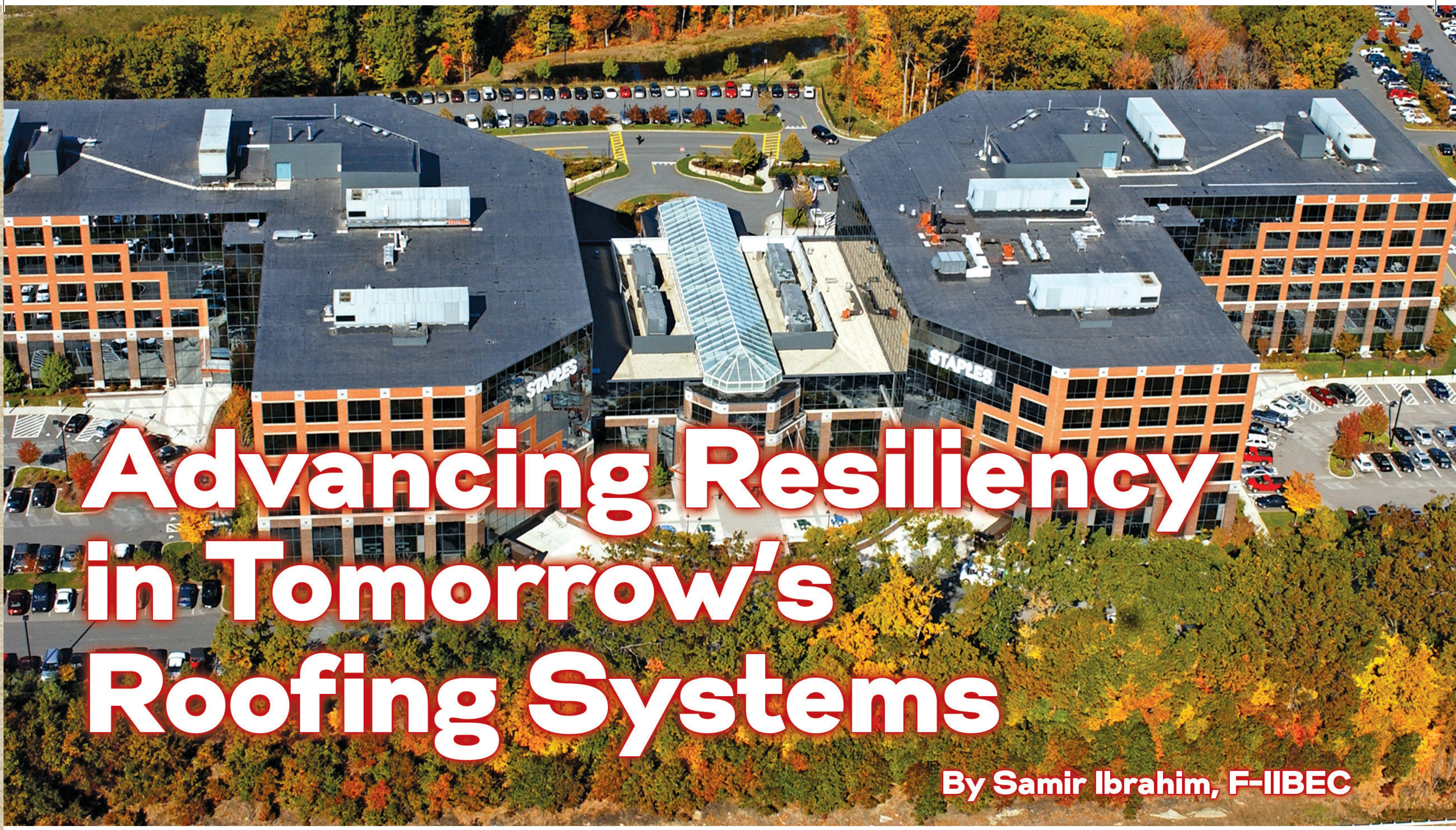

Advancing Resiliency in Tomorrow's Roofing Systems

By Samir Ibrahim, F-IIBEC

INTRODUCTION

The increase in the frequency and intensity of weather events, along with their massive disruption in building operations and loss of revenue, has clearly contributed to the resiliency conversation and eventually led many government and non-government agencies and trade associations to reach a consensus supporting the resiliency movement.

Building resiliency had been defined as the ability to adapt to changing conditions and to withstand and rapidly recover from disruptions due to emergencies. The key phrase that stands out in this definition is "withstand and rapidly recover." This phrase is now shaping the resiliency discussion in roofing.

RESILIENT ROOF KEY ATTRIBUTES

Consistent with the building industry, the goal for resiliency in roofing is to increase the roof system's adaptability to changes and to enhance its ability to quickly recover after a major weather event. A resilient roof system must have the following key attributes:

- Be designed with multiple lines of defense and greater durability standards to sustain extreme conditions without disturbing the building operation
- Be designed with components and products that can easily and quickly be repaired, even after the loss of electric power
- Be equipped with a secondary layer of a roofing membrane, a durable vapor retarder, or a strong air barrier to function as a temporary roof (in the event of a disturbance to the primary roofing system) until the assembly is repaired
- Be configured with a secondary drainage system to promote controlled drainage (at the air barrier level) in the event of damage of the primary roofing membrane
- Be equipped with roof vents to equalize pressure during heavy windstorms to minimize potential of wind disturbance on the primary roofing system.

As a resilient roof design will require a system approach rather than a component-by-component focus, the design will be influenced greatly by the region and the anticipated environmental impact. The future of resilient roofing is likely to include various levels of resilient assemblies—each customized for the anticipated weather extremes.

DURABILITY VS. RESILIENCY

Resiliency should not be confused with durability. All roofing assemblies have traditionally been designed to meet a certain level of durability so that the assembly is able to sustain the specific project conditions (wind, hail, snow, ice buildup, and rooftop activities). The intent has always been to minimize losses. But with the changes in weather patterns and the increase in storm intensity and frequency, the bar has been raised to meet stricter testing standards.

Resilient construction describes an assembly with greater durability standards, combined with a recovery system to "withstand and rapidly recover," as previously defined. It's not about over-designing, but rather about an integration of durable components into a robust design.

As is the case with durability in roofing—where different levels exist to address the various buildings and regional needs—roof assemblies with various levels of resiliency will very likely be encountered to address the variety of buildings and their use during emergencies.

ADVANCING RESILIENCY IN COMMON SINGLE-PLY ROOFING ASSEMBLIES

Many designers may automatically lean towards or favor a familiar assembly when thinking of resiliency. Most of the common

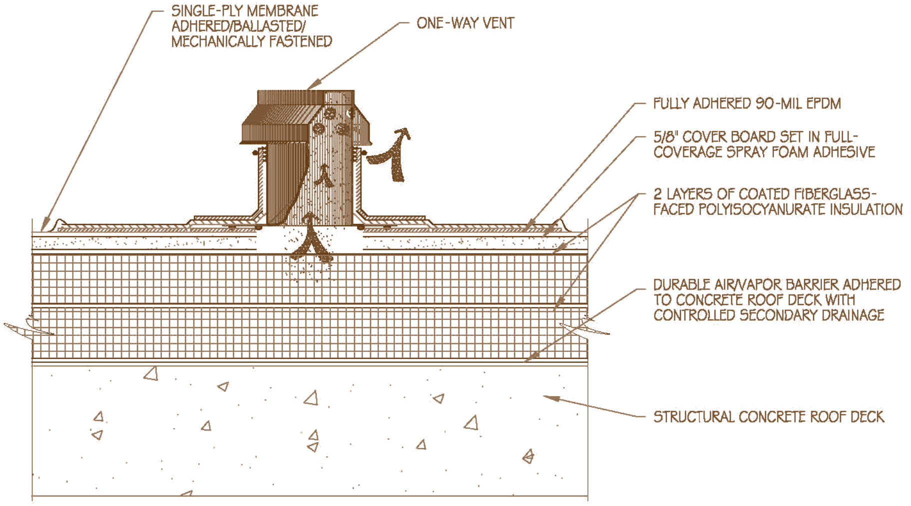

Figure 1

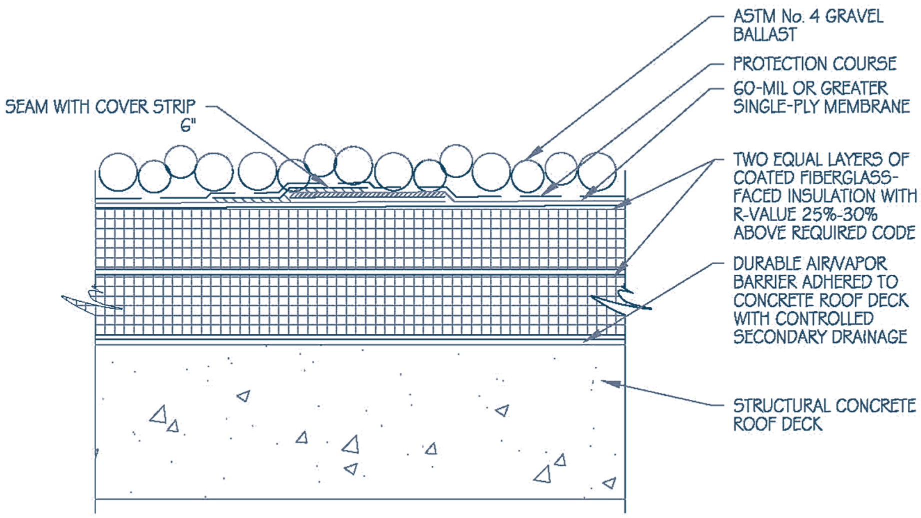

Figure 2

assemblies used in the market today—even ballasted roofs—can be designed to offer a viable, resilient roofing option that can offer an optimum level of protection when exposed to very severe hail. It's certainly not the type of roof to be placed on a skyscraper or to be marketed in hurricane zones, but with the proper design, it can deliver an assembly that is able to function at a very high level (*Figure 1*).

To advance resiliency in ballasted, adhered, or mechanically fastened membrane assemblies, certain common attributes should also be considered in these assemblies:

1. Incorporate a durable air barrier or a roofing membrane to serve as a secondary waterproofing layer.
2. Incorporate a secondary (smart drainage) system at the secondary waterproofing membrane level.
3. Consider the use of one-way vents to relieve pressure during major wind events and allow moisture to escape.
4. Select an insulation board with coated glass facers to provide the highest level of moisture resistance to serve as the first layer above the air barrier/secondary waterproofing membrane.
5. Consider the incorporation of a high-density cover board to provide maximum traffic and hail resistance.
6. For reroofing applications, consider the use of tapered insulation to provide positive drainage.

In addition to the attributes listed above, those named below are system-specific requirements that should also be considered.

BALLASTED ASSEMBLIES (*Figure 2*)

- Install multiple layers of insulation with an R-value of at least 25–30% above what is required by current codes.
- Use a thicker membrane, 60 mil or greater, with seam overlay. Sheet sizes can be selected so that the field splices are in up-slope areas.
- Provide a protection/drainage layer under pavers to facilitate drainage and extend paver service life.
- Incorporate larger stone gravel or pavers in the perimeter and corner areas, and consider parapets of 36 in. or greater in high-wind regions or on tall buildings.

ADHERED ASSEMBLIES (*Figure 3*)

- Incorporate multiple layers of insulation with an R-value of at least 25–30% above what is required by current codes.
- Set all boards in beads of foam adhesive, and install a suitable cover board.
- Select a thicker membrane that—with the appropriate cover board—can deliver the needed puncture and hail resistance.
- Select the appropriate technology for adhering the primary membrane

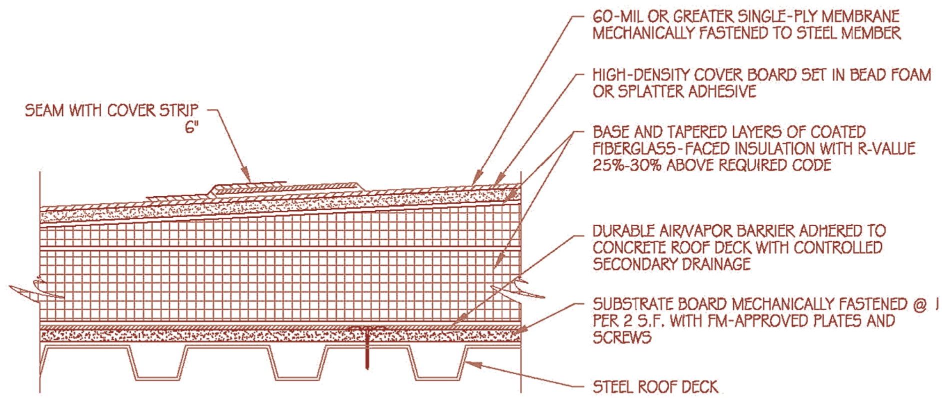

Figure 3

to yield the highest expected uplift rating desired.

MECHANICALLY FASTENED MEMBRANE ASSEMBLIES (*Figure 4*)

- Perpendicular to the steel deck flutes, install structural steel members at locations where field splices are to be encountered.
- Secure the structural steel members to the deck, and flash with pressure-sensitive flashings.
- Install the first layer of insulation flush with the top of the structural member, followed by additional layers and a cover board—all set in bead adhesive.
- Select a thicker membrane with greater fatigue resistance, and secure it to the previously installed structural steel members.
- Overlay all field splices to enhance watertight performance of the system.

For all assemblies, the use of prefabricated accessories, where possible, is strongly recommended, along with a comprehensive maintenance/inspection program to assess the roofing assembly condition.

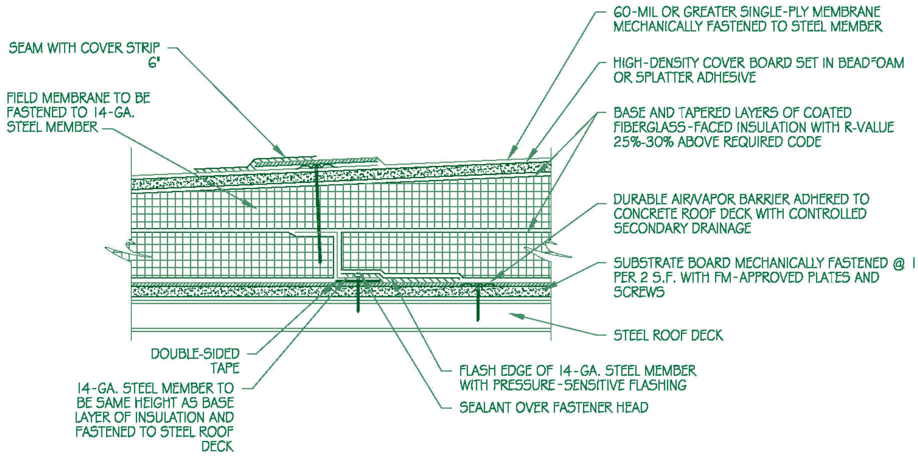

Figure 4

ROOF ASSEMBLY ABILITY TO RECOVER

Rapid recovery is a key attribute of a resilient roofing assembly to ensure minimum disturbance to the building interior and the facility operation. For example, during a major weather event, we may experience long-duration loss of electric power, and many streets could remain flooded, hindering the use of heavy repair equipment or power generators. Fuel shortage may also be encountered. Considering such conditions, the roof assembly should be designed to sustain no damage. However, if damaged, it should be assembled and constructed with components that facilitate quick and simple repairs.

- Various single-ply systems could be

repaired using pressure-sensitive flashing materials, whether they are thermoset or thermoplastic. The membrane is simply cleaned/primed, and the flashing is applied with no power or major equipment needed.

- Asphaltic roofs may be repaired with cold adhesives/emulsions, eliminating the use of hot kettles.
- Hail-damaged roofs could easily be temporarily repaired with simple hand tools and using high-solids coatings and sealants.

Simplicity and the quickness of repairs are factors that must not be overlooked when designing a resilient roofing assembly.

LOOKING AHEAD

As we continue to explore the resiliency movement, much testing and developmental work are expected—not because the current technology is lacking, but because the recovery concept was not the main driver when many of the durable roofing components and assemblies were being developed.

As we look forward, we can certainly expect the conversation on resiliency to continue, leading to an increased awareness and greater dialogue among roofing industry stakeholders. The development of new components is likely to occur, and the integration of smart materials and sensor technology is also probable.

ACKNOWLEDGEMENT

While the efforts put forth by the many organizations and agencies toward the subject of resiliency are gratefully acknowledged, many thanks to the National Research Council of Canada and the EPDM Roofing Association on their leading roles in bringing awareness to the roofing resiliency initiative and exploring various resiliency attributes.

Samir Ibrahim

Samir Ibrahim has been with Carlisle SynTec, a leading manufacturer of black and white single-ply membranes and polyiso/EPS insulation, since 1980, and he is currently its Director of Design Services. He holds a Bachelor of Science degree in architectural engineering from the University of Alexandria, Egypt. Ibrahim's group is responsible for systems and detail development and all code-testing operations. He is also the developer and coordinator of all Carlisle architectural and consultant training programs and holds a patent on an automated seaming device for thermoset applications.

It's a Park; It's a Shopping Mall; It's an Airport

Photo by Darren Soh. Courtesy of Safdie Architects.

Singapore's Jewel Changi Airport now contains a 135,700-square-meter mall camouflaged by a 5.6-acre atrium garden, a record-tall waterfall, and an elevated train slicing through it. The Jewel is the central connector between the existing airport terminals.

Designed by architect Moshe Safdie of Cambridge, MA, and engineered by RSP Architects Planners & Engineers Pte Ltd., five stories of retail are hidden by a forest under glass. The $1.25-billion project is almost completed.

At the apex of Jewel's glass roof is an oculus that showers water 130 ft. (40 m) and is billed as the "world's tallest indoor waterfall," serving as a 360-degree screen for sound and light shows run at night.

Airflow from the heat stack effect in the garden and heat beating down on the glass roof is mitigated by cool terraced landscaped levels and heat-stratification-based ventilation, as well as from cooling by the waterfall. Spectrally sensitive glazing offers high visual light transmittance and low solar gain. Retractable sails shade the event space, and roof smoke vents exhaust hot air.

Jewel also has a hotel and movie theater—all covered by the world's largest gridshell to enclose a building, according to the roof designer, the New York City office of Buro Happold. Gridshells—also known as thin shells—are shallower for the same span than trusses or space frames. The roof structure contains more than 6,000 solid steel nodes and 15,000 members entering the node at different angles and with different depths.

View the highlights of Jewel at https://youtu.be/owNABcxVY1g.

— *Architectural Record, ENR,* and Safdie Architects