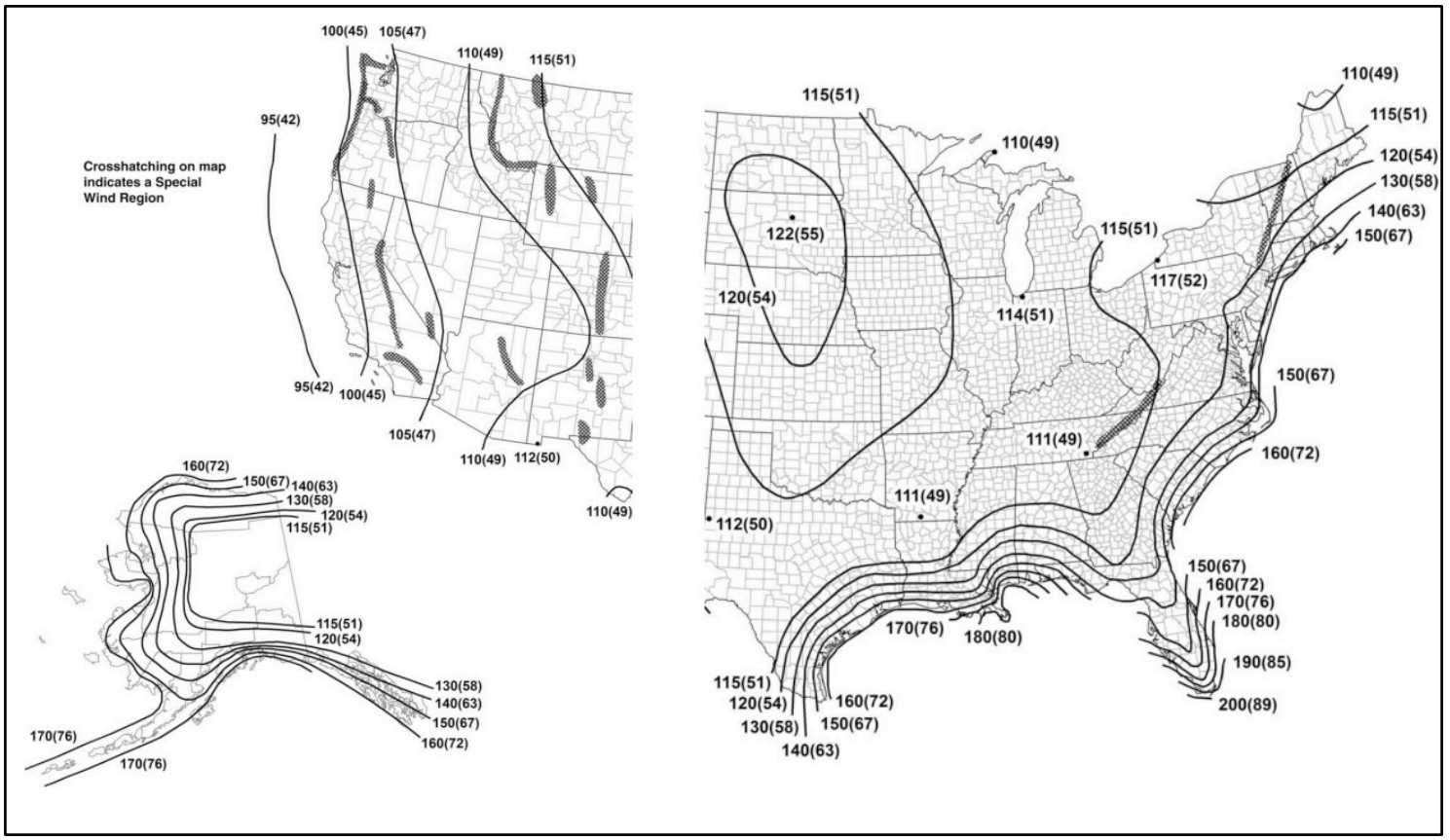


Figure 4: Basic Wind Speeds for Risk Category III Buildings and Other Structures

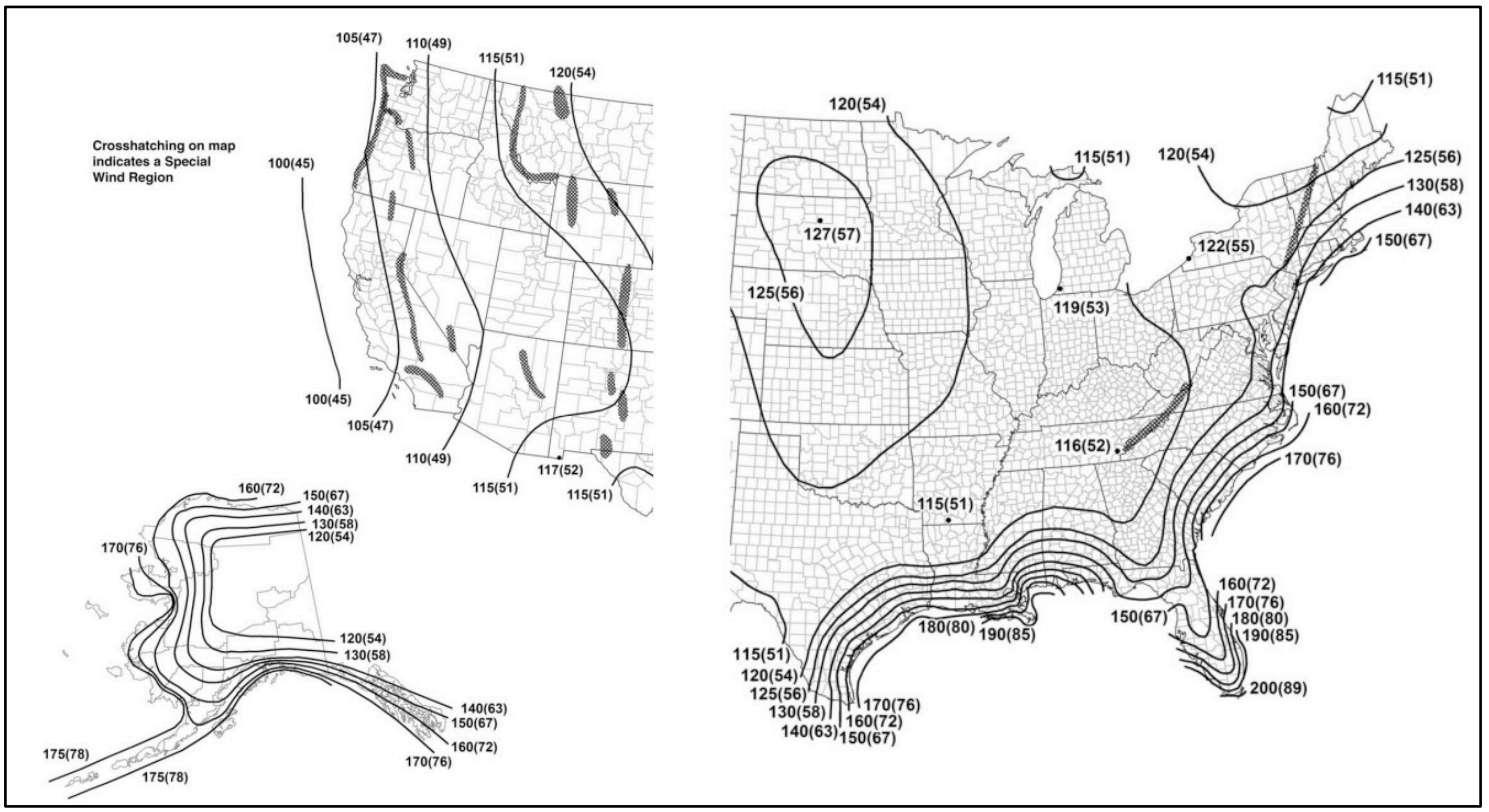


Figure 5: Basic Wind Speeds for Risk Category IV Buildings and Other Structures

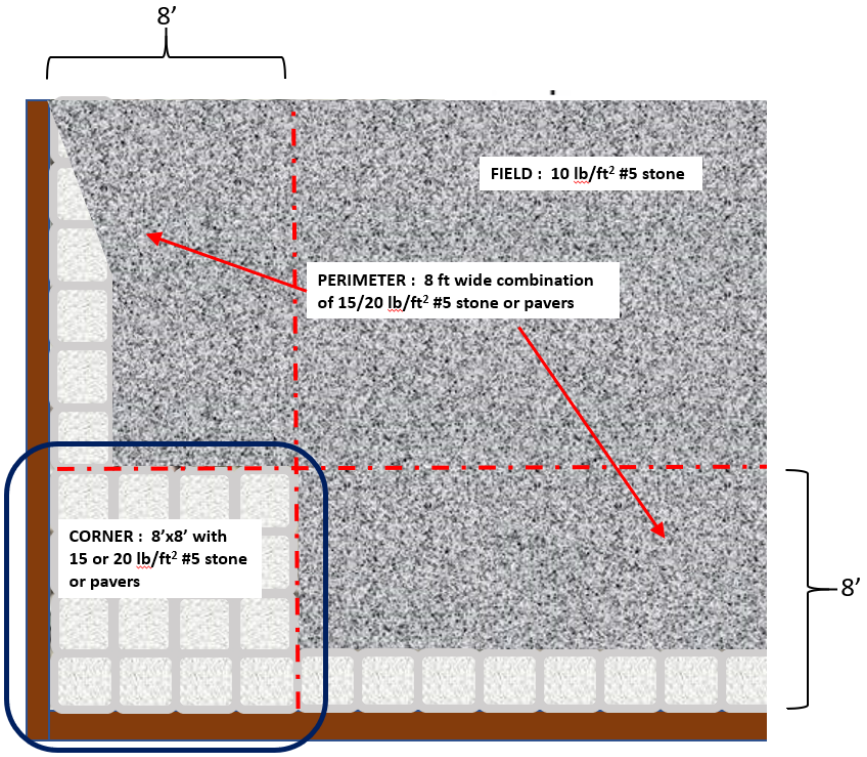


Figure 6: Standard Ballast System

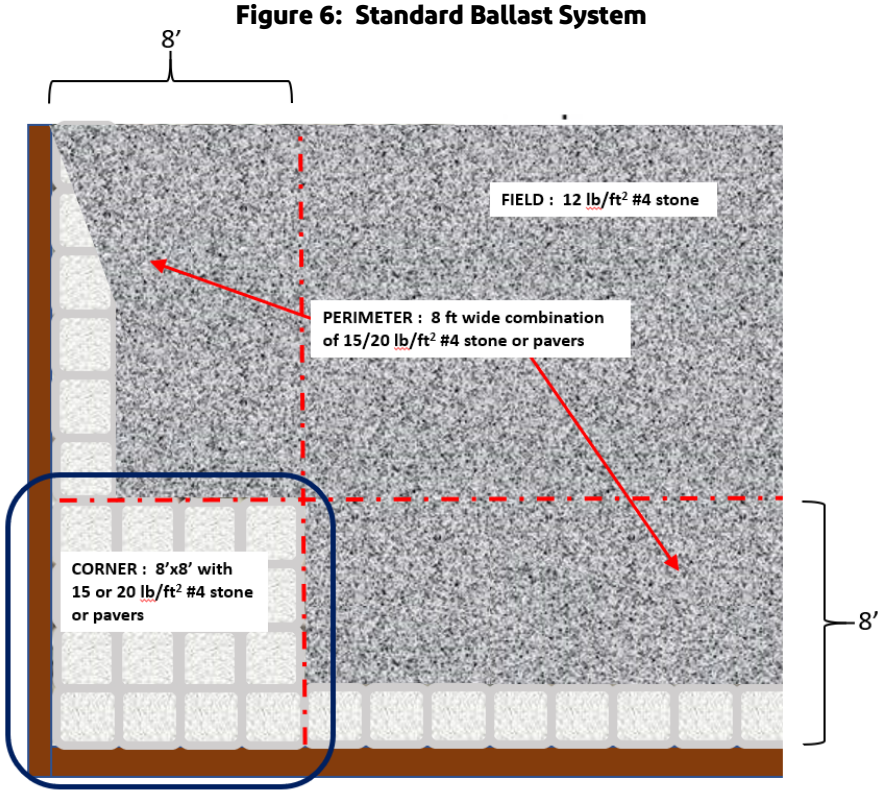


Figure 7: Ballast System #1

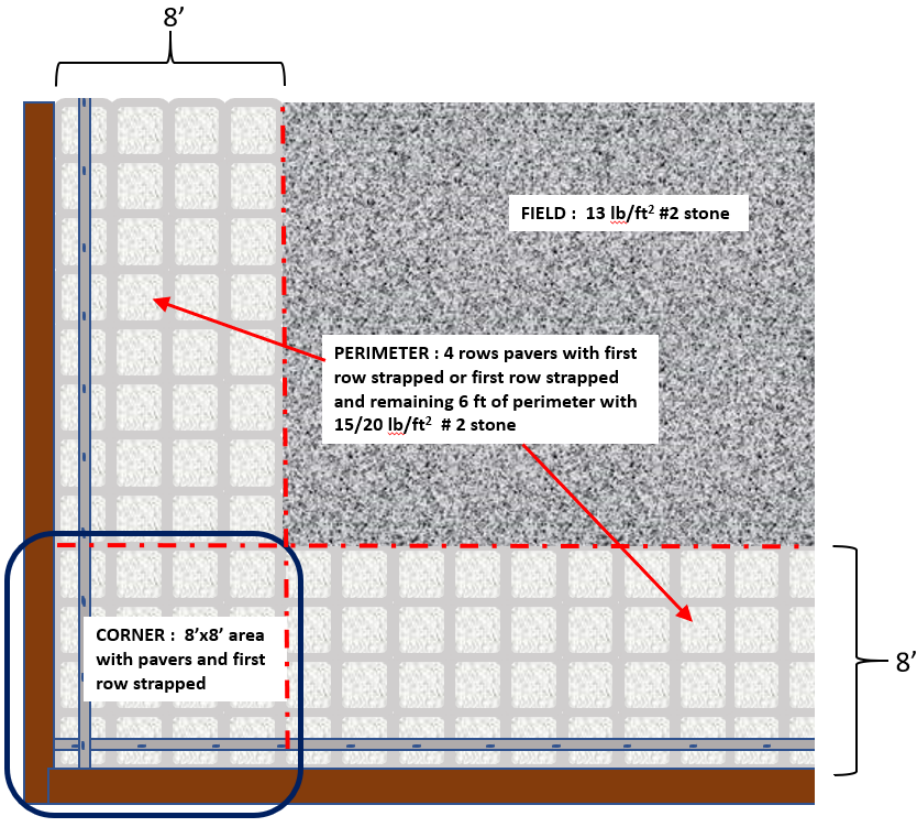


Figure 8: Ballast System #2

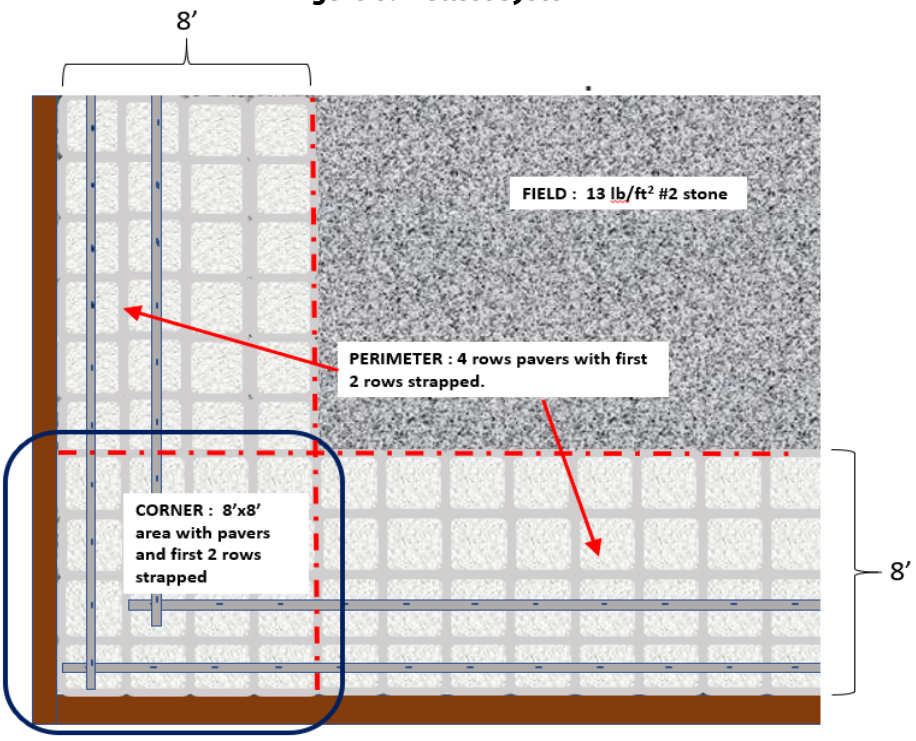


Figure 9: Ballast System #3

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