

Short-term solutions

Follow these preliminary design guidelines to temporarily secure wind-damaged low-slope roof assemblies

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When wind damages a roof assembly, a temporary roof often is needed to keep water from entering the building. However, because of a lack of adequate guidelines for the design of temporary roof securements, many damaged roof membranes and temporary roofs have been inadequately secured. When inadequately secured, they are vulnerable to blow-off and present a risk to people and property.

First steps

Following a wind event, a damaged roof should be investigated by a knowledgeable wind-damage investigator to determine the cause(s) of the damage and obtain data for designing the roof system repair or replacement. A quality investigation can help avoid or resolve disputes arising from the wind damage. Inadequate investigation and evaluation can result in a replacement roof assembly that possesses inadequate wind resistance, and it, too, may blow off.

When a roof is damaged by wind, it often is obvious the entire roof area needs to be replaced rather than simply repairing the damaged area. However, in many instances, repairing the damaged area is a viable, more economical approach. When determining whether it is appropriate to repair versus replace wind-damaged roofs, an investigator must perform suitable field testing and rigorous evaluation and analysis. With appropriate investigation, damaged or wind-vulnerable areas outside the apparent damage periphery likely will be identified and corrected, thereby avoiding future wind damage.

Ideally, the investigation should be performed before temporary repairs are made. However, if water is leaking into a building or a rain-storm is forecast before the investigation occurs, temporary repairs usually take precedence over preservation of the damage scene. If temporary repairs are performed or wind-borne debris is removed from the roof before the investigation occurs, I recommend someone take photos of the roof before debris removal or temporary repair takes place. Initial photos may alert the investigator to roof areas that may have been damaged by wind-borne debris, and the photos may assist with damage evaluation. I also recommend all roof system debris be retained for follow-up evaluation by the investigator, as well as the following:





Photo 1: Workers install sandbags on a detached roof membrane before sundown.



Photo courtesy of FEMA Mitigation Assessment team.

Photo 2: Most of the aggregate and insulation blew off this built-up roof system. The damaged membrane cannot be repositioned; a permanent or new temporary roof is needed to provide watertight protection.

- The building owner should notify his or her insurance company, attorney, roof system manufacturer, roof system designer, roofing contractor and general contractor that damage has occurred.
- It generally is not advisable to attempt temporary repairs until after severe weather has subsided because of the danger of high winds and possibility of lightning. Caution should be exercised when investigating and making temporary repairs because the work may be conducted during poor lighting or weather conditions (see Photo 1 on page 47), and/or storm damage may have created an extremely hazardous condition (such as live electrical conductors, openings through the roof caused by a blown-off roof deck or rooftop equipment, and/or broken gas lines).
- A professional roofing contractor should be retained to perform temporary repairs. To the extent possible, the repair should minimize changing the damage scene and facilitate a follow-up investigation. For example, if a roof membrane has blown away, you as the roofing contractor should consider loose laying and temporarily securing a single-ply membrane rather than mop-applying two plies of felt. With this approach, the temporary work can be removed easily during the investigation, allowing the investigator to inspect the membrane substrate. Mark emergency leak repairs on a roof plan for later permanent repair. Temporary repairs should include removal or temporary re-attachment of loose flashings and rooftop equipment. Also remove debris from the roof surface, roof drains, scuppers and conductor heads and

ensure the temporary roof has adequate drainage to avoid ponding-induced roof collapse. In addition, check lower-level roofs for damage by wind-borne debris from the damaged roof and remove debris from the ground around the building vicinity.

- If water leaked into the building, the building owner should have someone control the spread of water and initiate drying of the interior.

Damage scenarios

There are four primary damage scenarios:

- Ballast blow-off and/or scour
- Roof membrane detached but did not blow off
- Roof membrane blew off but can be temporarily repositioned
- Roof membrane blew off and cannot be repositioned

Ballast can be aggregate, concrete pavers or cementitious-coated extruded polystyrene panels. Scour is displacement of a few or several pieces of ballast where the membrane is left exposed but the displaced ballast is not blown off the roof. Ballast blow-off is similar to scour except some ballast is blown off the roof. If a roof is scoured but blow-off does not occur, the consequences may be minimal. In some instances, there is no subsequent damage to the roof system. In other instances, insulation boards shuffle below the membrane; the membrane may be punctured by wind-borne debris; or a seam may open because of ballooning. Ballooning occurs when a membrane lifts from the substrate and rises in the shape of a balloon. Ballast may be displaced by the balloon, or ballooning may occur after the ballast has been displaced.

With ballast scour or blow-off, the following actions typically are taken: The exposed membrane is checked for punctures, tears and ruptured seams, and, if damaged, either emergency or permanent membrane repairs are made. If insulation boards below the membrane shuffled, they can be repositioned. Then, the ballast is repositioned. If there is an insufficient amount of ballast to reposition because of ballast blow-off, temporary ballast is installed until replacement ballast can be installed.

According to the *SPRI/NRCA Manual of Roof Inspection, Maintenance and Emergency Repair for Existing Single-ply Roofing Systems*, if the exposed area exceeds 50 square feet or if ballast was blown off the roof, the ballast system should be evaluated to determine whether it complies with the current edition of ANSI/SPRI RP-4,



Photo 3: This building's roof was temporarily secured with a two-ply built-up roof. (Photo courtesy of FEMA MAT, Hurricane Charlie 2004.)

“Wind Design Standard For Ballasted Single-ply Roofing Systems.” If ballasted with square-edged concrete pavers and if the roof is outside the requirements of the ANSI/SPRI RP-4 tables, it is recommended the paver’s wind resistance be evaluated per the design procedure given in Appendix A of *Concrete Roof Pavers: Wind Uplift Aerodynamic Mechanisms and Design Guidelines—A Proposed Addition to ANSI/SPRI RP-4*. NRCA and SPRI recommend corrective action if the existing ballast design does not comply with ANSI/SPRI RP-4.

When an adhered or mechanically attached roof membrane detaches but does not blow off or blows off but can be temporarily repositioned, check the membrane for punctures, tears and ruptured seams. If damaged, make emergency repairs and temporarily secure the loose membrane with mechanical fasteners or ballast.

When a roof membrane blows off and cannot be repositioned, as in Photo 2 on page 47, install either a permanent or temporary roof.

Temporary securement options

Damaged membranes that remain in place or can be repositioned typically are temporarily secured with some type of ballast or mechanical fasteners. If a membrane blows off a roof, a single-ply membrane can be temporarily secured. Alternatively, a temporary or permanent membrane may be adhered as shown in Photo 3.

A variety of materials have been used for temporary ballast: concrete pavers, sandbags, tires, water bags, wood boards and wood sheathing.

At a job site I visited, a portion of the fully adhered single-ply membrane detached from the insulation. Concrete pavers randomly were placed to provide temporary securement. However, the paver layout was insufficient to prevent the roof membrane from lifting and progressively peeling beyond the pavers. The size of the detached area increased during subsequent modest winds. If a detached area subsequently spreads beyond the temporary ballast, the portion of the detached membrane that is not ballasted is vulnerable. If a seam fails or the membrane tears, substantial leakage may occur. Also, if the size of the detached area increases because of ineffective temporary securement, the cost of repairing the damage often increases.

When performing repairs, be mindful of unintended consequences. In one instance I observed, a roofing contractor placed rows of sandbags to provide temporary roof membrane securement. Although attention was



Photo 4: Emergency ballast was installed after a single-ply membrane detached from the insulation.

given to placing the sandbags, a subsequent moderate wind event caused the sandbags to shuffle out of position, allowing the membrane to balloon and open. Sandbags near the roof edge had been tied together. Some sandbags fell off the roof, but the rope attaching the sandbags kept some of them from reaching the ground.

In another instance, most of a fully adhered single-ply membrane between the parapet and equipment screen wall detached from the insulation. Tires randomly were placed to provide temporary securement, but the ballast was inadequate to prevent propagation of the detachment beyond the ballast. Ballast was not placed near the parapet to avoid overstressing the membrane’s base securement at the parapet. In several areas, the ballast was too far apart.

I also saw a fully adhered single-ply membrane that had detached from the insulation at a portion of the roof. Plastic bags partially filled with water were placed to provide temporary securement. The ballasting at the transition between the adhered and unadhered areas was inadequate to prevent propagation of the detachment beyond the ballast.

Note that tarps also can cause problems. I once saw temporary watertight protection provided by a loose-laid tarp that was ballasted with wood sheathing. Most of the sheathing panels were warped, making them more susceptible to wind uplift. In several areas, the sheathing was too far apart, and there was lack of ballast in a corner region.

Recommendations

In most instances, you will install emergency securement using readily available materials. This initial emergency securement is intended to quickly stabilize the roof (see Photo 4). Soon after the initial emergency securement is installed, assess it to determine whether additional work is necessary to provide the desired level of temporary securement. Subsequent winds with sufficient speed to

cause damage to an initial emergency securement could occur within a few days or a few weeks. Therefore, it is important to quickly assess the adequacy of the emergency securement and upgrade it if appropriate.

I recommend temporary securement with mechanical fasteners in lieu of temporary ballast unless conditions preclude fastening (such as when conduit is embedded in a concrete deck, conduits are attached directly to the underside of the deck or the deck type is not conducive to mechanical attachment). I recommend the following procedures:

- Calculate design uplift loads for corners, the perimeter and field of a roof using the current edition of ASCE 7, “Minimum Design Loads and Associated Criteria for Buildings and Other Structures,” and an appropriate serviceability mean recurrence interval (MRI). Figures CC.2-1 and CC.2-2 in ASCE 7-16 provide 10- and 25-year MRI speeds. For most of the continental U.S., the 10- and 25-year speeds range from 80–65 and 87–70, respectively. These are “allowable stress design” speeds (meaning a load factor of 1.6). Therefore, the 0.6 W load combination in ASCE

7-16 should not be used. Table C6-7 in ASCE 7-05 provides a table for determining speeds associated with various MRIs, including a five-year MRI. The ASCE 7-05 five-year MRI for most of the continental U.S. is 70 mph. In most instances, use

of the 10-year MRI given in ASCE 7 is sufficiently conservative. After calculating the design uplift loads for the three roof zones, design the fastener row spacing and spacing of fasteners along the rows. For steel roof decks, specify the fastener rows run perpendicular to the deck flanges. If there is a parapet, specify a row of fasteners near the roof/parapet interface (this is in addition to the existing base securement).

- If a membrane was adhered and portions of the roof remain adhered, at the interface between adhered

and unadhered membrane sections, install a row of fasteners over the adhered membrane about 6 inches inward from the adhered/unadhered boundary. Install an additional row of fasteners over the adhered membrane about 12 inches from the first row of fasteners. Space the fasteners along these rows 12 inches on center maximum.

- Specify a row of fasteners around the perimeter of penetrations (such as plumbing vents, roof drains and equipment curbs).
- If the base flashing is detached and the parapet height exceeds 3 feet, I recommend a row of fasteners be placed at intervals not exceeding 3 feet horizontally up the parapet. Add a row of fasteners near the coping unless the coping is believed to be capable of resisting as much load as the fastener rows below it.
- If the roof has a lightning protection system (LPS), typically it would not be checked for continuity while a temporary roof is in place. However, if the building occupancy or contents are such that a functional LPS is desired during the time the temporary roof is in place, a qualified LPS contractor should be retained.
- If emergency ballast was installed before temporary mechanical securement, remove the ballast after the mechanical attachment work has been completed.

Temporary ballast

There is a lack of reliable design data to produce a truly engineered temporary ballast solution. Therefore, temporary ballasting is recommended only when mechanical attachment is not feasible. Use of emergency ballast before installation of mechanical attachment can be appropriate. For temporary ballast, I recommend sandbags. If sandbags are not available, I recommend 24- by 24-inch concrete roof pavers.

An advantage of sandbags is they are less likely to damage roof membranes. However, if they are in place for a prolonged time, they may tear or the bags may deteriorate. Water bags can be inexpensive to deploy if a hose bibb is nearby, and they are inexpensive to demobilize. However, water bags are more susceptible than sandbags or pavers to shuffling caused by membrane ballooning. For emergency ballasting, use of other types of ballast can be appropriate when sandbags or pavers are not immediately available. If another type of ballast is used for the



Photo 5: This double row of sandbags occurs at the interface between adhered and unadhered areas.

emergency work, replace the other type of ballast with sandbags or pavers when the temporary ballasting work is performed.

Also, consider the following:

- For roofs higher than 60 feet, I do not recommend temporary ballast because of the increased potential for ballast being tossed off the roof by membrane ballooning.
- Along the parapet, place a row of sandbags. Along this row, leave a space of about 24 inches between each bag. Place the long dimension of the bag parallel to the parapet.
- If there is no parapet, place the first row of bags about 4 feet from the roof edge.
- At the perimeter zone, place rows of sandbags about 6 feet on center. Along these rows, leave a space of about 24 inches between each bag.
- At the field zone, continue placing rows of sandbags about 6 feet on center but leave about 4 feet of space between the bags.
- If a membrane was adhered and portions of the roof remain adhered, at the interface between adhered and unadhered sections, place a continuous row of sandbags on the unadhered membrane within about 6 inches of the demarcation line. Place another row of continuous sandbags on the adhered membrane within about 6 inches of the demarcation line (see Photo 5). This will result in a gap of about 12 inches between the two rows. If roof drainage is such that these rows of sandbags will impede drainage, leave a space of about 1 inch between the bags.
- At all roof penetrations (including pipes), place sandbags around the penetrations. If a penetration has a curb that is longer than 24 inches, place a minimum of two sandbags at each side of the curb. At roof drains, keep the bags about 12 inches from the drain so water can flow to drains.
- When applying emergency or temporary ballast, minimize stockpiling ballast to avoid overloading the structure and use caution when placing the ballast to avoid damaging the roof membrane.
- Before placing temporary ballast, have a structural engineer verify the structure can accommodate the proposed ballast load.

Temporary fully adhered membrane

If all or most of a roof membrane is blown away, an alternative to temporarily mechanically attaching or ballasting a membrane is to fully adhere a membrane. If insulation boards need to first be attached to the deck with fasteners or foam ribbon adhesive, design the attachment to meet the uplift load prescribed in the building code if the membrane will be permanent. However, if the membrane will be torn-off when the building is reroofed or if it will remain in place and a new membrane is mechanically attached to the deck, a more economical attachment of the temporary roof insulation may be used by following the recommendations provided earlier.

For more information

The following resources will provide additional information regarding temporary roof systems following a wind event. For links to these publications, go to www.professionalroofing.net.

- “The roof system blew off—now what?” *Professional Roofing*, August 2000 issue
- “The situation with steel decks,” *Professional Roofing*, March 2017 issue
- “Evaluating Wind-Damaged Low-Slope Roof Assemblies: A Preliminary Protocol” from the 12th Americas Conference on Wind Engineering
- *SPRI/NRCA Manual of Roof Inspection, Maintenance and Emergency Repair for Existing Single-ply Roofing Systems*
- *Manual for Inspection and Maintenance of Spray Polyurethane Foam-based Roof Systems: A Guide for Building Owners*
- *Manual for Inspection and Maintenance of Built-Up and Polymer-modified Bitumen Roof Systems: A Guide for Building Owners*
- *Manual for Inspection and Maintenance of Low-slope Structural Metal Panel Roof Assemblies: A Guide for Building Owner*
- *Repair Manual for Low-slope Membrane Roof Systems*
- ANSI/SPRI RP-4, Wind Design Standard For Ballasted Single-ply Roofing Systems
- “Concrete Roof Pavers: Wind Uplift Aerodynamic Mechanisms and Design Guidelines—A Proposed Addition to ANSI/SPRI RP-4” from *Proceedings of the 32nd RCI International Convention and Trade Show*

Monitoring

I recommend a temporary roof be inspected to determine whether the interface between adhered and unadhered membranes has moved and determine whether temporary ballast has shuffled. As a conservative trigger for inspecting, inspect the roof once per month (in some instances, inspections every other week may be appropriate). In addition to these periodic inspections, inspect the roof if winds are greater than 50 mph. In instances where there are special property or life-safety issues, a lower threshold may be prudent.

If inspections reveal relatively minor ballast shuffling occurred, repositioning the ballast is not needed. If shuffling is significant, reposition the ballast. Also, the ballast layout should be re-evaluated to determine whether additional ballast should be installed. If the interface between the adhered and unadhered membranes has moved, reposition the boundary ballast; or if the mechanical attachment was used at the interface, install additional fastener rows. Also, check each drain to ensure drainage is not impeded.

Pay attention

Temporarily securing wind-damaged roof assemblies is challenging for a variety of reasons, including the lack of design criteria. To minimize leakage and/or blow-off problems with temporary securement, pay special attention to the design and installation of the temporary securement and periodically monitor it. 🌀🔍

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