

TECH SOLUTIONS 508.1 BALLAST DESIGN GUIDE FOR PMR SYSTEMS (U.S.)



INTRODUCTION

This document has been developed for those who design, specify or install protected membrane roof (PMR) systems in the United States to help them select the appropriate stone or paver ballast design for each job. PMR places STYROFOAM™ Brand Extruded Polystyrene Insulation above the roofing membrane, protecting it from both physical abuse and the stress of temperature extremes. The function of the roof ballast, then, is to keep the insulation secure during wind and rain storms.

PMR systems that are installed in accordance with these recommendations may qualify for Dow's 10-, 15- or 20-year limited warranties, covering both the thermal resistance of STYROFOAM™ Brand Insulation and the wind resistance of the ballast design to a maximum wind speed of 80 mph.* See the PMR warranty certificates for details.**

The information presented is based on extensive wind testing of ballasted roofing systems at the National Research Council of Canada and from portions of the ANSI/SPRI RP-4 Wind Design Standard for Ballasted Single-Ply Roofing Systems. The ANSI/SPRI data was utilized for the mechanically attached and loose-laid systems.

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This document first presents some General Design Considerations, then a series of tables from which the proper ballast design can be selected. The final section describes the requirements and alternatives of four recommended ballast designs. It is the installer's responsibility to make sure that the PMR system fits the needs of each building. No warranties other than the standard PMR limited warranties are provided as a result of information provided in this Tech Solutions.

GENERAL DESIGN CONSIDERATIONS

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

Roof Structure

The building structure (either new or retrofit) must be strong enough to support the present and future dead loads on the roof, including the stone ballast, as well as the anticipated live loads.

Slope

The roof slope should not exceed 2" in 12".

Design Wind Speed

The design wind speed for the building location should be determined from the ANSI/ASCE 7-95 wind speed map, Figure 1, or from the local code authority.

Roof Height

The roof height from the ground level to the top of the new roofing system may vary on different sides of the building. Therefore, the height should be based on the worst-case elevation.

Parapet Height

The parapet wall height should be measured from the top of the ballast to the top of the parapet.

PMR places STYROFOAM™ Brand Extruded Polystyrene Insulation above the roofing membrane, protecting it from both physical abuse and the stress of temperature extremes.

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*Three-second gust wind speed

**Certificate form numbers are 179-05272 (10-year), 179-05274 (15-year) and 179-05275 (20-year).

If the height varies, the shortest parapet height should be used. For special cases, contact your Dow sales representative at 1-866-583-BLUE (2583).

Gravel Stop

If a gravel stop is used at the building perimeter, its height above the ballast should be a minimum of 2" when necessary to contain the ballast.

Areas Requiring Extra Ballast

Certain areas of the roof insulation require additional ballast to overcome high wind loads and to restrain the foam from floating during heavy rain storms. This ensures that individual stones cannot migrate to below the foam and abrade the membrane. Areas that require additional ballast are:

Perimeter Edge of Insulation, which is an 8.5' wide swath running along the perimeter edge of the roof insulation (including any insulation adjacent to higher walls).

Penetrations Through Insulation, which are 2' wide swaths running around any roof insulation penetrations that exceed 4' in any direction, such as skylights, expansion joints, equipment pads, etc.

Corners, where arrays of concrete pavers are required in PMR Ballast Designs #2 and #3.

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Building Exposure

The surrounding terrain has an effect on the overall wind exposure of the building. The exposure can be categorized as (P) Somewhat Protected or (E) Full Exposure to Winds. (P = Buildings located in protected areas, such as wooded areas or where buildings nearby are taller and offer some wind resistance. E = Buildings located on plains or shorelines, which offer little or no protection from winds.)

Concrete Pavers

Concrete pavers should be manufactured from minimum 3,000 lb/in² concrete and should weigh a minimum of 18 lb/ft².

Paver Venting

When pavers cover over 10 percent of the insulation surface, a 3/16" ventilating air space is usually required between the foam and the pavers to prevent freeze-thaw spalling of the concrete and moisture vapor buildup in the insulation. This air space can be achieved with paver pedestals, with STYROFOAM™ Brand Ribbed ROOFMATE™ Insulation or with ribbed or footed concrete pavers. In areas with less than 3,000 heating degree days, the air space is not required.

This air space is not required if the pavers are covering only a limited area, such as corners of the roof or narrow roof walkways.

Paver Strapping

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

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Interlocking Pavers

Proprietary interlocking pavers can be used as an optional ballast system.

These pavers are lighter in weight than the noninterlocking pavers described above. The wind resistance of proprietary interlocking pavers is not covered by the Dow warranties, but may be covered by the paver manufacturer's warranty.

**BALLAST DESIGN
 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. These designs vary with building height, parapet height, membrane attachment and wind speed. The tables (at right) are organized by membrane attachment method and building height, and list the ballast design that is required for each roof condition.

Table A: Adhered Membranes, roof heights 12'- 45'

Table B: Adhered Membranes, roof heights from 45'-70'

Table C: Adhered Membranes, roof heights from 70' - 500'

Table D: Mechanically Attached or Loose-Laid Ballasted Membranes, roof heights up to 150', maximum

To determine the appropriate design, work through one of these four tables by selecting the appropriate:

1. Roof membrane attachment (adhered or not)
2. Building height
3. Design wind speed
4. Parapet height
5. Building site exposure

Find the proper ballast design. If paver ballast is to be used and will cover over 90 percent of the insulation, determine if paver venting is needed and, if so, how it will be accomplished.

Then, after determining the appropriate ballast design, see "Requirements of PMR Ballast Designs" on page 4.

TABLE A MEMBRANE: ADHERED ROOF HEIGHTS: 12' TO 45'

A-1. For 2" high gravel stops to 36" high parapets

Design Wind Speed, mph	90	100	110	120	130&140
Site Exposure	P&E	P&E	P&E	P&E	P&E
Ballast Design	Standard	1	1	1	1

A-2. For parapet heights above 36"

Design Wind Speed, mph	90	100	110	120	130&140
Site Exposure	P&E	P&E	P&E	P&E	P&E
Ballast Design	Standard	Standard	Standard	Standard	Standard

TABLE B MEMBRANE: ADHERED ROOF HEIGHTS: 45' TO 70'

B-1. For 6" high gravel stops to 36" high parapets

Design Wind Speed, mph	90	100	110	120	130&140
Site Exposure	P&E	P&E	P&E	P&E	P&E
Ballast Design	Standard	1	1	1	1

B-2. For parapet heights above 36"

Design Wind Speed, mph	90	100	110	120	130&140
Site Exposure	P&E	P&E	P&E	P&E	P&E
Ballast Design	Standard	Standard	Standard	Standard	Standard

TABLE C MEMBRANE: ADHERED ROOF HEIGHTS: 70' TO 500'

C-1. For parapet heights 18" to 36" (for lower parapets, contact Dow)

Design Wind Speed, mph	90	100	110	120	130&140
Site Exposure	P&E	P&E	P&E	P&E	P&E
Ballast Design, feet					
>70 - 100	1	1	2	2	2
>100 - 200	1	1	2	2	3
>200 - 300	1	2	2	3	3
>300 - 400	1	2	2	3	NR
>400 - 500	1	2	2	3	NR

C-2. For parapet heights above 36"

Design Wind Speed, mph	90	100	110	120	130&140
Site Exposure	P&E	P&E	P&E	P&E	P&E
Ballast Design, feet					
>70 - 100	Standard	1	1	1	1
>100 - 200	Standard	1	1	1	2
>200 - 300	1	1	1	1	2
>300 - 400	1	1	1	2	2
>400 - 500	1	1	1	2	2

NR = Not Recommended

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NOTE: For roofs above 150', contact your Dow sales representative at 1-866-583-BLUE (2583) for an individual building analysis.

NOTE: These tables assume that you have specified proper provisions for sealing off openings in the roof deck and any perimeter blocking, so as to prevent air from getting immediately below the roofing membrane and exerting a "billowing" force on the membrane.

**TABLE D MEMBRANE: LOOSE-LAID BALLASTED OR MECHANICALLY ATTACHED
ROOF HEIGHTS: UP TO 150', MAXIMUM**

D-1. From 2" high gravel stops to 5.9" high parapets												
Design Wind Speed, mph	90		100		110		120		130		140	
Site Exposure	E	P	E	P	E	P	E	P	E	P	E	P
Ballast Design, feet												
0 - 15	S	S	1	S	1	1	1	1	2	2	NR	3
>15 - 30	S	S	1	S	1	1	1	1	2	2	NR	3
>30 - 60	1	1	1	1	2	2	2	2	3	3	NR	NR
>60 - 90	2	2	2	2	2	2	3	3	NR	NR	NR	NR
>90 - 120	2	2	2	2	3	3	NR	NR	NR	NR	NR	NR
>120 - 150	2	2	2	2	3	3	NR	NR	NR	NR	NR	NR

D-2. For parapet heights from 6.0" to 11.9"												
Design Wind Speed, mph	90		100		110		120		130		140	
Site Exposure	E	P	E	P	E	P	E	P	E	P	E	P
Ballast Design, feet												
0 - 15	S	S	1	S	1	1	1	1	2	2	3	3
>15 - 30	S	S	1	S	1	1	1	1	2	2	3	3
>30 - 60	1	1	1	1	1	1	2	2	3	3	NR	3
>60 - 90	2	2	2	2	2	2	3	3	NR	NR	NR	NR
>90 - 120	2	2	2	2	3	3	NR	NR	NR	NR	NR	NR
>120 - 150	2	2	2	2	3	3	NR	NR	NR	NR	NR	NR

D-3. For parapet heights from 12.0" to 17.9"												
Design Wind Speed, mph	90		100		110		120		130		140	
Site Exposure	E	P	E	P	E	P	E	P	E	P	E	P
Ballast Design, feet												
0 - 15	S	S	S	S	1	S	1	2	3	3	3	3
>15 - 30	S	S	1	S	1	1	1	2	3	3	3	3
>30 - 60	1	S	1	1	1	1	2	2	3	3	NR	3
>60 - 90	1	1	1	1	2	2	3	3	NR	NR	NR	NR
>90 - 120	1	1	2	2	3	3	NR	NR	NR	NR	NR	NR
>120 - 150	2	2	2	2	3	3	NR	NR	NR	NR	NR	NR

D-4. For parapet heights from 18.0" to 23.9"												
Design Wind Speed, mph	90		100		110		120		130		140	
Site Exposure	E	P	E	P	E	P	E	P	E	P	E	P
Ballast Design, feet												
0 - 15	S	S	S	S	S	S	1	1	3	3	3	3
>15 - 30	S	S	S	S	S	S	1	1	3	3	3	3
>30 - 60	1	S	1	1	1	1	2	2	3	3	3	3
>60 - 90	1	1	1	1	1	1	3	3	NR	3	NR	NR
>90 - 120	1	1	2	2	2	2	NR	NR	NR	NR	NR	NR
>120 - 150	2	2	2	2	3	3	NR	NR	NR	NR	NR	NR

NR = Not Recommended

D-5. For parapet heights from 24.0" to 35.9"												
Design Wind Speed, mph	90		100		110		120		130		140	
Site Exposure	E	P	E	P	E	P	E	P	E	P	E	P
Ballast Design, feet												
0 - 15	S	S	S	S	S	S	1	1	3	3	3	3
>15 - 30	S	S	S	S	S	S	1	1	3	3	3	3
>30 - 60	1	S	1	S	1	S	1	1	3	3	3	3
>60 - 90	1	1	1	1	1	1	2	2	3	3	3	3
>90 - 120	1	1	1	1	2	2	3	3	3	3	3	3
>120 - 150	2	2	2	2	3	3	3	3	3	3	NR	NR

D-6. For parapet heights from 36.0" to 71.9"												
Design Wind Speed, mph	90		100		110		120		130		140	
Site Exposure	E	P	E	P	E	P	E	P	E	P	E	P
Ballast Design, feet												
0 - 15	S	S	S	S	S	S	1	1	3	3	3	3
>15 - 30	S	S	S	S	S	S	1	1	3	3	3	3
>30 - 60	S	S	1	S	1	S	1	1	3	3	3	3
>60 - 90	1	1	1	1	1	1	2	1	3	3	3	3
>90 - 120	1	1	1	1	1	1	2	2	3	3	3	3
>120 - 150	1	1	2	1	2	1	3	3	3	3	NR	3

D-7. For parapet heights from 72.0" to 96"												
Design Wind Speed, mph	90		100		110		120		130		140	
Site Exposure	E	P	E	P	E	P	E	P	E	P	E	P
Ballast Design, feet												
0 - 15	S	S	S	S	S	S	1	1	3	3	3	3
>15 - 30	S	S	S	S	S	S	1	1	3	3	3	3
>30 - 60	S	S	1	S	1	S	1	1	3	3	3	3
>60 - 90	S	S	1	1	1	1	1	1	3	3	3	3
>90 - 120	1	1	1	1	1	1	1	1	3	3	3	3
>120 - 150	1	1	2	2	2	2	2	2	3	3	3	3

NR = Not Recommended

REQUIREMENTS OF PMR BALLAST DESIGNS

Stone Ballast

All references to stone ballast herein are references to ASTM D448. The sizes and sieve analyses of the aggregates recommended in this Tech Solutions are listed below.

ASTM D448: STANDARD SIZES OF COARSE AGGREGATE									
Weight Percent Finer Than Sieve Openings									
Size Number	Nominal Size Square Openings	3"	2-1/2"	2"	1-1/2"	1"	3/4"	1/2"	3/8"
2	2-1/2" to 1-1/2"	100	90 to 100	35 to 70	0 to 15	—	0 to 5	—	—
4	1-1/2" to 3/4"	—	—	100	90 to 100	20 to 55	0 to 15	—	0 to 5
5	1" to 1/2"	—	—	—	100	90 to 100	20 to 55	0 to 10	0 to 5

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BALLAST DESIGN GUIDE

FOR PMR SYSTEMS (U.S.)

The following tables describe the requirements for each of the four PMR ballast designs identified in Tables A, B, C and D, including alternate designs and corner paver arrays.

PMR BALLAST DESIGN: STANDARD

Field	Install 10 lb/ft ² of #5 aggregate (1" stone). It may be crushed stone or rounded riverbed stone.
Perimeter & Penetrations	Install 15 lb/ft ² of #5 aggregate. If the foam is 3" or more in thickness, install 20 lb/ft ² . As an alternate to either the 15 or 20 lb/ft ² of stone ballast, one row of 8" x 16" x 2" concrete pavers may be installed along the perimeter edge of the insulation and around penetrations of the insulation. The balance of the area should be covered with 10 lb/ft ² of #5 aggregate.
Corners	Same as Perimeter & Penetrations.
Options to above	A minimum of 18 lb/ft ² of concrete pavers may be installed over the entire roof. OR A minimum of 11 lb/ft ² of proprietary interlocking concrete pavers (warranted by others) may be installed over the entire roof.

PMR BALLAST DESIGN: #1

Field	Install 12 lb/ft ² of #5 aggregate (1-1/2" stone). It may be crushed stone or rounded riverbed stone.
Perimeter & Penetrations	Install 15 lb/ft ² of #4 aggregate. If the foam is 3" or more in thickness, install 20 lb/ft ² . As an alternate to either the 15 or 20 lb/ft ² of stone ballast, two rows (4') of 24" x 24" x 2" concrete pavers may be installed along the perimeter edge of the insulation and around penetrations of the insulation.
Corners	Same as Perimeter & Penetrations.
Options to above	A minimum of 22 lb/ft ² of concrete pavers may be installed over the entire roof. OR A minimum of 11 lb/ft ² of proprietary interlocking concrete pavers (warranted by others) may be installed over the entire roof.

PMR BALLAST DESIGN: #2

Field	Install 13 lb/ft ² of #2 aggregate (2-1/2" stone). It may be crushed stone or rounded riverbed stone.
Perimeter & Penetrations	Install 15 lb/ft ² of #2 aggregate. If the foam is 3" or more in thickness, install 20 lb/ft ² . As an alternate to either the 15 or 20 lb/ft ² of stone ballast, three rows (6') of 24" x 24" x 2" concrete pavers may be installed along the perimeter edge of the insulation and around penetrations of the insulation, with the first row of perimeter edge pavers strapped together, straps running parallel to the parapets.
Corners	Install Paver Array 1.
Options to above	A minimum of 22 lb/ft ² 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/ft ² of proprietary interlocking concrete pavers (warranted by others) may be installed over the entire roof.

PMR BALLAST DESIGN: #3

Field	Install 13 lb/ft ² of #2 aggregate (2-1/2" stone). It may be crushed stone or rounded riverbed stone.
Perimeter	Adhere the membrane to the roof deck 4' from the parapets. Install four rows (8') of 24" x 24" x 2" concrete pavers along the perimeter edge and strap the first two rows together, straps running parallel to the parapets.
Penetrations	Install 15 lb/ft ² of #2 aggregate. If the foam is 3" or more in thickness, install 20 lb/ft ² .
Corners	Install Paver Array 2.
Options to above	Minimum of 22 lb/ft ² 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 Minimum of 11 lb/ft ² of proprietary interlocking concrete pavers (warranted by others) may be installed over the entire roof.

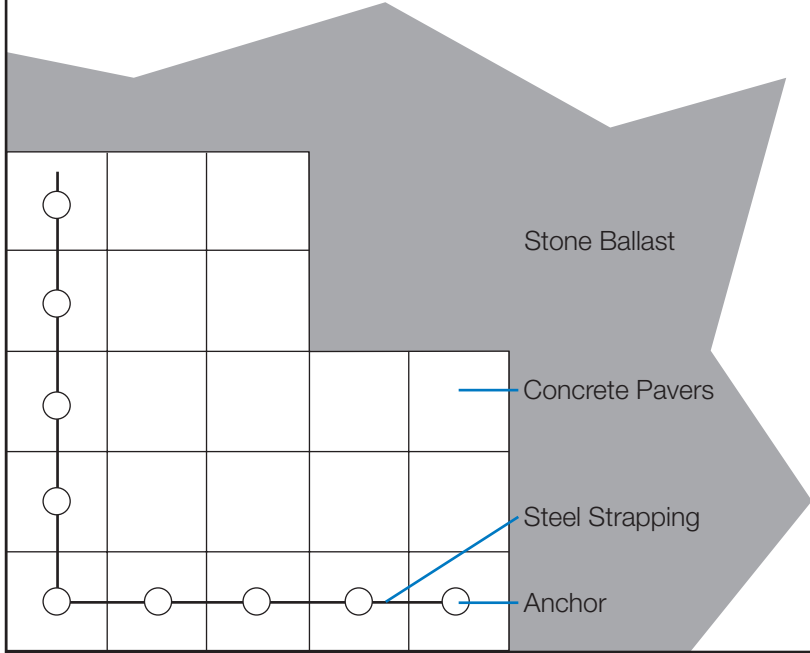
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Figure 1: Basic Wind Speed Map

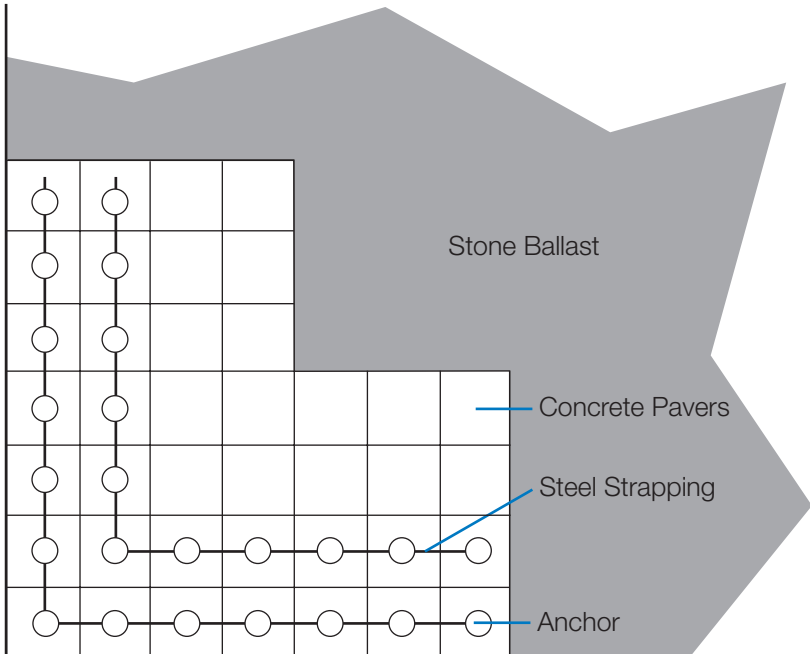


Reprinted from ASCE 7-95 Minimum Design Loads

Corner Paver Array 1, for Ballast Design #2



Corner Paver Array 2, for Ballast Design #2





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IN THE U.S.: For Technical Information: 1-866-583-BLUE (2583) . For Sales Information: 1-800-232-2436
THE DOW CHEMICAL COMPANY . Dow Building Solutions . 200 Larkin . Midland, MI 48674 . www.dowbuildingsolutions.com

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COMBUSTIBLE: Protect from high heat sources. Local building codes may require a protective or thermal barrier. For more information, consult MSDS, call Dow at 1-866-583-BLUE (2583) or contact your local building inspector. In an emergency, call 1-989-636-4400.

Building and/or construction practices unrelated to building materials could greatly affect moisture and the potential for mold formation. No material supplier, including Dow, can give assurance that mold will not develop in any specific system.

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