TechNote 508: Ballast Design Guide for IRMA Roofs

Introduction
This document has been developed for those who design, specify or install IRMA roofing systems by helping them select the appropriate stone or paver ballast design for each job. IRMA, remember, places STYROFOAM* brand 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.

IRMA roofing systems which are installed in accordance with these recommendations qualify for Dow's 10-year limited warranty, 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[1]. See the IRMA warranty certificate 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.

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 the four Ballast Designs that are recommended. It is the installer's responsibility to make sure that the IRMA system fits the needs of each building. No warranty other than the standard IRMA limited warranty is provided as a result of information provided in the TechNote.

General Design Considerations
The following factors should be considered when designing a ballasted IRMA roofing 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.

[1]Three-second gust wind speed.

Styrofoam Brand Insulation

Roof Height
The roof height from the ground level to the top of the new roofing system may be different 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. If the height varies, the shortest parapet height should be used. For special cases contact your Dow Technical Service Representative (1-800-441-4369).

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

Areas of Extra Ballasting
Certain areas of the roof insulation require additional ballasting 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 needing such additional ballasting are:

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

Penetrations Through Insulation, which are two-foot-wide swaths running around any roof insulation penetrations which exceed 4 feet in any direction, such as skylights, expansion joints, equipment pads, etc.

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

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 3000 lb/in.^{2} concrete and should weigh a minimum of 18 lb/ft^2.

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 build-up in the insulation. This air space can be achieved with paver pedestals, with ribbed STYROFOAM ROOFMATE* brand roof insulation or with ribbed or footed concrete pavers. In areas with less than 3000 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.

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

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

Ballast Design Options
Selection of the Proper IRMA Ballast Design
A designer of IRMA roofing systems has four Ballast Designs to chose from: Standard, #1, #2 and #3. These Designs vary with building height, parapet height, membrane attachment and wind speed. The following tables are organized by membrane attachment method and building height. And they list the Ballast Design which is required for each roof condition.

Table A: Adhered Membranes, heights to 45 feet
Table B: Adhered Membranes, heights from 45-70 feet
Table C: Adhered Membranes, heights from 70 to 500 feet
Table D: Mechanically attached or Ballasted Membranes, heights to 150 feet, maximum

To select the Ballast Design which is required for your roof, work through one of these four tables according to the following steps.

Select 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 you have determined the appropriate Ballast Design, move on to Page 7 to learn the requirements of that Design.

Table A **Membrane: Adhered** **Roof Heights: 12 to 45 feet**

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 feet**

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 feet**

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

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

NR = Not Recommended

Table D **Membrane: Loose-Laid Ballasted or Mechanically Attached**
Roof Heights: up to 150 feet, maximum

NOTE! For roofs above 150 feet, contact Dow TS&D for individual building analysis (800-441-4369).

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.

D-1. From 2-inch high gravel stops to 5.9-inch 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												
0 - 15 feet	S	S	1	S	1	1	1	1	2	2	NR	3
>15 - 30 feet	S	S	1	S	1	1	1	1	2	2	NR	3
>30 - 60 feet	1	1	1	1	2	2	2	2	3	3	NR	NR
>60 - 90 feet	2	2	2	2	2	2	3	3	NR	NR	NR	NR
>90 - 120 feet	2	2	2	2	3	3	NR	NR	NR	NR	NR	NR
>120 - 150 feet	2	2	2	2	3	3	NR	NR	NR	NR	NR	NR

D-2. For parapet heights from 6.0 to 11.9 inches

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												
0 - 15 feet	S	S	1	S	1	1	1	1	2	2	3	3
>15 - 30 feet	S	S	1	S	1	1	1	1	2	2	3	3
>30 - 60 feet	1	1	1	1	1	1	2	2	3	3	NR	3
>60 - 90 feet	2	2	2	2	2	2	3	3	NR	NR	NR	NR
>90 - 120 feet	2	2	2	2	3	3	NR	NR	NR	NR	NR	NR
>120 - 150 feet	2	2	2	2	3	3	NR	NR	NR	NR	NR	NR

D-3. For parapet heights from 12.0 to 17.9 inches

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												
0 - 15 feet	S	S	S	S	1	S	1	2	3	3	3	3
>15 - 30 feet	S	S	1	S	1	1	1	2	3	3	3	3
>30 - 60 feet	1	S	1	1	1	1	2	2	3	3	NR	3
>60 - 90 feet	1	1	1	1	2	2	3	3	NR	NR	NR	NR
>90 - 120 feet	1	1	2	2	3	3	NR	NR	NR	NR	NR	NR
>120 - 150 feet	2	2	2	2	3	3	NR	NR	NR	NR	NR	NR

NR = Not Recommended

Table D (cont.) **Membrane: Loose-Laid Ballasted or Mechanically Attached**
Roof Heights: up to 150 feet, maximum

D-4. For parapet heights from 18.0 to 23.9 inches

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												
0 - 15 feet	S	S	S	S	S	S	1	1	3	3	3	3
>15 - 30 feet	S	S	S	S	S	S	1	1	3	3	3	3
>30 - 60 feet	1	S	1	1	1	1	2	2	3	3	3	3
>60 - 90 feet	1	1	1	1	1	1	3	3	NR	3	NR	NR
>90 - 120 feet	1	1	2	2	2	2	NR	NR	NR	NR	NR	NR
>120 - 150 feet	2	2	2	2	3	3	NR	NR	NR	NR	NR	NR

D-5. For parapet heights from 24.0 to 35.9 inches

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												
0 - 15 feet	S	S	S	S	S	S	1	1	3	3	3	3
>15 - 30 feet	S	S	S	S	S	S	1	1	3	3	3	3
>30 - 60 feet	1	S	1	S	1	S	1	1	3	3	3	3
>60 - 90 feet	1	1	1	1	1	1	2	2	3	3	3	3
>90 - 120 feet	1	1	1	1	2	2	3	3	3	3	3	3
>120 - 150 feet	2	2	2	2	3	3	3	3	3	3	NR	NR

D-6. For parapet heights from 36.0 to 71.9 inches

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												
0 - 15 feet	S	S	S	S	S	S	1	1	3	3	3	3
>15 - 30 feet	S	S	S	S	S	S	1	1	3	3	3	3
>30 - 60 feet	S	S	1	S	1	S	1	1	3	3	3	3
>60 - 90 feet	1	1	1	1	1	1	2	1	3	3	3	3
>90 - 120 feet	1	1	1	1	1	1	2	2	3	3	3	3
>120 - 150 feet	1	1	2	1	2	1	3	3	3	3	NR	3

D-7. For parapet heights from 72 to 96 inches

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												
0 - 15 feet	S	S	S	S	S	S	1	1	3	3	3	3
>15 - 30 feet	S	S	S	S	S	S	1	1	3	3	3	3
>30 - 60 feet	S	S	1	S	1	S	1	1	3	3	3	3
>60 - 90 feet	S	S	1	1	1	1	1	1	3	3	3	3
>90 - 120 feet	1	1	1	1	1	1	1	1	3	3	3	3
>120 - 150 feet	1	1	2	2	2	2	2	2	3	3	3	3

NR = Not Recommended

Requirements of IRMA Ballast Designs

Stone Ballast

All references to stone ballast herein are references to ASTM D 448. The sizes and sieve analyses of the aggregates recommended in this TechNote are listed below.

ASTM D 448: 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

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

IRMA 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.

IRMA Ballast Design: #1

Field	Install 12 lb/ft^2 of #4 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 (four feet) 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.

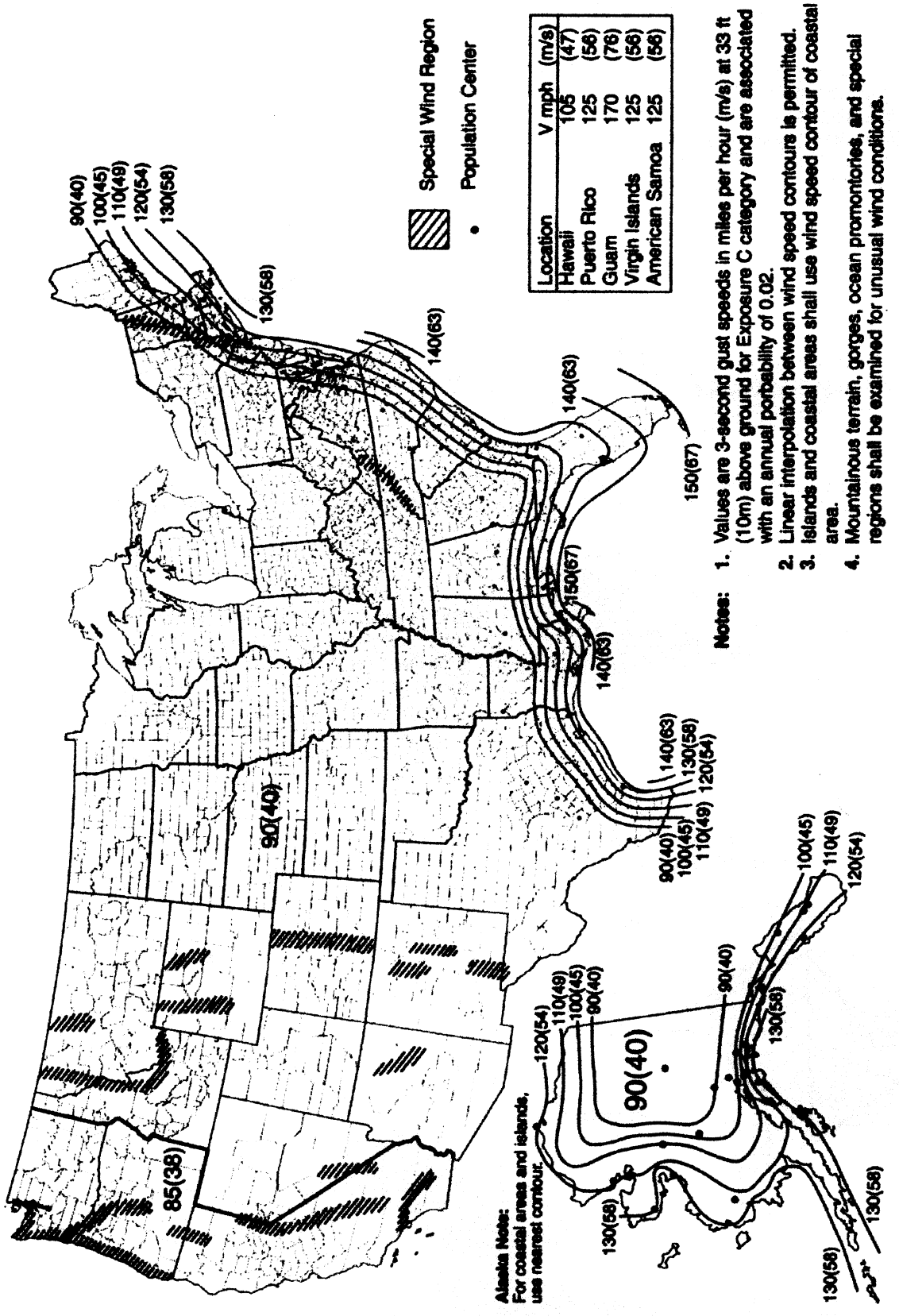
IRMA Ballast Design: #2

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 (six feet) 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 being 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 being 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.

IRMA Ballast Design: #3

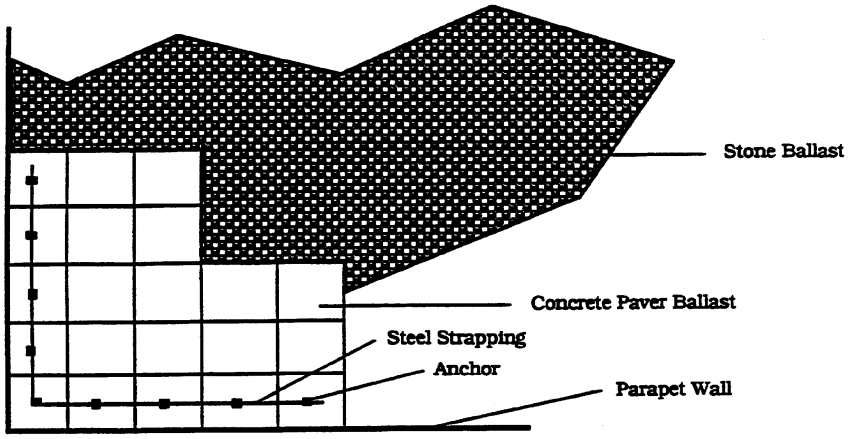
Field	Install 13 lb/ft^2 of #2 aggregate (2-1/2" stone). It may be crushed stone or rounded riverbed stone.
Perimeter	Adhere the membrane to the roof deck for four feet in from the parapets. Install four rows (eight feet) of 24" x 24" x 2" concrete pavers along the perimeter edge and strap the first 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 being 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.

Figure 1
BASIC WIND SPEED MAP

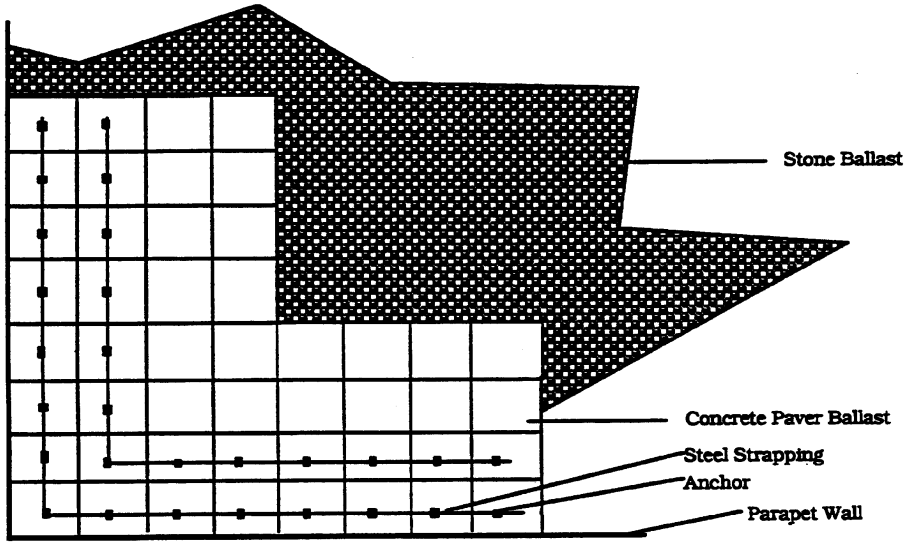


Reprinted from ASCE 7-95 Minimum Design Loads

Corner Paver Array 1, for Ballast Design #2



Corner Paver Array 2, for Ballast Design #3



NOTICE: STYROFOAM brand insulation is combustible. Protect from flame and other high heat sources. For more information, consult MSDS and/or call Dow (1-800-441-4369). In an emergency, call (1-517-636-4400). Local building codes may require a protective or thermal barrier. Contact your local building inspector for more information.

For technical information, call 1-800-441-4369

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