BUILT-UP ROOF INSPECTIONS

By Donald Kilpatrick

Through periodic or full-time construction observation, quality control observers attempt to address workmanship issues that can detract from the desired quality of a roof installation. The roof inspector's role is to document that the specified materials are being installed in compliance with the project specifications. Compliance with published industry and manufacturer guidelines, related to the installation of components, is also given consideration. During the inspections, it is not uncommon to sample individual components or the total assembly as a means to further establish that the products provided are as specified and are being installed in a manner that is consistent with applicable standards and tolerances. Through sampling, it may be determined if the commodities offered are of lesser value or quality than specified *(Photo 1)*.

There are hundreds of recognized standards available to establish or identify desirable characteristics and qualities of roofing materials. Consensus standards, such as those developed by ASTM, set the bar for initial product properties as a proxy for performance characteristics. Participants in that process include manufacturers, consultants, building owners, and industry members such as contractors and their affiliated professional organizations. Consultants routinely reference many of these standards in their specifications. The majority of the published standards include descriptive text related to sampling and testing procedures intended to provide the end user with data that will hopefully predict performance characteristics of the subject material. Physical properties, dimensions, and mass are some of the values that can be used in the subsequent comparative analysis. The industry, through experience and research, has established requirements for roofing products intended as minimum target values for the manufacturers. These target values may be considered by some as the initial benchmarks of quality.

The importance of such standards cannot be understated. Without them, a flood of new and continually reinvented roof system components would likely appear. In the absence of minimum, published physical properties, the initial benchmarks of quality would, in some instances, be forgotten.

As consultants and design professionals, our firms take pride in specifying quality materials for use on our projects. This provides the roof consultant, contractor, and building owner with reasonable assurances that the materials are consistent with established standards and should contribute favorably to the expected long-term performance of the roof assembly. However, the true measure of quality cannot be judged by materials alone. A roof system of good quality is not as simple as "green side up."

Photo 1: Humans have always made a practice of sampling things to determine their value.

The foundation of quality cannot be properly represented without acknowledging the importance of installation procedures and workmanship issues.

Typically, the result of any sampling program, pursuant to the recognition of product quality, is based on establishing, acknowledging, or improving the characteristics of a single component, or, in the case of a roof assembly, a combination of components that rely on one another for optimum performance. Most would agree that a responsible sampling program, in conjunction with construction observation, can improve the quality of the installation.

Many of the test methods available are probably not routinely used or considered appropriate for the purpose of quality control as they relate to the role of the design professional. For example, it is doubtful that many consultants ever intend to sample fiberglass felts in increments equal to one half the cubed root of the total shipment, as described and required by ASTM D-146, "Test Methods for Sampling and Testing Bitumen-Saturated Felts and Woven Fabrics for Roofing and Waterproofing."[1] Acceptance of individual components is typically limited to a cursory review of submittals and checklisting of materials against those required by the project specifications. For the most part, it is assumed that the individual materials specified will meet the physical properties criteria of the referenced standards as advertised and promoted on the product labels. We trust that the manufacturers are "minding the store" related to quality through testing at the production level.

Assuming that, through practical experience, a consultant's project documents exclude products that may be considered "also rans," or those materials with limited or less than desirable performance histories, the products on his jobs will be of top quality. It is likely that, huddled on a pallet, tightly bound in factory wrappers, these individual components are just fine. When the wrapper is removed, all bets are off, as the singular material properties and qualities initially represented can be compromised by the integrity of the installation. Installation of these materials could be considered the equivalent of a "fire and forget" weapon. There is but one chance to get it right; incorrect installation and latent defects can result in callbacks or a compromise in the desired long-term performance of the assembly.

The storage, handling, and installation of roof system components are the responsibility of the contractor. The premise of quality, as it relates to the finished roof assembly, is largely contingent upon the contractor's ability to install the specified components in compliance with the requirements of the project specifications. As the quality of products, system selection, and design can vary, so too can the means and methods of the installing contractor.

The amount of product or system testing to be conducted in conjunction with construction observation is limited only by the budget and need to know. Most clients would not be interested in sponsoring a series of tests to determine the kerosene number of asphalt-saturated organic felt. While this requirement (or standard) has a basis, presumably adopted because of some proven or desirable characteristic relative to performance, there is no reason to promote this type of testing, the cost of which would ultimately be passed on to the client. The availability of recognized tests that can be done economically, with meaningful results, and the potential to acknowledge or improve the integrity or quality of the installation, are few in number.

Following are some of the test procedures and inspection methods specific to the installation of built-up roofing, that can be used to assist in determining certain qualities of individual components or assemblies.

Bitumen

Temperature of bitumen at the point of application is perhaps one of the most important and often overlooked elements of a quality installation. Significant industry-sponsored research has been done, determining that EVT, or equiviscous temperature, plays an important role in a contractor's ability to apply the materials in compliance with subject tolerances. Operating temperatures of tankers and kettles need to be monitored to assure the proper temperature at the point of application. Different EVT temperatures for like materials have been adopted for applications using both mechanical spreaders and hand mopping. Research indicates that operating within the limits of the described EVT range will improve the mopping characteristics of the bitumen and result in more uniform interply applications of materials. Check the temperature of the bitumen at the heated source and point of application *(Photo 2)*. Asphalt temperatures in tankers and kettles should not exceed the finished blowing temperature (FBT) (approximately 490° F) for extended periods of time. Overheating can result in fallback, or a change in the softening point of the material. Where applicable, require that the bitumen be installed within 25° F of the EVT. For safety reasons, avoid the

Photo 2: Asphalt temperatures need to be checked at the point of application.

heating of asphalt to within 25° F of the flash point. Require that the contractors' heating, transporting, and dispensing equipment be fitted with working thermometers *(Photo 3)*.

Samples of bitumen should be taken on the first day of production at the point of application. Submittal samples from the supplier and chunks off kegs are not representative of materials at the point of application. Asphalts are graded and categorized by softening and flash points, penetration ratings, ductility, and percent solubility in trichloroethylene, all of which are referenced in the body of ASTM D-312,[2] "Standard Specification for Asphalt Used in Roofing." ASTM D-36, "Standard Test Method for Softening Point of Bitumen (Ring-and-Ball Apparatus),"[3] is a relatively simple test that can be used to determine if the appropriate grade of asphalt has been delivered to the job site. Failing that criteria alone is cause for rejection of the lot or shipment represented by the sample. This can be significant, especially when the roof system construction involves structural slope that requires a specific grade of mopping bitumen.

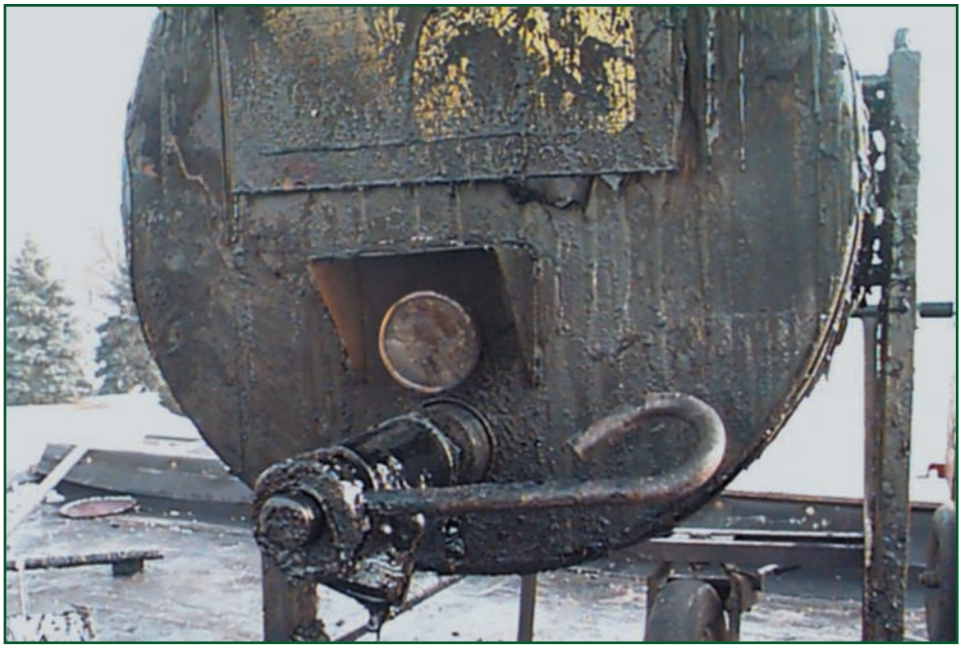

Photo 3: Typical condition of thermometers on dispensing equipment.

Flood Coat and Aggregate Surfacing

The importance of flood coat and aggregate surfacing cannot be understated. Flood coat and aggregate provide the first line of defense for the underlying felt plies. The flood coat is the initial waterproofing component of the conventional built-up roof assembly. Aggregate surfacing protects the bitumen flood coat from damaging solar radiation. While there are advantages to the selection of the aggregate-surfaced, built-up roof, its selection or specification is contingent upon structural capacities and can be driven by budget limitations.

Established industry guidelines suggest that a flood coat be installed at a rate of 60 pounds per square (100 sq. ft.). Typically, the aggregate surfacing is to be applied at a rate of 400 lbs. per square, with 60%, or 240 lbs. per square, embedded in the flood coat. The contractor's ability to install these materials in compliance with subject tolerances is influenced by the size of the job and application techniques. The uniformity and coverage rates can vary significantly if the contractor is required to use pour cans and shovels to distribute the materials versus hot spreaders and gravel buggies.

Regardless of the methods available or employed, it is imperative that this element be applied in a manner consistent with the aforementioned industry standards. Currently, there are no ASTM standards that quantify the applied material as it relates to flood coat and aggregate surfacing, aside from ASTM D 2829 ("Standard Practice for Sampling and Analysis of Built-up Roofs").[4] That procedure requires test cuts from finished roof assemblies and is typically thought of as being reserved for use on roof systems exhibiting performance problems. That leaves the flood coat and aggregate open to interpretation relating to the quantity of applied materials.

The following guidelines can help determine if applied quantities are appropriate:

1. When mechanical distribution is used, the aggregate dropping into the hot asphalt should push asphalt, resulting in a wave.
2. A 60-pound-per-square flood coat is approximately 1/8" thick. A wet film thickness gauge similar to that used in the protective coatings industry can be used to assist in determining that the applied flood coat is approximately 1/8" thick.
3. Double flood and gravel means just that. The initial application is provided at the rates previously described. The loose gravel is swept away after the asphalt has cooled, followed by a second application, or the equivalent of 120 pounds per square of asphalt and 700-800 pounds per square of aggregate. This is typically required around mechanical units, roof hatches, or areas where heavy traffic is anticipated.

Sampling of New, Unsurfaced, Built-up Roof Membranes

Much has been said about the practice of sampling and analysis of new built-up roof systems at the time of application. References to the perfect square in studies sponsored by the industry suggest that this type of testing lacks credibility and the derived results vary significantly. One such study is based on samples taken from a 5'x13' test area.[5] Reportedly, the construction of the test area was closely monitored, using state-of-the-art application procedures. Based on the study, the author determined that the foundation of quality is based on good roofing practices and application procedures, a philosophy with which most would agree. The results challenged the validity of roof cuts when used to establish parameters for quality control.

The practice of sampling new built-up roofs is misunderstood and misrepresented. It is not intended to establish the parameters of quality control. It is a means by which to establish some level of confidence that the contractor has the ability to install the specified materials in compliance with accepted industry standards. The aforementioned parameters of quality are self-imposed by the industry and manufacturers, both of which have adopted and promoted specific application rates for materials. All major component manufacturers publish certain guidelines that are to be followed when installing their products; more specifically, average mopping tolerances, the uniform distribution of applied materials, and application temperatures. It can be said with reasonable certainty that these guidelines are the result of some performance-based criteria, information obtained from samples or systems that did not perform as intended, or, perhaps, research that has been done as the roofing community continues to develop industry-recognized standards. Without the benefit of test cuts, many of these industry standards would be unverified and possibly forgotten.

A responsible sampling program that intends to acknowledge or potentially improve the quality of the roof membrane as it relates to the quantity of applied materials must be initiated at the face of the work, prior to the introduction of the surfacing. If, for example, a sample from a given day's work was weighed, and the calculated average mopping came in at 15 lbs./sq., the presence of surfacing materials would all but eliminate the option of installing an additional two plies as a recommended corrective action. While some would argue that a void-free assembly with 15-lb. moppings will perform just fine, it is close to one-half of that recognized as the high end of the accepted industry standard for interply moppings and is not representative of what would be considered appropriate material quantities.

Sampling provides a means to analyze built-up roof system construction at the time of application, with an emphasis on the quantity of applied materials and the integrity of the membrane components before the introduction of surfacing. The intent is to sample the roof system with construction underway. The results can be immediately shared with the installing contractor, so as to either acknowledge or improve the quality of workmanship, or to provide a basis for any adjustments that may be required in the application of the materials relative to the desired quantity. Specific to built-up roof system construction, the quantity of applied materials is a property that should not be overlooked or left to chance.

The first quantitative element is headlap, as it relates to felt ply coverage. Missing or deficient headlap will result in coverage that is less than that which is required by the specifications. This characteristic of the assembly can be established without the benefit of a test cut and is easily determined with a measuring device configured to represent the 36" or 1 meter width of the applied roll goods. A specially fabricated template, with attached increments displayed in tenths of inches, works best, as it will later be used in the sampling process. Template

Photo 4: Measuring felt ply headlap in predetermined sample area.

Photo 5: The template is laid perpendicular to the shingle sequence, across the limits of the sample area.

size is based on the width of the installed materials. Standard tape measures and even remnants from butt rolls of the installed product can also be used with similar results. The chosen measure is moved across the exposed upper felt edges within the limits of the selected sample area. Deficient headlap is immediately recognized through this simple process. The measured headlap, as encountered in the random sample area, is recorded on a worksheet for use in determining the approximate quantity of applied materials. Headlap is but one of the two variables required to perform the necessary calculations *(Photo 4)*.

The remaining variable is weight. Place the template on the predetermined sample area, or where the headlaps were measured. With a utility knife, follow the template with repeated strokes on all four sides until such time as the blade has cut through all felt plies into the receiving substrate *(Photo 5)*. Carefully push a screwdriver or similar tool into one corner of the sample test area and pry up. This provides the opportunity to pull the sample out of the roof system. The sample is then weighed and the average mopping, or approximate quantity of interply materials, can be calculated.

Photo 6: Results that can be anticipated when application temperatures are well above the product's EVT. Note the "picture framing" as a result of excessive temperatures and bleed-through at joints in the insulation.

Some would stop here and choose not to assess the integrity or quality of workmanship as it relates to characteristics such as uniformity and distribution of interply asphalt and voids. To some, a four-ply sample, with extrapolated results reflecting 27-pound interply moppings and 2.0" headlap, would be adequate as a basis for acceptance.

By simply looking at the sample section, additional information can be obtained. It is not uncommon to advise the foreman several times to turn the burners down or off, if the measured temperature at the point of application is well in excess of the product's advertised EVT. It's summertime with clear skies and ambient temperatures hovering around 95° F. The foreman argues, "Yeah, but look at that nice bleed through." The bantering continues, and the guy pulling the felt layer starts to expound upon his personal experience with the three different kinds of steep asphalt. The quality observer's repeated attempts and requests for the crew to more closely monitor the asphalt temperatures at the point of application have been ignored and, on some occasions, ridiculed. He may place a call to the project superintendent to explain his plight and concerns, and the latter may choose to respond or not.

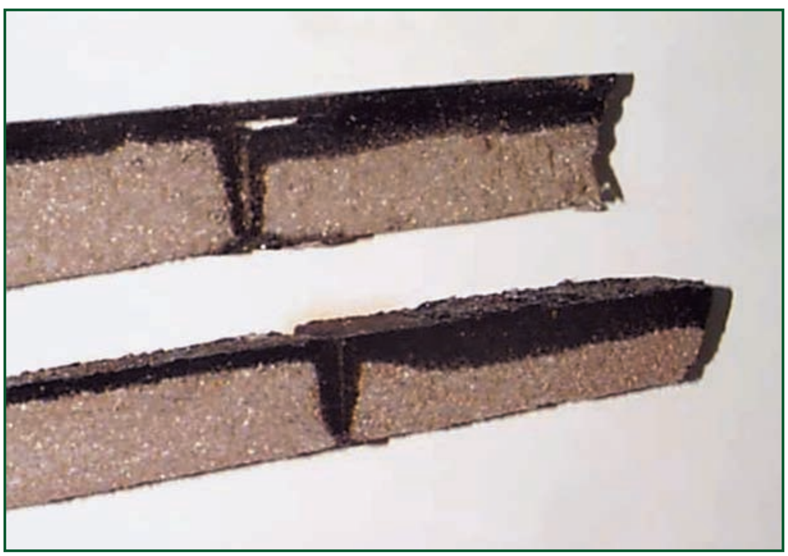

Photo 7: Increase in rate of absorption when asphalt is heated and installed well beyond the EVT.

Through sampling, concerns over application temperatures will be self-evident *(Photo 6)*. Having looked at hundreds of samples, some of which were undoubtedly put together with operating temperatures well above the acceptable EVT, the absorption of mopping asphalt into the perlite or wood fiber substrate is easy to see *(Photo 7)*. Keep in mind that 1/8" thickness of asphalt represents about 60 lbs/sq. A sample section revealing absorption in excess of 1/8" is an indication that the materials were installed at temperatures well above the EVT.

In some instances, we have quantified the bottom mop, or that portion of the interply mopping that interfaces with, and was absorbed by, the insulation substrate, due to elevated temperatures at the time of application, and deducted it from the sample gross weight. In theory, approximately 75% of this mopping asphalt was initially installed as an interply component of the assembly. Using traditional methods (those which do not address application temperatures and absorption), a sample gross weight of 145 lbs./sq., with five 2.0" headlaps would yield an average mopping of approximately 27 lbs./sq. By isolating, quantifying, and deducting the bottom mop from the gross sample weight determined in this

Photo 8: Covering the removed sample with a blanket of dry ice prior to separating the felts.

example to be 60 lbs./sq., the average interply mopping is reduced to approximately 17 lbs./sq. This information can easily be shared with the contractor to demonstrate the need to comply with the established guidelines related to EVT at the point of application. Now the consultant can explain to the guy running the felt layer his experience with the three kinds of steep asphalt: too hot, too cold, and just right. Two more plies, please.

Freezing the sample with dry ice makes it possible to separate the felt plies and provides the opportunity to quantify the bottom mop, as described above, and further document the interply characteristics, such as voids, and the presence of moisture or debris. *(Photos 8 and 9)* Routine foot and cart traffic across a recently installed membrane, that has not had an opportunity to cool or set, will result in asphalt displacement and voids *(Photo 10)*.

Communication

Communication and documentation are tools that are used as part of the construction observation process. Communicate with the foreman on a daily basis. Let him know your expectations. Communicate with the building owner's representative. Be careful with presentation of issues, real or imagined, associated with what may be perceived as less than desirable performance on behalf of the installing contractor. Respect the contractor's position with the owner and roofing community as they, too, are continually trying to develop relationships with existing and future clients. If blatant performance issues are brought to the attention of the foreman and reasonable efforts are not made to correct the problem, document the occurrences in a letter addressed to the president of the roofing company.

Staff projects with qualified individuals. The construction observer should be familiar with all aspects related to the installation of subject materials and applicable industry standards. Provide construction observation representatives with the necessary tools, resources, and training.

Be proactive. Work with the contractor. On reroofing projects, make test openings at critical details in the existing assembly a part of the construction observation process. This allows confirmation of existing conditions related to flashing heights and blocking configuration, to determine the applicability of the intended design. It also fosters the development of a team effort toward the common goal of a quality assembly delivered on time. This extra effort reflects favorably on both the construction observation entity and contractor. Review of the details in advance provides the opportunity to minimize “time lost” due to incongruities.

Summary

Those assuring quality control, through or in association with the service described as construction observation, are mistaken in assuming liabilities that are the responsibility of the contractor. The quality of the installation is the responsibility of the contractor. In some instances, the reference or use of the term “quality control” could be considered a misnomer. Give consideration to the occasional projects where the contractor is doing all the right things, the inherent characteristics of quality are represented at all levels. On these projects, the control of quality is, as it should be, in the qualified hands of those installing the materials. The use of the word “control” in conjunction with “quality” suggests that excessive, or too much, quality is something that must be controlled.

Individuals engaged in the construction observation process are faced with many challenges. The observer’s primary responsibility is to document the efforts of the contractor – good, bad, or indifferent, as they relate to the installation of roofing materials. Without fail, through the course of the project, difficulties can and will arise. The appropriate response to these unexpected difficulties should be communicated in a manner that will foster a spirit of cooperation, so that the common goal of a quality roof installation can be achieved.

Photo 9: The relationship of individual felt plies to the sample area and measured headlap.

Photo 10: Interply voids or lack of continuity in mopping.

REFERENCES

1. ASTM, *Annual Book of Standards, Volume 4.04, Roofing, Waterproofing and Bituminous Materials, 1999.*
2. Ibid.
3. Ibid.
4. Ibid.
5. Cullen, Bill C., “The Perfect Square: Can it be Built?” *Roofing Spec,* 1987, pp. 37-40.

About the Author

Don Kilpatrick is a project manager and field technician with INSPEC, Inc. in Milwaukee, Wisconsin. He joined the company in 1985 and spent a dozen years in the firm’s materials testing lab. He is fully experienced in roof evaluations, inspections, field testing, nondestructive testing, sample analysis, and roof construction procedures. Kilpatrick is a Certified Asbestos Inspector and a member of RCI’s *Interface* Peer Review Committee.

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