

Detection and Repair to Uplift-Compromised Adhered Single-Ply Roof Membranes

By Marc N. Boulay

ADHERED ROOF ASSEMBLY OVERVIEW

Adhered roof assemblies have been a popular method of attachment for single-ply membranes for over 30 years, and the popularity of these systems continues to grow despite increasingly stringent regulations on the volatile organic compounds (VOCs) used in bonding adhesives. While the vast majority of these systems perform adequately for extended periods of time, a number of adhered systems experience uplift compromise ranging from limited areas of failure to complete failure. The overall integrity of an adhered single-ply system is only as strong as its weakest links, which, in the case of these assemblies, are sections of less-than-optimally bonded membrane.

ADHERED ROOF UPLIFT FAILURE

Reasons for uplift failure of an adhered single-ply membrane include the usual suspects of substrate compromise involving foam core collapse, facer delamination (usually in high-traffic areas), moisture compromise of wood fiberboard, and—to a lesser degree—moisture-compromised hardboard cover panels.

Moisture compromise of the adhesive bond can be the result of leaks and/or elevated levels of interior moisture that migrate up and erode the adhesive bond, as most adhered roof assemblies presently in service did not employ an air or vapor barrier, and more often than not, used a single layer of insulation—all contributing factors to compromise of the bonding adhesive. There are a number of other factors in the equation that result in an increasing

number of failures of adhered single-ply roof systems. They include compromise of the bonding adhesive itself due to substandard manufacturing, inadequate storage, incomplete mixing of the adhesive prior to installation, and application during weather conditions outside the design parameters of the adhesive.

The primary external force involved with the failure of adhered roofing systems is negative air pressure, which is created



Figure 1 – The roof drain and cast-iron leader were dislodged by the uplift pressure on this roof system.



Figure 2 – Uplift damage to adhered PVC roof assembly.

as the wind passes across the roof surface. Such uplift pressure can be sufficient to pull the membrane free of a properly adhered insulation stratum firmly attached to a structural, poured-in-place concrete roof deck. An example of such a condition is shown in *Figure 1*, where the roof drain and the cast-iron leader were dislodged by the uplift pressure (this on a roof system less than four years old and only in a select, middle area of that roof system—nowhere near a roof edge). Concrete pavers in the image were taken from another portion of the building and relocated beside the damaged area to temporarily stabilize the membrane until the permanent repairs could be performed.

Adding to the uplift pressure on some buildings is positive air pressure, ranging from minimal added pressure created by mechanical equipment to extensive air pressure created when wind enters a building through openings in the sidewalls. This condition is most prevalent on large warehouse buildings where the percentage of wall openings can approach and exceed 50%, which will dramatically increase the overall uplift pressure on the roof system. Another component of increased uplift failure scenarios is the increase in severe weather attributed in part to climate change, which is being experienced in geographic areas not typically exposed to such weather and the higher intensity of these storm events.

The result is an ever-increasing number of uplift failures on adhered single-ply roof systems. To put the condition into perspective, the author's office has experience with over 1.6 million sq. ft. of uplift-compromised single-ply roof systems involving both EPDM and PVC roof membranes from differing manufacturers, in various

geographic locations, and atop varying roof decks, from corrugated steel—where positive air pressure introduced through large wall openings was a notable contributing factor, to poured-in-place structural concrete—where positive pressure was a nonfactor. In these cases, a number of failures were noted as having commenced along the roof edge (as shown in the PVC roof system

failure in *Figure 2*) to select areas of the roofs that were nowhere near a roof edge and that had occurred at a relatively lower wind speed (45 to 65 mph) than we would have anticipated.

This PVC roof uplift damage occurred while the building was still under construction, without the building envelope being sealed, and with temporary coverings on walls and door openings. After occurrence of numerous uplift-compromised areas in the field of the roof and away from a roof edge, a series of investigations were conducted to closely examine all conditions and factors contributing to the uplift failure of this particular roof system, which over a number of years had increased to affect over 400,000 sq. ft.

Testing included placing anemometers about the roof to record wind speeds in random locations; creation of a scaled model of the large, uniquely shaped building; and wind-tunnel testing, each of which failed to provide a definitive reason for the routine uplift failures.

An extensive series of test cuts were taken throughout the roof, which revealed the insulation facer firmly attached to the polyisocyanurate insulation foam core, turning the focus to the bonding adhesive. Test cuts in failed areas, as well as at still-adhered sections, were taken and shipped to a well-known testing lab for analysis. In this particular instance, the culprit was identified as substandard bonding adhesive, which was embrittled and unable to adequately restrain the membrane when exposed to moderate levels of uplift pressure.

Disbonded single-ply membrane areas are apparent when the roof is noticeably elevated in what appears from a distance to resemble the top of a large balloon such as the EPDM and PVC roofs seen in *Figures 3* and *4*. Other failures are detected by the sound of flapping membrane and/or leakage at compromised membrane areas.

Damage to roof systems attributed to



Figure 3 – Uplifted EPDM at compromised area.



Figure 4 – Uplifted PVC roof at compromised area.

uplifted single-ply membranes can include roof drains, as can be seen in *Figure 5*. In this example of a dislodged roof drain on an EPDM roof system atop a corrugated steel roof deck assembly, the PVC piping fractured and the membrane tore free of the building, resulting in widespread leakage and interruption to the building operation.

Unreinforced EPDM membrane—the predominant single-ply sheet for adhered roof systems—tears relatively easily in contrast with scrim-reinforced single-ply membranes, which do not easily rupture and, as such, tend to magnify the extent of uplift damage to drains and rooftop penetrations, distorting and even fracturing lateral rooftop gas lines and conduit.

As part of roof maintenance, a cursory inspection may be performed on a suspected



Figure 5 – Dislodged roof drain on uplifted EPDM area.



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Figure 6 – Disbonded EPDM membrane area in foreground; adjacent area in background is still bonded.



Figure 7 – Disbonded EPDM membrane with iso facer adhered to underside, pulled free of the foam core.

uplift-damaged, adhered roof system during a period of elevated wind conditions (20 to 25 mph), which is sufficient to allow an observation and identification of disbonded areas that will elevate, billow, and flutter to a degree commensurate with the size of the disbonded areas. Scrim-reinforced membranes do not billow to the extent that an unreinforced EPDM sheet does; and as a result, it is slightly more difficult to detect smaller areas of disbonded membrane in comparison with an unreinforced EPDM sheet. An adhered EPDM roof membrane with a fleece or felt backing, and those adhered to alternately secured insulation (hot-asphalt bitumen or adhesive-grade, low-rising polyurethane foam) without plates and screws, have a smooth appearance, making it difficult to determine areas of disbonded membrane. On these roofs, carefully dragging a shoe heel will reveal a disbonded roof membrane. Alternatively, use a plunger to test a suspected loose area. Adhered systems with unreinforced EPDM membrane with insulation secured with plates and screws will telegraph on the roof surface.

On such assemblies, disbonded areas are easily detected during inspection. An example of a disbonded EPDM area with a smooth surface that peeled away from the

insulation facer is shown in the foreground of *Figure 6*, while the adhered plates of the solidly adhered membrane area are shown in the background of the same image.

Uplift damaged or disbonded EPDM membrane areas where the insulation facer pulled free of the foam core and remains adhered to the backside of the disbonded membrane have a very distorted surface appearance, as seen in *Figure 7*. Once disbonded areas of an adhered single-ply membrane are identified, remediation work should commence in a timely fashion to halt the size of uplift-damaged areas.

REPAIR OF UPLIFT-COMPROMISED AREAS

If emergency repairs are initiated when the membrane is actively lifted, extreme care must be exercised to ensure personnel are not injured. A billowing single-ply roof membrane is capable of lifting a person off the roof deck. Therefore, we recommend that repair personnel move about a billowing membrane area in a relatively tight cluster of three or four persons to create a point load that is sufficient for people to remain firmly atop the roof surface.

In order to mitigate a large billow-

ing area, carefully cut a round, 6-in. hole in the roof membrane, leaving no sharp or trailing edges (most critical on the unreinforced EPDM membrane, which will tear wide open along any sharp edge). Once the membrane is cut, install plate and screw fasteners positioned 36 to 48 in. away from and around the membrane opening, using four to six fasteners. These new membrane openings should be covered as soon as possible with a larger-diameter (6-in.), spun-aluminum, one-way air vent in order to return the cut areas to an effective, watertight condition.

Plates and screws should be covered with appropriate new membrane patches, installed using recommended application procedures for the respective roof membrane being patched.

Weight is also typically deployed to secure the loose and billowing membrane; however, caution must be used to ensure the proper type of weight is used. Concrete pavers used atop a billowing roof edge without battens or air vents have resulted in the pavers being tossed over the roof edge. Rubber tires spaced atop a large disbonded single-ply roof area without the benefit of air vents also have resulted in billowing membrane, lifting the tires and allowing them to roll about and even off of the low-profiled roof edge. The use of sandbags—while effective in a point-loading capacity—is only to be used as a short-term remedy. Long-term UV exposure tends to erode the integrity of the bags, resulting in the bags breaching and depositing sand and gravel atop the roof surface. If sandbags are deployed in a cold-weather climate, repetitive freeze/thaw cycles may compromise the bags and result in the same outcome, with aggregate atop the roof surface.

Once the excessively billowing, disbonded, single-ply membrane areas are addressed (and if areas are manageable without cutting pressure-relief holes), then the perimeter of the disbonded areas should be mechanically secured to contain the uplifted areas and prevent them from expanding. Securement on a scrim-reinforced membrane may be performed with plates and screws or with batten



Figure 8 – One-way air vents installed along edge of disbonded EPDM membrane area.

strips, while all unreinforced EPDM membrane areas should employ a batten strip. Metal battens may be used if they are the only battens available—metal is not the optimal component, due to issues with thermal expansion and bridging—instead, polymer battens are preferred for such work. Securement into a composite decking will require appropriate auger-style fasteners, while concrete decks should be secured with heavy-duty screw fasteners, as drive pins are difficult to remove and will complicate the eventual reroofing project.

Concrete pavers may be used in rows and in select locations, positioned atop appropriate slip sheets to augment membrane restraint. Before permanent repairs to uplift-damaged areas are initiated, a fair amount of data must be collected, including the type and age of the roof system, the manufacturer, and if any warranty coverage remains on the assembly. If warranty coverage is in effect, check the wind speed limitation and compare it against the closest weather station for the highest recorded wind speed and gusts experienced during a recognized storm event or going back over a number of weeks or even months in order to locate the elevated wind conditions that resulted in the uplift damage. If the uplifted area was detected during a rooftop inspec-



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Figure 9 – Tightly clustered batten securement of an uplifted, fiberglass-reinforced PVC membrane area.

tion and/or during a period of a lower wind speed, establishing the date and time of the uplift damage may not be easily determined. An easy method of locating wind speed documentation is online at websites that include archived weather data, such as Weather Underground. If it is possible to determine the wind speed at which the roof failed, and it is below the wind speed cov-

erage on the warranty, repair to the uplift damage may be covered under the warranty/guarantee. Regardless of whether the damage occurred below or above the wind speed limitation on an active warranty, the roof system manufacturer should be notified in a timely fashion with as much detail of the failed area as possible. The building insurance carrier should also be notified of the roofing system loss, typically by the building owner. Depending on the particulars of the insurance policy, including deductible, permanent repair/replacement work may be dictated by the insurance company or the owner. Options always include full removal and replacement of the failed area; how-

ever, there are instances when an owner wishes to obtain additional service from an uplift-damaged/disbonded single-ply roof membrane area—e.g., if he or she is self-insured and/or the affected areas are relatively sound.

In such an instance, the disbonded roof area should be examined to determine the feasibility of repairing the areas and converting the system into a hybrid mechanically attached assembly with a series of batten strips and one-way air vents. Proceeding with a repair project involves installing the battens around the perimeter of the uplifted areas, around roof drains, and at set intervals through the body of the uplifted areas, positioned perpendicular to the steel deck direction. Once battens are installed atop an EPDM membrane, the areas should be properly cleaned with a weathered EPDM cleaner, then primed and covered over with a semi-cured EPDM/butyl tape membrane. New one-way air vents should then be installed along the roof area perimeter at intervals of 20 to 30 ft. and about the body of a larger uplifted area, with the number and position to be determined by the field conditions and the size of the area involved. The air vents act as purge valves, minimizing the uplift pressures on the membrane by providing a means of egress for positive air pressure on buildings with large wall openings and on buildings with a mostly enclosed envelope, allowing negative air pressure to act as a downward force on the membrane.

Disbonded single-ply roof areas that were repaired using this combined method of battens and one-way air vents have been in successful service for upwards of ten years on various assemblies. An example of one of the roofs repaired in this manner is on a building on Long Island, NY, shown in Figure 8. Note that this hybrid repaired area is positioned nearly 50 ft. high and with open exposure due to the surrounding low terrain. It has, over the years, successfully weathered a series of subsequent high-wind events that resulted in uplift damage to other, lower portions of this same building without any issues on the repaired area.

Repair to uplift-damaged PVC roof membranes is similar to that of EPDM roof systems, in that the disbonded membrane must be secured with battens or plates and fitted with air vents to limit billowing and uplift pressure in the sheet. If the PVC roof membrane used is a fiberglass-reinforced sheet, the battens or plates will require



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placement at a tighter spacing than if the sheet is a polyester scrim membrane, due to the fact that fiberglass-reinforced PVC membranes cannot withstand routine flexure without compromise.

An example of a tight (3-ft.) spacing of polymer battens on an uplifted, compromised area of a fiberglass, scrim-reinforced PVC membrane is shown in *Figure 9*.

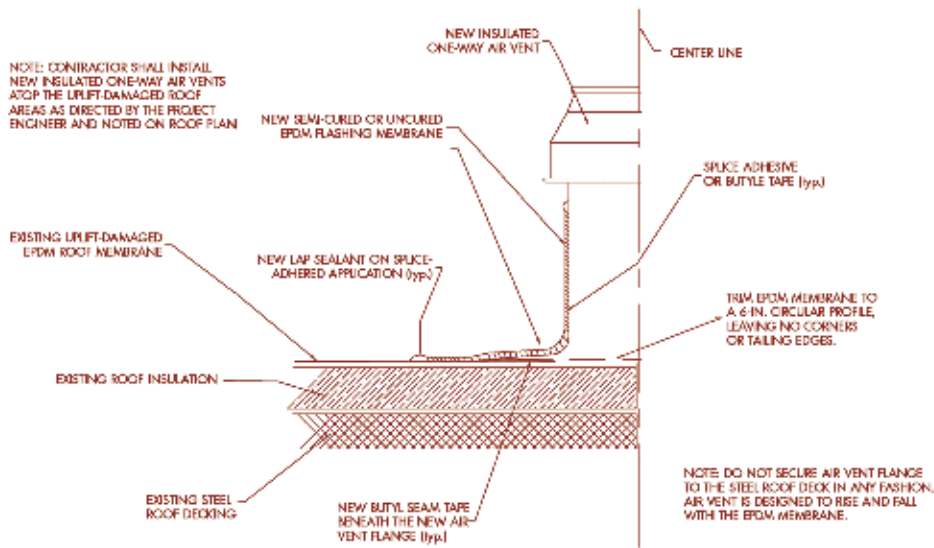
Such extensive batten work is costly, and it may be less expensive to simply replace the membrane area with a polyester scrim PVC membrane for a permanent repair. Temporary repair could have employed battens around the roof drains and at wider intervals, with one-way air vents installed. An example of such a repair is shown in *Figure 10*, with that particular area awaiting installation of the one-way air vents.



Figure 10 – Battens around roof drain on uplifted area.

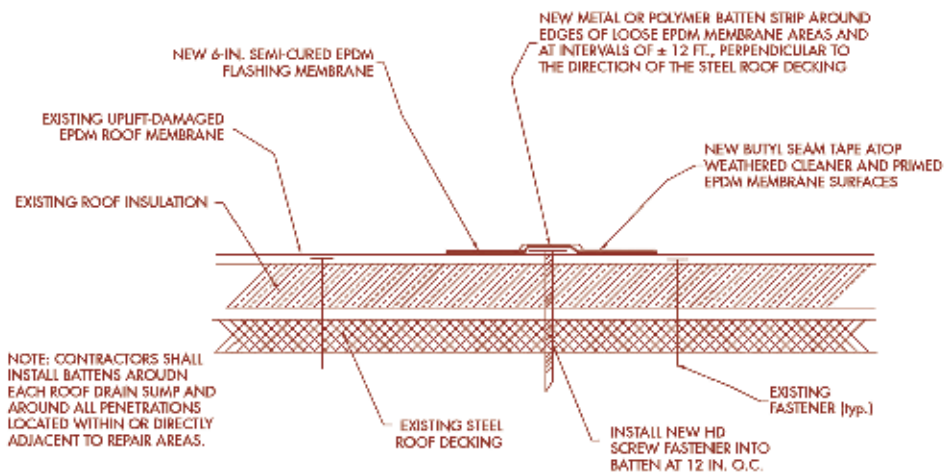


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NEW ONE-WAY AIR VENT FLASHING DETAIL (For use in repairing uplift-damaged roof areas)


Figure 11 – One-way air vent flashing detail.



NEW BATTEN AND COVER STRIP DETAIL (For use in repairing uplift-damaged roof areas)

Figure 12 – Batten and cover strip detail.

Cleaning an aged PVC membrane to a level that will facilitate a hot-air-welded PVC membrane cover strip could also prove to be a chore if the surface has microbial growth or particulates that are tightly adhered to the membrane surface.

If a building owner wishes to extend the usable life of a disbonded, single-ply roof membrane area, and the membrane remains mostly sound (simply loose from the insulation substrate), turning it into a hybrid, mechanically attached assembly is a viable option. Such a repair application must be properly designed for field conditions and executed using proper components and time-proven detail applications. The example details provided (Figures 11 and 12) are for use in repairing an unreinforced EPDM roof system, but may be readily adapted for use in the repair of an uplift-compromised PVC or TPO roof membrane area. 



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