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Roof Condition Surveys:

What They Are and Why They Matter

Deborah J. Costantini, AIA

As roofs age, they evidence small signs of wear that begin to mount over time, until the roof reaches a point at which it no longer provides reliable protection. Roof failure can happen gradually, beginning with small leaks that become larger ones, or it can happen all at once, as with a roof blow-off during a weather event. In either case, signals of impending roof distress likely emerged well before the roof reached the point of failure. The idea of a roof condition survey is to identify emerging problems, develop a program of maintenance and repair to maximize roof lifespan, and plan for eventual replacement.

Unless roof surveys are conduted routinely, deterioration can go undetected and lead to premature roofing failure.

With building codes evolving in response to performance benchmarks for energy efficiency and resistance to weather extremes, resiliency is key. While it is clear that new construction must meet demanding structural and thermal standards, what does the push for higher-performing buildings mean for existing structures? Specifically, how do the latest building codes and standards impact traditional reroofing projects? If new requirements mean greater expense for owners in the evaluation, design, and construction of roof replacements, many owners will, understandably, opt to eke out as many extra years of life as possible from existing roofs. Assessing the cost-to-benefit ratio of maintaining an old roof versus installing a new one is more complicated than ever, with new options and codes leaving many owners unsure about the best choice for their building and situation.

The first step to determining roofing needs and finding solutions is to evaluate the existing assembly. Without a thorough investigation, there is no baseline for establishing the progress of observed conditions or for identifying roof areas in need of urgent attention. A detailed roof condition survey allows for advance planning, with maintenance items, major repairs, and replacement that can be anticipated, budgeted, and addressed before sudden failure makes emergency rehabilitation an unexpected priority.

Why Inspect the Roof?

Roof warranties from manufacturers may require annual inspection by a design professional, so it's important to keep detailed records of these surveys to verify that the terms of the warranty have been upheld. If there is a problem, verifying that routine inspections have been conducted in compliance with the conditions of the warranty can be vital to obtaining coverage for premature failures.

Leak detection is another key reason to inspect the roof regularly, as some leaks may not be immediately

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apparent at the building interior. For warranty protection, leaks typically must be reported to the manufacturer within a stated time period (e.g. 30 days), or coverage may be voided. Leaks should also be identified as early as possible to protect against widespread moisture damage. The longer a leak persists, the further infiltrated water can seep into building components.

Roof maintenance relies on close observation to identify conditions requiring repairs. To maximize the service life of the roof, facility managers need to respond promptly to bent flashings, punctures and tears in the membrane, storm debris, clogged drains and gutters, and other repair and maintenance items. Unless these minor issues are addressed, they can lead to major problems, which can become costly to remediate and may even require partial or full replacement of the roof system.

Planning for roof replacement depends on routine roof inspections, as changes in conditions from one evaluation to the next can indicate that a roof's lifespan is coming to an end. Documenting the age and condition of waterproofing, flashings, attachments, and accessories provides a record of the speed and progress of deterioration, allowing owners to anticipate and budget for replacement.

Before a reroofing project, a thorough roof survey is vital to preparing comprehensive and accurate construction documents. With new code requirements for wind uplift, diaphragm analysis, thermal performance, and other standards that may not have been in place at the time of the previous roof installation, assessing the existing system and determining which upgrades are necessary to meet current codes is vital to avoiding unexpected and costly change orders once the roof replacement is underway.

Creating a Roof Inspection and Maintenance Checklist

Ideally, at the end of a roof installation project, the design team should create **a small-scale roof plan** to use for future inspections. Such a drawing could be copied for each inspection, creating a ready-to-use blueprint for marking locations of distress, failure, leaks, damage, and other deficiencies.

In addition, **a log for those going onto the roof** is a useful tool to track traffic and create a record of interventions that can be reviewed should a problem arise. Documenting the date, who went onto the roof, and why, can aid in tracing the source of damage. Any mishap that inadvertently occurs should be noted immediately. The log can also require certification that hazardous materials were not introduced to the roof area.

Roofs should be inspected by facility personnel **every fall and spring,** as well as **after major weather events.** It is prudent to retain a design professional to conduct a more rigorous roof survey at the first sign of problems, or as the roof begins to approach the end of its lifespan – whichever comes first.

The checklist accompanying this article may serve as a guide for maintenance personnel in conducting routine inspections. Note, however, that the list is not comprehensive and should serve not as an exhaustive inventory of detrimental conditions, but rather as a first step in the roof evaluation and maintenance process. Such informal assessments cannot take the place of comprehensive roof surveys conducted by design professionals, which are typically required at regular intervals to maintain warranty coverage.

Given the wide range of roofing types and applications, inspections should be tailored to the building and situation.

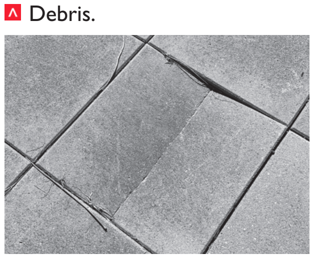
What to Look For: Low-Slope Roofs

Ponded water.

Debris.

Membrane alligatoring, cracks, splits, or tears.

Clogged drains.



Cracked pavers.

Damage at roof penetrations.

Displaced / damaged flashings.

What to look for on a rooftop recreational space, for instance, is not the same as what merits attention on a historic slate roof. However, common to all roof assemblies are waterproofing and drainage systems, as well as some method of adhesion or attachment. Protecting the building from the elements and remaining solidly affixed to the structure are essential characteristics of any functional roof system. Therefore, careful evaluation of the roof's performance in these capacities should form the framework of an inspection. Once the waterproofing and structural integrity have been affirmed, evaluation of accessories, appurtenances, equipment, and other features should round out the roof survey.

What to Do with the Survey Results

Once the inspection is complete, areas that require immediate attention should be prioritized for maintenance or repair. Conditions that persist from one inspection to the next, or those that have worsened or emerged suddenly, should be evaluated by a design professional. Maintaining records of inspections not only provides documentation for warranty purposes, it establishes a history of roof conditions that can prove valuable in determining when it's time to replace the roof.

Beyond Visual Inspection

When evidence of water infiltration points to roof leaks, but it is difficult to identify the source or extent of water infiltration by observation alone, it may be valuable to incorporate additional testing into a roof survey.

Infrared scans use thermographic cameras to produce thermal images of heat loss. During the day, wet insulation absorbs more heat from the sun than does dry insulation, so it releases more of this stored heat energy at night. Infrared scans pick up these differences in temperature to produce a detailed picture of where moisture is present beneath the roof covering.

Nuclear surveys apply the principle of neutron moderation to the detection of water in roof assemblies. Neutrons emitted from a radioactive isotopic source collide with hydrogen neutrons, altering their speed. Nuclear detectors measure these changes in velocity, which are compared with a dry material baseline. Readings taken in a grid are used to generate a statistical map of increased hydrogen levels, indicating likely sites of moisture presence.

Capacitance testing measures electrical impedance and resistance to identify sites of increased conductivity and, thus, increased moisture. An alternating electric field is generated using transmitting and receiving electrodes, and the capacitance of the roof area between these points correlates with the presence of water in the assembly.

Flood testing evaluates the effectiveness of the waterproofing system on low-slope assemblies by temporarily adding a measured amount of water to the roof. Visual inspection can then identify leaks at the building interior, which can be extrapolated to the roof area. Since it does not pinpoint the source of infiltration, flood testing is used less frequently than other methods. For some buildings, it may be precluded by structural concerns due to the weight of the accumulated water.

Electric field vector mapping (EFVM) is an alternative to flood testing, in which a low-voltage electric current is applied to the wet surface of the roof to identify breaches in the waterproofing. A conductive wire loop is laid out around the test area, and a potentiometer with two probes is used to detect where current flows through breaches in the membrane to

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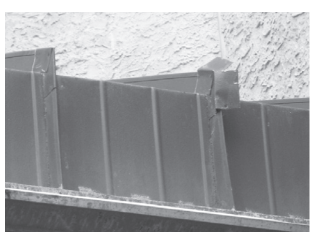
What to Look For: Steep-Slope Roofs

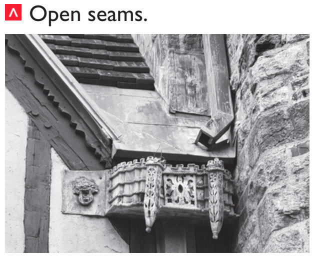
Broken tiles or shingles.



Open seams.

Failed past repairs.

Exposed fasteners.



Clogged drainage.

Loose, displaced, or missing shingles.

Roof Diaphragm Analysis: *New Requirements for Existing Structures*

Lawrence E. Keenan, AIA, PE

With the 2015 edition of the *International Building Code* (IBC), the International Code Council eliminated the chapter on existing structures, which had, until then, offered an alternative to the *International Existing Building Code* (IEBC) for roof replacements. The 2015 IBC instead requires that IEBC be used, which incorporates new and challenging requirements for roof replacement projects.

Although the change in the IBC took place years ago, states and municipalities tend to be slow to adopt new versions of the code. For many jurisdictions, the change in requirements is much more recent, within the past couple of years, or just now taking effect. While many are unaware of the change to the code, the impact on reroofing projects is profound.

What are the new requirements?

For buildings in coastal areas, special wind regions, or other locations with design wind speeds greater than 115 mph, and for higher risk category buildings, if more than 50 percent of the roof will be replaced, the IEBC now requires that a ***roof uplift and diaphragm analysis*** be performed.

Roof blow-offs and damage during recent natural disasters has drawn public awareness to the safety of roofing assemblies, particularly on older buildings. As the effects of wind on buildings has become better understood, design loads for wind resistance have risen considerably in the past couple of decades, and wind loading has become a far more significant factor in the design of new buildings. Earlier building construction, therefore, may be inadequate by modern standards in terms of structural design for wind load resistance.

> "Structural evaluation of the roof diaphragm on existing buildings is often challenging, and, in some instances, it simply cannot be done."

The new IEBC provisions aim to compel assessment of buildings in high wind regions to ascertain whether roofs provide sufficient strength and attachment, and to undergo structural improvements if deficient.

What is a roof diaphragm?

Buildings are subject to various loads due to wind. As the wind approaches and flows around a building, it presses against the forward face and pulls on the leeward face. The air also compresses and accelerates around and over the building, creating low pressure zones. These forces are resisted directly by the building ***components and cladding,*** where they are collected and distributed to the ***lateral force resisting system*** of the building.

A roof deck that collects the lateral forces and distributes them to the lateral force resisting system is a ***diaphragm.*** Essentially, a diaphragm is a very flat and deep beam on its side. As wind load is applied to the walls, the load is carried to vertical elements, such as wall braces, shear walls, or steel frames, by the beam action of the roof diaphragm.

Wind loads on components and cladding are calculated differently from those for the lateral force resisting system. Small, localized portions of the building are more apt to be subject to high wind loading, as compared with the lateral force resisting system, which is unlikely to sustain the same high loads across the entire surface area. Consequently, calculated design wind loads on components and cladding are higher than those on elements of the roof diaphragm. The IEBC requires that roof decks, their attachments, anchorage to exterior walls, *and* the roof diaphragm be able to support 75 percent of current design values.

Why is this change important?

Unfortunately, structural evaluation of the roof deck, attachments, and the diaphragm on existing buildings is often challenging, and, in some instances, it simply cannot be done. Different types of roof structures have been used throughout the years, many of which were proprietary and were never designed or tested for either wind uplift or diaphragm forces.

Moreover, where original construction documents have been lost to time, there is little information regarding building systems, materials, and construction details. To perform the required calculations, as-built information is essential. However, for buildings where structural elements are concealed, sometimes behind hazardous materials like asbestos, obtaining the necessary information becomes a project in itself.

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When should diaphragm evaluation be performed?

The IEBC states that roof diaphragms, connections of the diaphragm to framing members, and roof-to-wall connections must be evaluated for wind loads "where roofing materials are removed from more than 50 percent of the roof diaphragm." Predicating the standard on roofing ***removals*** implies that the evaluation should be performed during construction; however, to avoid costly change orders and delays, diaphragm analysis should begin early in the design process.

The ***roof survey phase*** is the optimal time to conduct a preliminary investigation of the roof for diaphragm and wind uplift requirements. This initial assessment may suffice to determine the likely cost for required upgrades, or it may serve to identify the extent to which further investigation is or is not necessary.

Later, during the contract documents phase, structural evaluation should be completed, so that any roof structure augmentation necessitated by the IEBC can be cost-effectively included with the documents for bidding purposes. As existing roofing is removed during construction, additional evaluation of the deck condition should be performed, as per the IEBC.

What if the building does not have a roof diaphragm?

For many older buildings, the lateral force resisting system is inadequate or missing entirely, which means that there can be no roof diaphragm. A diaphragm is created by developing loads and transferring them to lateral supports. If there are no supports, diaphragm forces cannot develop, and therefore a roof diaphragm does not exist.

In such cases, the diaphragm and connections cannot be strengthened against loads that do not exist, so it is not clear that any further action is required to meet IEBC requirements for roof diaphragm evaluation and remediation. Since the IEBC does not address all likely scenarios, particularly regarding older buildings, interpretations of the code should be made in consultation with a design professional and the building official. ■

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Wind uplift testing for IEBC compliance and FM Global insurance certification.

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the grounded deck. EFVM can identify pinhole openings in the membrane that might not be readily discernable otherwise. Unlike flood testing, EFVM can be used on steep-slope and vegetated roofs. Because this test method relies on the electrical resistance of the membrane, roof systems, such as black ethylene propylene diene terpolymer (EPDM), that act as conductors, rather than insulators, are not compatible with the technique.

High-voltage electronic leak detection (ELD) is performed on a dry surface and requires less setup time than EFVM, so it may be a less expensive option. High-voltage ELD applies a small current at high voltage from a conductive metal electrode brush to a grounded lead. As the brush sweeps over the membrane and flashings, electricity flows through any breaches, completing the circuit. Since the brush must make direct contact with the membrane, roofs with overburden cannot be tested with high-voltage ELD without first removing the ballast, pavers, plantings, etc., so EFVM may be a better option for these assemblies.

Based on the type of roof system and observed conditions, a design professional can recommend appropriate non-invasive testing to detect concealed sites of moisture infiltration. Once the compromised areas are identified and repaired, testing may be repeated to confirm that roof integrity has been restored. Testing may also be used prior to roof replacement to pinpoint areas that are sound and dry and may be considered for recovering.

New Codes and Standards

When considering options for full or partial roof replacement, owners should keep in mind that updated building codes may require changes to the roof assembly. New requirements for thermal performance and

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Routine Roof Inspection Checklist for Building Managers

Roof Area: ______________________ Inspector: ________________________ Date: ____________

Reported leaks:			Repairs / modifications since last inspection:		
Leaks occur:		Every time it rains		In wind-driven rain		During ice / snow build-up

	LOW-SLOPE ROOFING			STEEP-SLOPE ROOFING
GENERAL OBSERVATIONS				
	Debris on roof			Debris on roof
	Evidence of ponding water			Displaced shingle / tile / slate / panel
	Clogged drains / scuppers			Missing shingle / tile / slate / panel
	Missing drain baskets			Clogged gutters / conductor heads / leaders
	Physical damage			Physical damage
FIELD OF ROOF				
	Membrane open laps / fishmouths / ridges			Deteriorated roofing material
	Membrane punctures / cuts / tears			Displaced / missing roofing component
	Surface alligatoring / cracking / blisters			Dented, corroded, or cracked roof material
	Bare spots in gravel / coating			Ice dams / icicles
	Protruding fasteners			Exposed fasteners
PERIMETER OF ROOF				
	Deteriorated flashing material			Deteriorated flashing material
	Flashing open laps / fishmouths / ridges			Flashing open laps
	Flashing punctures / cuts / tears			Flashing punctures / cuts / tears
	Flashing wrinkles / ridges			Missing flashing materials
EDGE METAL (Gravel Stops / Fascia / Copings)				**(Drip Edge / Rake / Ridge Caps / Counter-Flashing)**
	Missing or displaced metal flashing			Bent / damaged metal components
	Open metal laps / punctures			Open seams / laps
	Missing fasteners			Missing fasteners
	Rusting / deteriorated metal			Rusting / deteriorated metal
PENETRATIONS (Equipment Curbs / Skylights / Vent Pipes)				
	Deteriorated flashing material			Deteriorated flashing material
	Flashing open laps / punctures / tears / blisters			Flashing open laps / cracking / punctures
	Metal counter-flashing missing / damaged			Metal counter-flashing missing / damaged
	Sealant deterioration			Sealant deterioration
	Equipment covers unsecured / missing			Rusting / deteriorated metal
ACCESSORIES				
	Walkways damaged / displaced / missing			Snow guards displaced / missing
	Guardrail post flashing / conduit support failures			Snow rail assembly issues
	Skylight glazing and guard deterioration			Skylight glazing and guard deterioration
	Antennas damaged / missing			Antennas damaged / missing

representative projects

Roof Condition Surveys

Roof assessments are a critical component of maintenance programs and warranty compliance protocols, and they are essential for resolving leaks, assessing remaining roof lifespan, and preparing for reroofing. Hoffmann Architects' design professionals focus on details that are easy to overlook, from flashing and drainage conditions to proper slope and penetration detailing. Our architects and engineers have provided customized roof surveys for diverse facilities, including:

Choate Rosemary Hall
Nichols Building
Wallingford, Connecticut
Slate Roof Leak Investigation

Verizon, 567 East 105th Street
Brooklyn, New York
Coated Bitumen Roof Condition Survey

Chatsworth Gardens
Larchmont, New York
Terra Cotta Roof Survey and Replacement

Union Station
Washington, District of Columbia
Steel Panel Roof Condition Assessment

Church of the Heavenly Rest
New York, New York
Single-ply Roof Condition Survey

Worcester Polytechnic Institute
Higgins House
Worcester, Massachusetts
Historic Clay Shingle Roof Survey, Restoration

The Metropolitan Opera House
New York, New York
Annual MBR Roof Inspection

Office Building, 700 Eleventh Street
Washington, District of Columbia
Condition Survey of 10 Roof Terraces

Fairfield Public Schools
Fairfield, Connecticut
Preparation of Roof Warranty Manual

4 Columbus Circle
New York, New York
Assessment of Roof Recreation Spaces

Wellesley College
Wellesley, Massachusetts
Campus-Wide Masonry and Roof Evaluation of 31 Buildings

Scholastic Headquarters
New York, New York
MBR Roof Survey, Partial Replacement

Connecticut College
Winslow Ames House
New London, Connecticut
Wind Uplift and Roof Diaphragm Analysis, Roof Replacement

Smithsonian Institution
Paul E. Garber Facility
Suitland, Maryland
Metal Panel Roof Leak Investigation

Woodberry Forest School
Barbee Center
Woodberry Forest, Virginia
Single-ply Parabolic Roof Condition Survey

Rockland Psychiatric Center
Orangeburg, New York
Metal and Clay Tile Roof Investigation

Herrity Building
Fairfax, Virginia
MBR Roof Investigation and Replacement

Office Building, 50 Locust Avenue
New Canaan, Connecticut
Single-ply Roof Structural Assessment and Diaphragm Analysis

Fairfield University
Barone Campus Center
Fairfield, Connecticut
Vegetated Roof Investigation and Repairs

1001 Pennsylvania Ave., Washington, DC, *Roof Terrace Surveys and Replacements.*

Connecticut College, Fanning Hall, New London, Conn., *Slate Roof Condition Survey.*

101 Avenue of the Americas, New York, NY, *Modified Bitumen Roof Condition Survey.*

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continuous air barriers, guardrails, wind uplift resistance, and, in some jurisdictions (notably New York City, per the Climate Mobilization Act / Local Laws 92 and 94 of 2019), for vegetated roofs and solar arrays, among other stipulations, may preclude in-kind replacement. Throughout the lifespan of a roof, working with an architect or engineer familiar with up-to-date code requirements allows owners and facility managers to anticipate and budget for mandatory roof upgrades.

As manufacturers rush to keep up with evolving building codes and design standards, roof replacement may provide an opportunity to improve roof performance without overspending. A well-insulated roof protects against heat loss and reduces strain on HVAC equipment, as well as improving indoor comfort. In municipalities where energy benchmarking data is publicly available, an efficient building enclosure not only provides energy cost savings, it can help attract and retain desirable tenants.

New roof systems with easier and more reliable application, less downtime, and better energy profiles can ease the burden of roof replacement. Even some requirements, such as those for green or solar roofs, which have high up-front costs can yield reasonable return-on-investment, as energy cost savings and reduced wear and tear on protected roof assemblies help recoup the initial expenditure.

Roof Management Strategies that Take the Long View

Systematic, thorough, regular roof surveys, coupled with diligent maintenance, allow owners and managers to maximize roof lifespan. When it does come time for replacement, a facility with organized records is well positioned for informed reroofing choices that meet performance requirements and provide the desired service life. ■

JOURNAL is a publication of Hoffmann Architects, Inc., specialists in the rehabilitation of building exteriors. The firm's work focuses on existing structures, diagnosing and resolving problems within roofs, facades, windows, waterproofing materials, structural systems, plazas/terraces, parking garages, and historic and landmark structures. We also provide consulting services for new building construction, as well as litigation and claim support.

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