Guide and Considerations for Ballasted Roofing

By Carole M. Ceja and Ethan T. Rattray

Carole M. Ceja

Ethan T. Rattray

Understanding the special restrictions and allowances for ballasted roofing included in the 2018 International Building Code (IBC) is important for both design and roofing construction professionals. To expand knowledge of this topic for all involved parties, an overview of the basic step-by-step process is provided in further detail below. For any roofing project—reroofing or roof replacement—it is recommended to include a licensed design professional as part of the construction team.

The most widely used industry standard used for ballasted roof assembly design is ANSI/SPRI RP-4, *Wind Design Standard For Ballasted Single-ply Roofing Systems.* This standard was developed following a series of research projects utilizing wind tunnel testing and has remained largely unchanged since the mid-1980s.

While the ANSI/SPRI RP-4 document outlines a design process, the 2018 IBC is the presiding Code. The 2018 IBC directly references and incorporates the ANSI/SPRI RP-4 design process, and further adds restrictions on the application of ballasted roof assemblies. To look at it another way, the IBC is a cookbook that must be followed, and ANSI/SPRI RP-4 is a single recipe included within that book for ballasted roofing specifically.

The current ballast restrictions are understood to have been highly influenced by historic events, including the hurricane seasons of 2005 and 2006. This time frame marks a significant change in the application of ballasted roofing. When reroofing systems installed prior to 2005, the designer must ensure the building still qualifies for selection of new ballasted roof assemblies.

TERMINOLOGY

Before diving in, there are several key terms used in the 2018 IBC which must be understood before the ballasted design can be executed.

1. ROOF ASSEMBLY: "A system designed to provide weather protection and resistance to design loads. The system consists of a roof covering and roof deck or a single component serving as both the roof covering and the roof deck. A roof assembly can include an underlayment, a thermal barrier, insulation or a vapor retarder."
2. ROOF COVERING: "The covering applied to the roof deck for weather resistance, fire classification or appearance."
3. ROOF DECK: "The flat or sloped surface constructed on top of the exterior walls of a building or other supports for the purpose of enclosing the story below, or sheltering an area, to protect it from the elements, not including its supporting members or vertical supports."
4. ROOF REPLACEMENT: "The process of removing the existing roof covering, repairing any damaged substrate and installing a new roof covering."
5. ROOF REPAIR: "Reconstruction or renewal of any part of an existing roof for the purposes of its maintenance."
6. HEIGHT, BUILDING: "The vertical distance from grade plane to the average height of the highest roof surface."
7. BALLAST: "In roofing, ballast comes in the form of large stones or paver systems or light-weight interlocking paver systems and is used to provide

uplift resistance for roofing systems that are not adhered or mechanically attached to the roof deck."

[Terms 1-7, Ch. 202, IBC 2018]

The ANSI/SPRI RP-4 defines ballast material relatively simply as "large stones, . . . or paver systems or light-weight interlocking paver systems." Through the design process, there is considerably more detail for this definition including sizes, weights, and distribution density for different ballast materials addressed below. It is fair to say, however, that all ballasted roof assemblies include a weighty material used to hold down loose-laid, single-ply roofing membranes to prevent wind uplift without any other direct connection (adhered or mechanical) to the roof deck.

CODE REQUIREMENTS AND STANDARDS

This article reviews the 2018 IBC, which is already adopted by several Chicago suburbs and will be the adopted Code for the City of Chicago by August 2020.

At the onset of a project with a single-ply ballasted roof assembly, it is important to know if the building height is greater than 150 feet above the grade plane. If so, according to the IBC, the roof assembly must be designed by a registered design professional using wind-engineering practices consistent with the American Society of Civil Engineers (ASCE) 7-10. An additional limitation is roof slope. If the roof slope is greater than 10 degrees (2:12), then a registered design professional with experience in roofing wind design shall provide the design. Approval from the authority having jurisdiction must be met in both cases. The 2018 IBC also blanketly limits the use of any aggregate or ballast material on buildings in regions prone to hurricanes.

Where design wind speeds are greater than 140 mph, as defined in ASCE 7-10, the ANSI/SPRI RP-4 does not recommend installation of ballasted roof assemblies; however, if the ballasted type of roof is required by the building owner, the roof assembly must be designed by a registered design professional.

Perimeter details can be executed with edge metal or a parapet. Edge metal flashing should always be taller than the ballast component (2-inch minimum upturn) (Photo 1). Parapets improve the wind resistance of the ballasted roof assemblies—generally, the taller the parapet, the greater additive wind resistance to the roof assembly. Parapet height detailing can be restrictive based on building height, exposure category, and wind speed. For example, when a parapet is less than 1 foot high, ANSI SPRI RP-4 limits the allowable roof height of the building to 75 feet above the grade plane.

Building geometry can influence wind speeds. Careful consideration should be given to wind loads at

irregularities in the building, including reentrant corners or corners of bay windows. Irregular wall surfaces can lead to higher localized wind pressures that can displace ballast material at the perimeter of the building.

The location of the building within the larger environment is also critical for selection of ballast material. Small aggregate ballast not designed under ANSI/SPRI RP-4 can lead to aggregate ballast blow off during tornadoes and hurricanes but is less likely during other storms. Aggregate ballast blown off the roof can break windows and skylights and damage other building surfaces. For this reason, installation of stone or aggregate ballasted roof assemblies in hurricane-prone regions is not permitted by the 2018 IBC. In hurricane- and tornado-prone areas, selection of a paver ballast assembly is sometimes permitted since pavers are less likely to cause small missile damage to surrounding buildings during an extreme weather event.

BALLAST SELECTION STEPS

Typical ballast systems designed under the ANSI/SPRI RP-4 document follow the steps below to ensure conformance. Some special exceptions and construction types exist; however, the basic process remains the same.

1. **Wind Maps**—Determine the ultimate wind speed from the correct wind speed map in IBC Section 1609.3. There are multiple copies of each map, which are based on the risk category assigned to the individual building type. A hospital must be designed to resist more severe weather than a warehouse, for example.

2. **Design Wind Speed**—Convert the map-listed ultimate wind speed to a nominal design speed by IBC Table 1609.3.1 or Equation 16–33.

3. **Exposures**—Identify exposure type for the surrounding area of the new roof assembly. In general, the more objects that are in the way of the wind, the less impactful the wind is on the roofing system.

    - **B–Urban or Suburban**: Mostly closely spaced single-family dwellings or larger or wooded land.
    - **C–Grasslands**: Flat open grassland with scattered obstructions of heights generally less than 30 feet above the grade plane.
    - **C–City Centers**: Densely packed city centers have documented unpredictable wind issues in wind tunnel studies; therefore, ANSI/SPRI RP-4 *recommends* utilizing Exposure C category for city center applications.
    - **D–Shoreline** (excludes shorelines in hurricane-prone zones): 600 feet from an open body of water at least 1 mile wide.

4. **Heights**—Check mean roof assembly height limitations of a building with IBC Table 1504.8 using exposure category and calculated nominal wind speed. Small changes in minimal wind speed or building height can have a large impact on allowed roof heights. See Table 1 below for some examples.

5. **Ballast Type**—Select a ballast system based on the nominal wind speed and parapet height. Ballast # type descriptions, including weight distributions, are provided in Table 2 below. Caution should be exercised not to quickly define any paver as true ballast because not all pavers qualify as ballast material due to their size or weight. There are just three different allowable ballast systems, according to ANSI/SPRI RP-4. Individual definitions of the dimension of corner and perimeter zones on the roof are also provided in the design document.

    - **System 1**: #4 ballast across the full roof covering surface.
    - **System 2**: #2 ballast in corner and perimeter zones of the roof and #4 ballast in the field zone.
    - **System 3**: #2 ballast in the field zone of the roof covering and corners and perimeter zone fully adhered or mechanically attached based on ASCE 7 design.

6. **Structural Considerations**—Confirm building structural capacity to support the selected system.

7. **Manufacturer's Instructions**—Coordinate installation with the selected roofing membrane manufacturer's written instructions. Some membrane manufacturers publish separate design guidelines with additional restrictions or ballast type limitations.

ROOF MAINTENANCE AND REPAIRS

While properly designed and installed ballast is not expected to blow off the roof, it is possible to experience shifting over time, especially after significant wind events. Corner conditions are highly susceptible to wind scour (Photo 2). Ballast needs to be periodically redistributed to ensure long-term uplift resistance of the roof assembly. Additionally, ballast needs to be moved to repair the roof covering (membrane) or install additional rooftop equipment. Since maintenance and repairs on

a ballasted roof assembly involve redistributing ballast, understanding the initial requirements are essential. Any ballasted roof assembly requiring System 2 or System 3 should maintain the proper type and distribution of ballast materials, especially at the corner and perimeter zones of the roof.

In addition to wind uplift issues, ballast might provide key components to fire rating. In order to maintain the fire properties required, the ballast needs to be maintained as it was described in the initial listing. NFPA 1, *The Fire Code,* mentions roofing specifically as part of the maintenance requirements for fire protection.

Note, roof maintenance does not include activities to systematically replace small sections of roofing to avoid Code requirements that are included with roof replacement, such as increased need for thermal insulation. Those activities are defined as roof replacement.

ROOF REPLACEMENT

There are a few important conditions to be aware of during replacement of ballasted roof assemblies. Just because a building has an existing ballasted roof assembly does not mean it can be replaced with a new one. Ballasted roof assemblies installed in the early 2000s faced fewer restrictions on the building type and location for which it could be used. Also, since parapet height plays into ballast system selection, any alterations to the parapet height may alter the applicability of a ballasted roof assembly.

Prior to removal of ballast, the building should be evaluated for any structural ramifications from the reduced weight. This is especially pertinent for high-efficiency metal deck and bar joist buildings, where the bottom chord of the joists may be susceptible to buckling once the ballast weight is removed, but weight distribution can also be a consideration for maintenance and repair efforts.

Finally, if a new ballasted roof assembly is to be installed where one did not exist previously (or ballasting a previously adhered system), then a licensed professional must verify that the building structure can handle the extra dead load.

CLOSING

The step-by-step process laid out in the ANSI/SPRI RP-4 document can be a straightforward tool once all the limiting factors added by the 2018 IBC are understood.

Whether living under, providing general maintenance to existing systems, or designing or installing completely new ballasted roof assemblies, professional designers, code officials, building owners, and roofing contractors are encouraged to consider the basics provided above.

Photo 1: Edge metal must be higher than ballast (2-inch minimum). (Raths Raths & Johnson photo)

Table 1–Wind Speeds and Height Limitation Examples for the Chicagoland Area

Building Type	Risk Category	Ultimate Wind Speed (mph)	Nominal Wind Speed (mph)	Exposure Category	Height Limitation
High School	III	114	88	B	145 feet
Hospital	IV	119	92	B	96 feet
Office Willowbrook	II	107	83	B	170 feet
Office on LSD	II	107	83	D	30 feet
Office Downtown	II	107	83	B (C*)	170 feet (60 feet*)

*Height restriction recommended by ANSI/SPRI RP-4 due to unpredictable winds in city centers.

Table 2–ANSI/SPRI RP-4 Ballast Types

#4 Ballast

Stone	1½-inch smooth river rock	10 lbs/ft^2 minimum
Standard Paver		18 lbs/ft^2 minimum
Lightweight Interlocking Paver		10 lbs/ft^2 minimum

#2 Ballast

Stone	2½-inch smooth river rock	13 lbs/ft^2 minimum
Standard Paver		22 lbs/ft^2 minimum
Lightweight Interlocking Paver	Specifically documented as approved equal to #2 ballast	10 lbs/ft^2 minimum

Photo 2: Past work or wind scour has moved river rock around in the more critical corner zone potentially leaving the membrane more vulnerable to uplift damage. (Raths Raths & Johnson photo)

Carole Ceja is an architect and a registered roof consultant at Raths, Raths & Johnson, Inc. She has over 12 years of architectural experience specializing in the evaluation, investigation, design, and repair of roofing and waterproofing systems. Her experience has involved commissioning and witness testing of building enclosures and components, and thermal modeling to analyze their performance. For more information, contact cmceja@rrj.com

Ethan Rattray is an architect at Raths, Raths & Johnson Inc. and has over six years of architectural experience in field investigation and evaluation of water intrusion and air infiltration through building enclosures, condition survey documentation, repair design, and construction administration. For more information, contact etrattray@rrj.com