Roof Restoration of Atlanta's Fox Theatre

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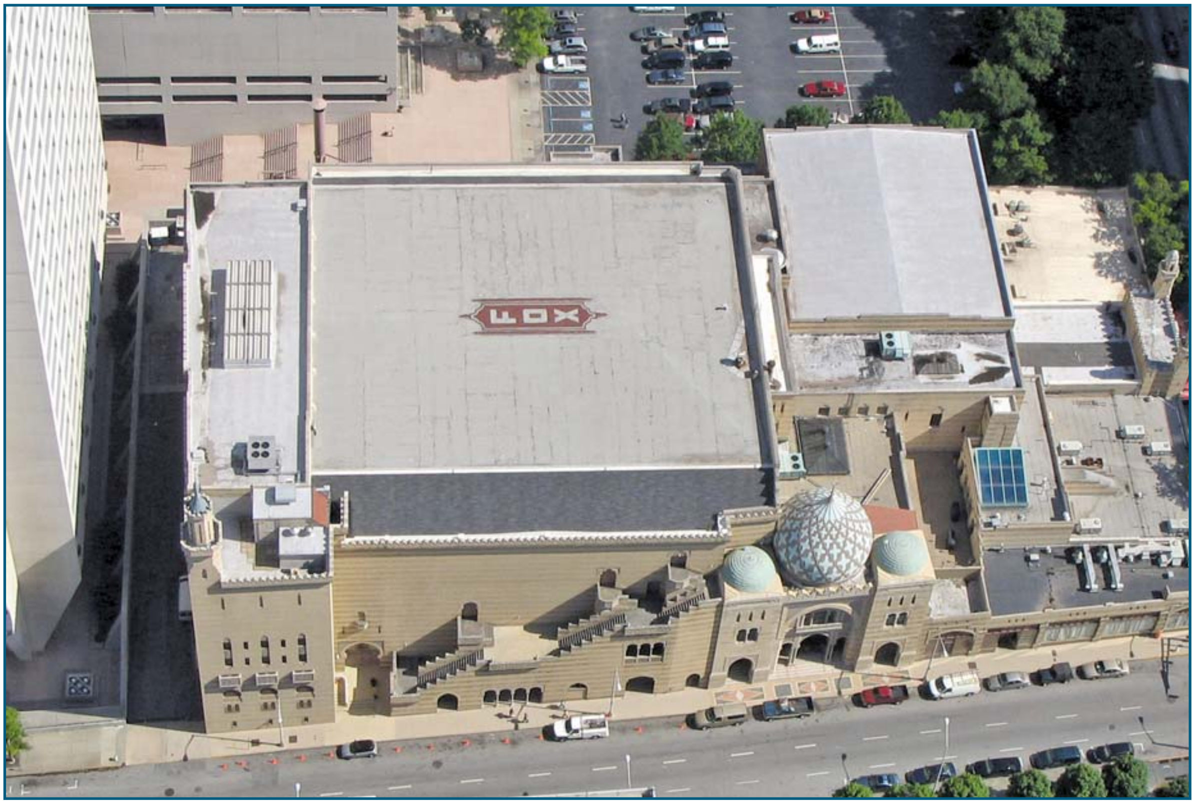
The Fox Theatre in Atlanta is only 80 years old, but the design, history, and high profile use of the building have led to its inclusion on the National Register of Historic Places. Originally intended as a Yaarab Shriners Temple, the Shriners leased the auditorium to movie theater mogul William Fox as a movie film palace to help finance its construction. Unfortunately, the opening of this facility in 1929 coincided with the stock market crash, which led to the movie palace's soon falling into bankruptcy. However, the Fox Theatre was able to reestablish and rebuild itself into the magnificent premier musical, reception, stage performance, and entertainment center that may be seen today on Peachtree Street in Atlanta.

A tour of the facility reveals a structure that retains the interior and exterior extravagances of the 1920s. The Shriners influenced the Moorish mosque-style exterior design, with the minarets and onion domes; while the interior décor is Egyptian-themed in the detailing of the walls, ceilings, and fixtures. The Fox Theatre today has been fully restored, down to the "Mighty Mo," which is the original Fox Theatre's custom-made Möller organ. This pipe organ is the second largest theater organ in the world, with over 3,500 pipes spread out over five chambers in the facility.

With almost 5,000 theater seats and reception facilities for up to 1,200 people, the Fox Theatre will not tolerate roof leaks. In 1983, a storm resulted in the blow-off of the 110-sq auditorium roof, which had to be repaired immediately for a show featuring Rudolph Nureyev and the Boston Ballet. Soon thereafter, the Fox Theatre contracted to have the same roof torn off down to the gypsum deck and replaced with a nailed base, followed by a four-ply, cold-process, fiberglass-ply BUR system surfaced with granules in cold-process adhesive.



Overview of the historic Fox Theatre roof systems. This photo was taken prior to the restoration of the auditorium roof, which is the largest roof area of the structure, and sports the Fox logo.

View of the mansard edge, which originally leaked due to differential movement from a buried I-beam at the perimeter.

This cold-applied BUR has performed since 1983, a testimony to the longevity of BUR. However, the Fox Theatre operations staff understands the key to preserving an asset is to keep it from deteriorating in the first place. The roof system was evaluated according to a prescribed process to determine if it could be restored. Ultimately, a national roof manufacturer and local contractor teamed up to restore the existing BUR and flashings and to warranty the continued watertight performance of this roof system.

This article describes the evaluation and restoration process for existing BUR and modified bitumen (MB) roof membrane systems, using the Fox Theatre as an example of the application of this process. Restoration is a cost-effective alternative to reroofing or retrofitting over an existing roof, but the system must be properly evaluated to ensure the risk of extending the service life of these existing assets is justified and worthwhile. This process addresses membrane issues and then incorporates new/updated flashings, along with new surfacing. It can be used on BUR and MB roof systems to greatly extend the life of existing roof membranes that may be aged but are in good condition. The restoration process addresses many of the factors that lead to the deterioration of a roof membrane, allowing the roof system to become a sustainable component of the building.

Evaluation of the Roof

When should the restoration process begin? Restoration of an existing roof system is most successful when it is still in good condition but may be starting to display minor cosmetic damage. A roof will resist aging from the elements but will show these effects in the following way:

- Fading (of coatings or other surfacing/flashing materials).
- Wind gravel scour.
- Signs of movement (especially along flashing locations).

As long as this type of aging has not begun to compromise the membrane and flashings by leaking or tearing, there is a good opportunity to preserve the roof through restoration. However, the roof's appearance is not enough to justify restoration. The membrane system has qualities and characteristics that can be measured. Additional diagnostics need to be conducted to determine these properties, and the results must be considered in making the decision whether or not to restore the membrane.

The first step in qualifying a roof system for restoration is to inspect the facility, including the roof and exterior walls, along with the interior surfaces. A roof condition report summarizes the information obtained in this inspection. During this survey, the professional must determine if the roof is on the verge of failure and if restoration is even feasible at this point. The following observations are examples of conditions that indicate the system is most likely not restorable:

- Extensive wet insulation.
- Open laps.
- Splitting.
- Broken membrane blisters.
- Embrittled and exposed plies.

The roof-condition report should list all findings and make a recommendation for the next step, which could be for further investigation towards restoration. This report will assist the specifier in developing a scope of work by identifying existing conditions and features of the structure.

RESTORATION STEPS FOR BUR & MB

1. CONDUCT A VISUAL INSPECTION.
- Splits.
- Blisters.
- Roof leaks.
- Ponding water.
- Fading.
- Flashings.
- Details.
- Interior of building.
- Structural considerations.
- Use observations to determine if restoration is feasible.

2. OBTAIN A ROOF SAMPLE.
- Identify materials and construction.
- Interply adhesion and coverage rate.
- Tensile strength of membrane.
- Characterize condition of plies and adhesives.
- Evaluate insulation, component, and system attachment.
- Deck condition.
- Is restoration still feasible?

3. MAKE A MOISTURE ANALYSIS.
- Infrared.
- Nuclear.
- Capacitance.
- Is restoration still feasible?

4. UPGRADE THE ROOF SYSTEM.
- Remove and replace of wet insulation.
- Prepare of surface.
- Make necessary repairs.
- Replace perimeter flashings.
- Upgrade penetration flashings.
- Install a fire-rated surfacing.

5. INSTITUTE A MAINTENANCE PROGRAM.
- Follow up inspections.
- Minor maintenance.
- Repeat restoration steps in 5 to 10 years?

If the roof system is not in a failure mode, the diagnostic work can begin. Cut a roof membrane core to identify the construction of the membrane and insulation system and to verify the substrate type. In addition to identifying the system, a larger-sized membrane sample should be collected per ASTM D 2829[1] and tested to quantify the following performance properties of the roof membrane:

EVALUATING & RESTORING THE FOX THEATRE ROOF SYSTEM

The existing four-ply, cold-process BUR roof on the Fox Theatre Auditorium provided 18 years of service before developing leaks into the facility. Even though the leakage was considered minor, stains began to grow along a ceiling-to-wall edge.

The inspection began with a visual survey of the facility's roof and interior. It confirmed that the perimeter was the source of leakage. The edge detail along two perimeter walls consists of a metal I-beam that terminates the gypsum deck (instead of wood blocking) along the length of a shingled mansard roof. The I-beam presented two problems:

- The high movement of the metal I-beam caused high movement along the perimeter, eventually leading the flashing ply to tear open and leak.
- Conventional flashings could not be attached to the I-beam like they could be secured to a wood nailer.

This flashing issue was solved by the selection of a reinforced elastomeric membrane flashing that accommodates the movement and provides a long-term watertight performance. This flashing material, 45-mil-thick reinforced Hypalon, has the additional advantage of being compatible with the asphaltic roof system that it was stripped into.

The new flashing repairs were installed fairly quickly and permanently resolved the roof leaks at the Fox Theatre. The initial inspection revealed a roof system that, although almost 20 years old, was in remarkably good condition. This roof did not appear to be in need of replacement, and its owner were interested in keeping this roof in good shape to perform even longer. They committed to a roof evaluation program with the goal of determining if the roof was a restoration candidate.

Professionals first analyzed core roof samples to determine how strong the roof membrane was. As stated in the adjoining article, these results were compared against the 200-lbf tensile benchmark as described in NBS-555. The tensile strength results were excellent, as shown here:

Tensile Strength at 0°F (machine direction): 285 lbf/in
Tensile Strength at 0°F (cross machine direction): 250 lbf/in

It is important to note that cured, cold-process interply asphalt adhesive cannot be tested for softening point or penetration. The main function of a cold-process adhesive is to laminate fully coated felts. A well-bonded, cold-process system cannot be easily delaminated in a lab analysis the same way that hot-applied felts can be.

A cold-process roof sample does not come apart in discrete layers upon freezing; instead, the plies tear apart. Hot bituminous roof samples delaminate neatly in ply layers upon freezing, which makes it easy to collect interply bitumen for performance testing. In addition, there is a lower quantity of interply adhesive in a cold-process system (10 to 12 lbs/sq) than in a hot system (nominal 25 lbs/sq). Cold-process BUR systems use heavier ply sheets (28 lbs/sq minimum) to provide watertight performance as compared to a hot-ply sheet, which by itself is porous and weighs a nominal 11 lbs/sq.

Once the roof system strength was confirmed as being sufficient, the Fox Theatre agreed to a moisture analysis of all the roof areas on the facility. This moisture scan by infrared camera was conducted after sunset on a day when the roof received sufficient solar loading to heat up the systems. Infrared moisture analysis detects areas of wet insulation because wet areas transmit more heat energy from the building than surrounding dry areas. These areas of temperature differential are then read by the camera operator. Suspected wet areas are marked on the roof and noted on a detail drawing of the area. In addition, each suspected wet area is cored to verify if wet insulation is present. No additional wet areas were discovered on the auditorium roof.

The Fox Theatre wanted to maintain the existing appearance of the Auditorium roof, so a ceramic granule surfacing was selected. The specified surfacing included 3.5 gallons/square of cold-process adhesive and 60 lbs/square of #11 ceramic granules. The perimeter was stripped in with a polyester/fiberglass-reinforced, asphalt-coated felt, fully adhered in asphalt mastic adhesive. The material manufacturer and contractor have issued a warranty against roof leaks.

- Membrane material type.
- Number of plies.
- Average amount of interply bitumen.
- Softening point or penetration of the interply and surfacing bitumen.
- Tensile strength of the membrane.

Application of cold-process surfacing adhesive over primed surface prior to granule application.

Select the roofing test sample from an area of the roof that appears representative of the entire section. A larger sample (14 in x 18 in) is recommended in order to have sufficient material to conduct tensile strength and bitumen testing. If the roof is broken up into sections, several membrane samples should be collected. Note the condition of the membrane sample while removing it. Are the plies delaminating? Is the bituminous adhesive overly brittle? What are the interply coverage rates? A roof that has low interply adhesive coverage rates may be deficient in waterproofing, making a restoration a risky proposal. All of these observations are relevant in deciding whether or not the roof can be restored.

Physical performance test results of the existing membrane can give the roofing professional insight into the condition of the roof. If the bitumen softening point is drastically higher than the range for asphalt as defined in ASTM D 312[2] or coaltar pitch in ASTM D 450[3], the bitumen may be excessively aged and could be too brittle to perform as a part of the restored roof. Needle penetration per ASTM D 5[4] can provide another indication that the bitumen is too brittle and not within an acceptable range. On the other hand, test results consistent with standard performance ranges for these materials provide data to verify observations that the roof membrane is in good shape.

Why is the tensile strength of the existing membrane important? Low tensile strength indicates the membrane may not withstand future thermal shock and could split. This is important, because some restoration treatments initially soften the membrane system for an extended period. The roof membrane must have the necessary strength to resist the various forces to which it will be exposed, such as thermal cycling and other types of movement. How strong must the membrane be? A benchmark for roof membrane tensile strength of 200 lbf/in is provided by NBS 55.[5]

Various testing labs across the continent can provide results on these types of core analyses, but interpretation of these results is the responsibility of the roofing professional. These results should be considered as part of the decision-making process, but the decision to restore should not rest upon a single criterion. Instead, the data should be considered as part of the entire evaluation, with consideration given to all the observations, quantitative and qualitative.

Roof Deck and Substrate Considerations

While conducting the core analysis, the roof deck must also be investigated to determine its type, condition, and other factors that could make a restoration an inappropriate choice. If the deck is inadequate, deteriorated, or otherwise faulty, a tear-off of the existing membrane becomes necessary in order to make the required upgrades or repairs. A structural engineer must be consulted for any issue or condition that deals with the structural integrity of the building envelope.

The following conditions must be examined:

- Signs of corrosion, dry rot, or other deck deterioration are structural issues that must be properly addressed.
- Single-layer insulation over steel decking or systems containing EPS insulation have the potential for high movement of the membrane system over the insulation, which could cause splitting of the restored membrane.
- V-groove stiffened steel decks can transfer considerable movement to the membrane.

Membrane systems applied directly over decks signal restoration risks. Deck movement, especially at panel joints, can be transferred directly to the membrane. This movement can translate to stresses in the membrane, which could lead to its splitting after the new restoration surfacing has been applied.

Evaluate the attachment and securement of all system components, such as the insulation, membrane, metal flanges, coping caps, curbs, and the deck itself. This attachment is necessary for the roof system to continue to resist wind uplift forces. If any component is determined to be insufficiently secured, it may be possible to refasten it in a cost-effective manner and continue with the restoration. However, a poorly secured roof system is not a restoration candidate.

Two layers of insulation with polyisocyanurate as the base layer and a coverboard offset staggered and adhered to the base can be an ideal insulation substrate. Two layers of insulation will diminish the effects

Broadcasting ceramic granule surfacing into cold-process adhesive.

of potential deck movement, while a coverboard of wood fiber, gypsum, or perlite will provide a smooth substrate for the membrane, as well as a solid traffic surface for the roof. Avoid restoring membranes that are applied directly to the isocyanurate, since this is not a sound substrate and could experience issues related to the facer or damage from roof traffic during the restoration process.

Finally, beware of phenolic insulation over steel decks. Even if the roof has not leaked and corrosion has not yet occurred, retaining phenolic insulation over a steel deck is a tremendous liability. Properly treating the underlying steel deck and replacing the existing roof is a more responsible recommendation than trying to save a phenolic-insulated system.

Moisture Analysis

The next step of the diagnostic phase includes a moisture analysis of the existing roof system. Thermal imaging using infrared, electrical capacitance, and nuclear scans are all accepted methods for determining if moisture is present in the underlying insulation layer(s). Ideally, the moisture survey will determine that no moisture infiltration has occurred, but even if some areas are found to have wet insulation, this does not automatically take roof restoration out of consideration.

A roof system over a significant amount of wet insulation is not a restoration candidate, but if these wet areas are small and/or isolated, it may be cost effective to cut out areas of wet insulation and replace the roof in these areas to match the existing membrane. Follow preestablished criteria for conducting a moisture analysis of roof systems and reporting the results.[6,7,8] Use qualified technicians trained in these procedures to assure reliable data.

Making the Recommendation

Once the data have been collected, a qualified recommendation can be developed and proposed to the building owner. Summarizing the data, observations, and recommendations in a roof condition report provides a powerful and credible document for the building owner. (To quote a colleague, "In God we trust. All others must bring data.") With all the documented knowledge of a roof's components, a scope of work and specification for the work will be easier to develop.

Specifying the Roof Restoration

The scope of work must address the repair, reinforcement, and restoration of the perimeters, projections, drains, and other flashing details. Cyclic movement can occur near penetrations, insulation joints, and deck panel direction changes. Over time, this leads to wear and tear that can compromise the watertight integrity of the membrane in areas. Upgrade all details to meet NRCA standards,[9] including adding metal flashings for projections where they may not currently exist. Spot repairs and reinforcement of the roof membrane are accomplished with trowel-grade roof mastic and mesh fabric, but asphalt emulsion coatings and polyester reinforcement may also be used together to strengthen areas in need of attention.

The choice of materials for the membrane restoration will depend on the existing conditions and the surface finish that the building owner desires. Although it is not appropriate to change an aggregate-surfaced roof to a smooth one, many other options exist. Bituminous adhesives bond new aggregate to the roof after the existing/aged stone is removed from the roof. The International Building Code (IBC) does not allow the existing aggregate to be reinstalled,[10] presumably because old stone can include dirt, glass, nails, and other sharp debris that are harmful to the restored roof.

When specifying a restoration surfacing system, it is important to make sure the completed roof will provide the fire resistance that is required by the local building code. Reputable manufacturers of restoration systems will be able to offer a fire-rated restoration system such as those listed in the UL Roof Systems Directory.[11] Most fire-rated restoration systems will maintain the fire rating of the existing system when the restoration system is installed over a roof that is already fire-rated.

Surfacing adhesives for restoration are formulated from asphalt or tar to be compatible with the existing roof. Both solvent-based and water-based surfacing adhesives are available that can help to minimize odors when restoring a roof over an occupied facility. In addition, there are also California Energy Code Title 24-compliant, cold-process, aggregate adhesive options available to increase the solar reflectance and cooling efficiency for the building.

Restoring a BUR with a hot asphalt flood coat is not recommended due to the potential for thermal shock and subsequent damage to the existing membrane from the hot asphalt. Additionally, the new bitumen may have compatibility issues with the existing surface, which could lead to adhesion issues along the bond/fracture line between the existing roof and new flood coat, especially in areas where alligatoring occurred on the existing roof.

While preparing the surface for restoration, avoid power brooming the existing gravel from the roof, since doing so could damage the existing membrane. Instead, specify a wet vacuum of the loose gravel. When applying new gravel, the use of air blowing equipment is preferable to using gravel carts or wheelbarrows, whenever possible, so as to avoid damage to the existing roof from equipment use. Minimize the storage and use of large equipment on the roof, such as pumps, barrels, and motorized carts, for the same reason.

Smooth-roof restoration materials include solvent-based bituminous coatings and water-based asphalt emulsion coatings. For a smooth-roof system, polyester or fiberglass reinforcing fabric can be used to increase the strength of the existing system and provide a more durable surface. A highly reflective aluminum or acrylic coating is recommended over smooth restoration to slow down the aging of the smooth-roof system, in addition to improving the cooling efficiency of the building.

Long-Term Maintenance

Once the restoration is completed, do not forget about the roof. If it was capable of being restored once, it may be a solid base that could possibly be restored again some day. The chances for this can be improved by developing a roof inspection and maintenance plan that will identify adverse conditions early and allow them to be corrected in a timely manner.

Part of sustainability is about making existing assets last as long as possible. A roof is no longer sustainable if it deteriorates or if the system becomes obsolete. BUR and MB systems are far from becoming obsolete, so the restoration process makes sense, both from an environmental standpoint and from a financial standpoint to the building owner.

The Fox Theatre Operations Group knows a lot about restoring the interior and exterior furnishings of this historical property. The owners have taken the same proactive approach to maintaining their roofing assets, achieving a sustainable solution while managing their budget wisely.

References

1. ASTM D 2829, Standard Practice for Sampling and Analysis of Existing Built-Up Roof Systems, ASTM International, Volume 4.04, revision issued annually.
2. ASTM D 312, Standard Specification for Asphalt Used in Roofing, ASTM International, Volume 4.04, revision issued annually.
3. ASTM D 450, Standard Specification for Coal-Tar Pitch Used in Roofing, Dampproofing, and Waterproofing, ASTM International, Volume 4.04, revision issued annually.
4. ASTM D 5, Standard Test Method for

BUILDING ENVELOPE KNOWLEDGE ASSESSMENT

Test your knowledge of building envelope consulting with the following questions developed by Donald E. Bush, Sr., RRC, FRCI, PE, chairman of RCI's RRC Examination Development Subcommittee.

There are a number of concepts and definitions that are the key to understanding the building envelope requirements identified in ANSI/ASHRAE/IESNA Standard 90.1.

1. **What are exterior loads?**
2. **What are interior loads?**
3. **Which three space-conditioning categories are recognized by the standard?**
4. **How is the term "fenestration" defined in the standard?**
5. **When does sloped glazing fall into the skylight category?**
6. **What are the limits for the window/wall ratio and the skylight/roof ratio?**

Answers on page 18

??? BUILDING ENVELOPE KNOWLEDGE ASSESSMENT

Answers to questions from page 17:

1. **Exterior loads include solar gains through windows, conduction losses due to temperature differences across envelope surfaces, and air leakage (infiltration). They change as the outdoor temperatures change, the position of the sun changes, and as wind changes speed and direction.**
2. **Interior loads are heat gains from lights, equipment, and people. They consist of both sensible gains (elevated air temperature) and latent gains (moisture added to the space).**
3. **Nonresidential, residential, and semiheated.**
4. **Fenestration refers to the light-transmitting areas of a wall or roof – mainly windows and skylights – but also glass doors, glass block walls, and translucent plastic panels.**
5. **When it slopes less than 60° from the horizontal.**
6. **The window/wall ratio is limited to 50%, and the skylight/roof ratio is limited to 5%.**

REFERENCE:
User's Manual for ANSI/ASHRAE/IESNA Standard 90.1

Penetration of Bituminous Materials, ASTM International, Volume 4.03, revision issued annually.

5. Robert Mathey and William Cullen, *Preliminary Performance Criteria for Bituminous Membrane Roofing, National Bureau of Standards Building Science Series 55*, U.S. Department of Commerce, November 1974.
6. ASTM D 7053, Standard Guide for Determining and Evaluating Causes of Water Leakage of Low-Sloped Roofs, ASTM International, Volume 4.04, revision issued annually.
7. ASTM C 1153, Practice for Location of Wet Insulation in Roofing Systems Using Infrared Imaging, ASTM International, Volume 4.06, revision issued annually.
8. *Standard Practice for the Detection and Location of Latent Moisture in Building Roofing Systems by Nuclear Radioisotopic Thermalization*, RCI, Inc.
9. *NRCA Roofing Manual: Membrane Roof Systems*, National Roofing Contractors Association, 2007.
10. 2006 International Building Code, Chapter 15, Roof Assemblies and Rooftop Structures, Section 1510.5, International Code Council.
11. *Roofing Materials and Systems Directory*, Underwriters Laboratories Inc., www.ul.com, revision issued annually.

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