THE INS AND OUTS OF LABORATORY TESTING OF ROOFING MATERIALS

By René M. Dupuis, Ph.D., P.E.

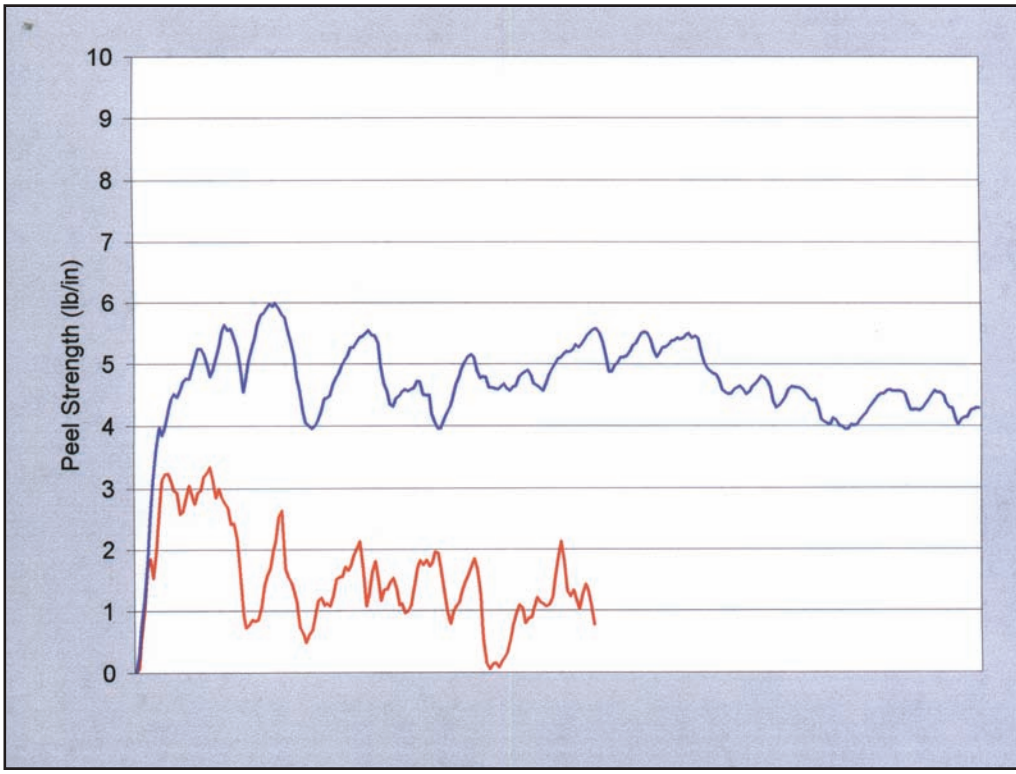


Figure 1

A roof testing laboratory is a facility with various pieces of testing equipment, support apparatus, and environmental conditions for conducting scientific experiments, tests, and investigations on roofing materials and systems. The easy part is obtaining the equipment; the hard part is performing the tests or experimenting with roof materials that may be in distress. If a testing laboratory is asked to perform a simple analysis of moisture content, membrane weight-area, or density, that's one thing. Trying to find out why a roofing material is not working is quite another.

This article will outline which tests are easy, which are difficult, and some interesting observations gained in testing roof materials.

Testing Labs

To begin with, there are many commercial testing labs available today. There are fewer labs with roof material testing experience and only a handful that can perform serious research. If product testing on a new roof material is needed, most commercial labs can provide that service. Weathered, non-performing roof materials are much more difficult to analyze since the ASTM product standards assume that new materials are being tested. One can test the weathered or aged material according to the new material standard but cannot declare failure if the results fall below. Roof materials change as they weather and heat age; the ASTM product standards cannot quantify this rooftop change. Judgment, experience, and comparative reasoning are used to opine the condition of aged roof materials.

Beware if the testing lab cannot provide an interpretation of the results. That may be a tip off that they know how to conduct the test but really do not understand what they are testing for and how the roofing material may respond. A roof consultant may want to interpret the results, since the test lab may not have experienced staff or get to see the roof in question. A knowledgeable roof consultant will use lab test results to help explain what happened to the roof system.

The testing lab needs adequate quantities of materials to run a battery of ASTM tests. Far too many clients cut out small roof samples (4 square inches) and want tensile, elongation, and hardness, tear strength, etc. from this tiny amount of material. Experienced consultants will know that a fair amount of material is needed to perform a battery of tests. Another important topic is roof sampling. Do not select the best- or worst-looking area of the roof—do both. Testing labs will need a "control" piece of roof material—one that appears to be typical based on the consultant's inspection. Then go after the problem area.

Properly bag and identify roof samples for shipment to the testing lab. Cardboard, plastic bags, and shipping tape are inexpensive; use plenty to make sure the sample is protected during shipment. It can be very expensive for the client if the consultant has to return to the roof for more samples.

If moisture content testing is needed, double bag the roof samples, seal each one, and get them into the shade if possible. If water condenses in the clear polyethylene sample bag, the moisture content of that material is high. The testing lab still needs to quantify the amount of moisture.

ASTM Standards

Every testing lab has well-worn copies of ASTM standards which outline specifications for roof materials, test methods to use, guides, and practices. Few roof designers understand the differences that exist in test methods for roof materials. For instance, the PVC and EPDM material specification in ASTM use the same tear strength test but call for different tear resistance tests. Look at ASTM D-4434 and D-4637 to find out, yet both membranes may be considered for use on the same roof. (The presence of reinforcing fibers may have something to do with it.)

Test results can be easily influenced by operator error if shortcuts are taken. For example, ASTM calls for low temperature flexibility tests to be run inside a refrigerated unit. The best unit, in the author's opinion, is a sealed refrigerated (controlled temperature) unit with glove ports. Yet, some manufacturers and test labs use chest freezers, open the door, reach in, and run the test. Worse yet, some test labs pull the samples out of the refrigeration unit and run the flex test out in the open. Guess which (sloppy) method gives the best results (lowest temperature at which no visible cracks form). Now, there is nothing wrong if you do this for expediency when trying to find out within which temperature range the material can flex. However, the actual certification tests and the numerical results published by the manufacturer should be run in strict accordance with the prescribed ASTM method.

Other popular ASTM tests are D-2829 and D-3617, standard practice for sampling and analysis of existing or new built-up roof membranes respectively. D-2829 has been around since 1969; D-3617 came out in 1983. Both standards advise in their scope that "approximate quantities" of felt and bitumen can be determined by these methods. Yet we see design specifications citing these standards as absolute methods; they are not. Can these methods tell us a lot about the felt area and approximate average interply bitumen present? Yes. Will these results tell us whether the roof will perform? No. Another hidden number is present in these standards that few people realize. Both methods assume a felt weight of 7.0 lb/square for ASTM D-2178 type IV and VI fiberglass felt in the calculations. Do you know what the actual type VI glass felt weights have been? D-226 says a #15 felt has a minimum weight of 11.5 lb/square; D-2829 uses 11.5 lb/square; while D-3617 uses 13 lb/square.

Many people are confused by this. Test methods and material standards are not always synchronized and fully coordinated. Often a testing lab is left to interpret the method called for as best they can. Coordination of all the test methods is a large task, and the ASTM committee D-08 works very hard at it.

EPDM Lap Seam Tests

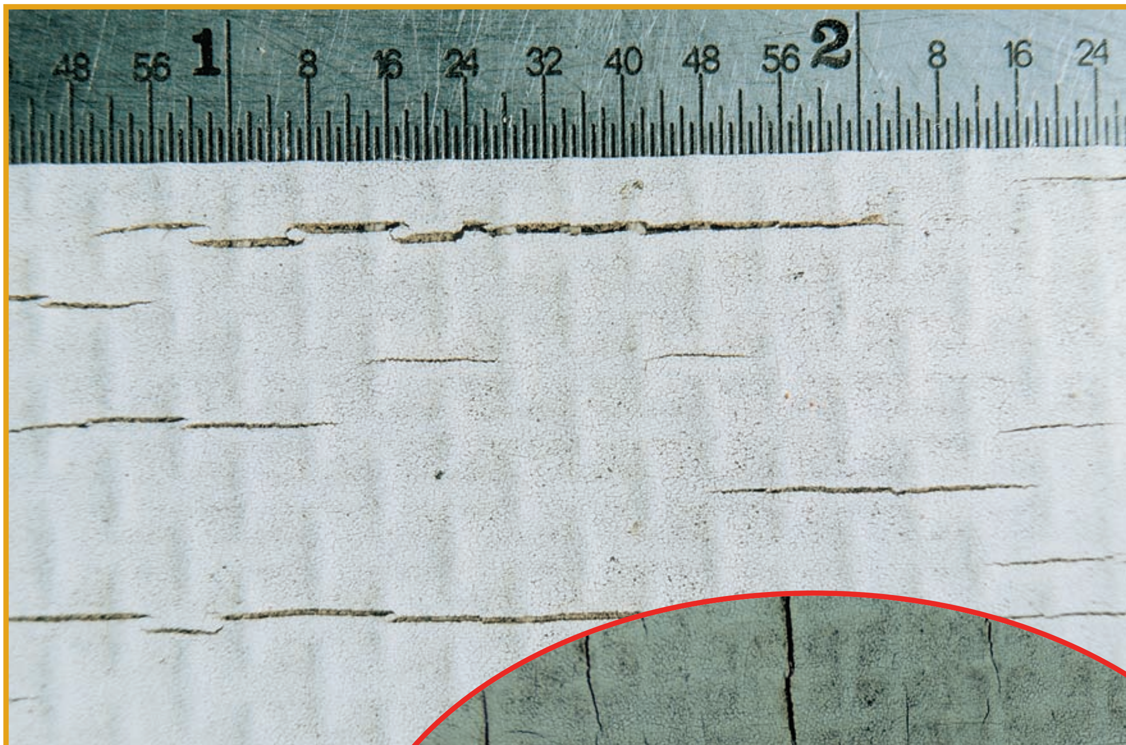
When EPDM came into wide use in the early 1980s, lap seams were made with liquid Neoprene adhesive. This material was weak and water sensitive but user friendly. In 1986, liquid butyl replaced Neoprene adhesives for the most part. Butyl adhesives have much better strength and water resistance but can be tricky to apply in hot weather (or very cold temperatures). But the roofing industry has seen an overall improvement in seam strength. In the 1990s, butyl tape came into wide use; our lab has seen a decline in EPDM lap problems since the introduction of butyl tape for seaming.

EPDM lap seams are tested in the 180º peel mode at 2 inches per minute in a constant rate of elongation tensile test machine. *Figure 1* shows a poor lap in red on the lower part of the graph. It barely reached 3 lb/inch of peel resistance; the average strength is about 1.5 lb/inch. Notice how the peel force goes down to almost zero at one point, then regains strengths as the lap is pulled apart.

The upper blue line of *Figure 1* shows the actual peel resistance of a good EPDM lap splice. Note how the maximum peel resistance goes over 6 lb/inch; the average peel is about 4.5 lb/inch—three times that of the poor lap seam shown in red. Does the consultant accept this job based on these results or should more tests be run? EPDM manufacturers have their own acceptance criteria (which are not publicized).

Testing Aged Single Ply

Some single-ply membranes present difficulties in assessing or quantifying failure. For instance, plasticizer extraction of aged PVCs may give false indications as some plasticizers have undergone a change and may not be extractable with the solvent which is used.



Above: Figure 2

Inset: Figure 3

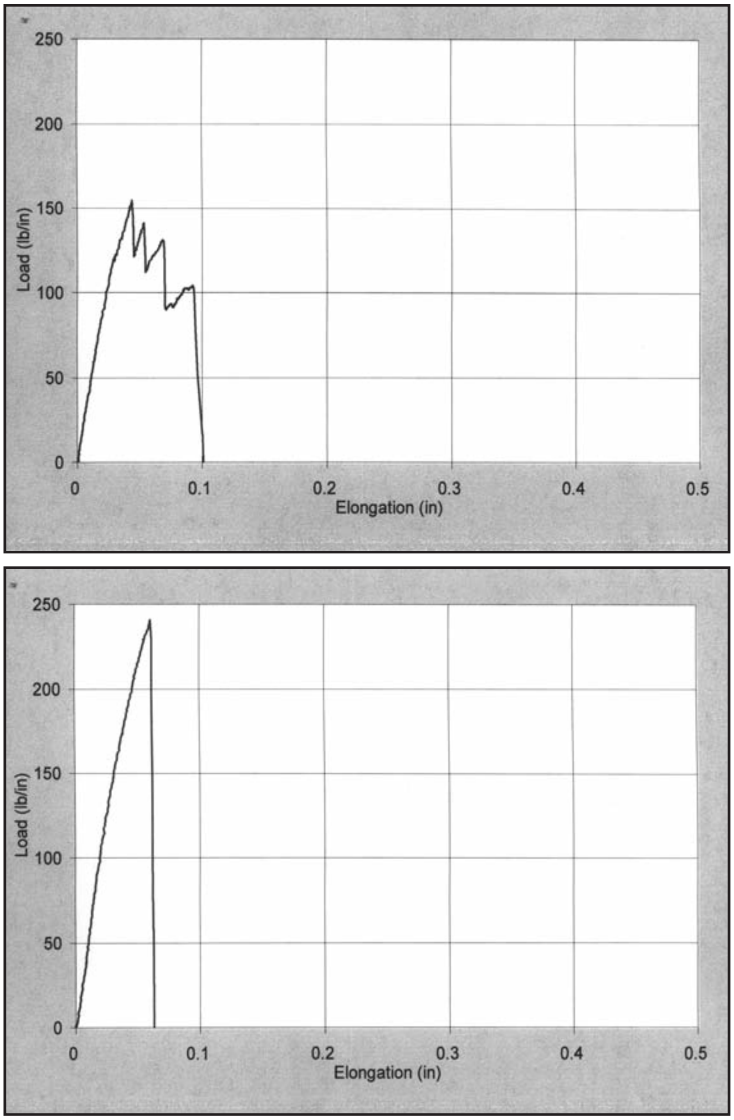


Figure 4

In other instances, physical testing alone may explain what is happening. Look at the aged CSPE samples in *Figures* 2 and 3. Notice how all the membrane splits run parallel and seem to be joining together. Also note that many of the individual splits start out at ± 1/8 inch and then grow together. *Figure* 3 is a sample of the failed CSPE over a light table. Obviously the membrane lets water through, but the good news (if there is any) is that the reinforcing scrim is doing its job by holding the membrane together.

The membrane samples shown in *Figures* 2 and 3 came from a mechanically-fastened roof that saw a lot of wind action. The majority of splits was observed to parallel the lap. Cold flex testing of good portions of this membrane showed that the material has a cold flex temperature of +70º F, not -40º F as manufactured. The cold flex temperature had increased 110º F due to a change in the material as it aged. Thus, every time the winds buffeted this mechanically-fastened roof, small cracks were initiated in the membrane if the temperature was below 70º F and the buffeting was severe enough to snap wrinkle the sheet. This is a good example of how a testing lab can explain the failure phenomena observed on a roof.

Fiberglass Felt BUR with Heavy Voids

Concerns over roof splits and tensile strength of BUR membranes no longer dominate testing as they once did. This is due to the use of fiberglass felt in BUR construction. A type IV fiberglass felt should have 44 lb/inch of tensile strength, according to D-2178. A type VI felt should exhibit 60 lb/inch of tensile strength. Compare this to organic felt at 15 lb/inch in the cross machine direction, and you can see why tensile strength is no longer a hot topic.

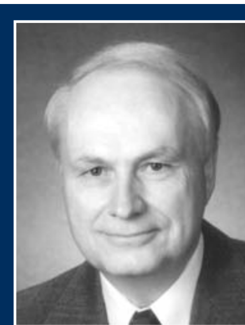
But we also know from experience that fiberglass roof membranes can have interply voids if someone trafficked over them while the asphalt was still hot. Our concern has not been that voids weakened the fiberglass roof, but that it may be a slow leaker due to asphalt being displaced by foot traffic. Heavy voids do weaken a fiberglass membrane when compared to one with little or no voids. Look at *Figure 4* where the top graph shows a four-ply fiberglass/asphalt BUR being tensile tested at 0º F. Note how the heavy voids have forced the membrane to break one ply at a time. The first ply broke at 150+ lb/inch, and the fourth ply failed at 105 lb/inch. Now look at the bottom graph where the same tensile test was run on a membrane sample with few or no voids. The four plies worked together and achieved in excess of 240 lb/inch of strength as a true composite. Does this mean voids cause roof splits? No, it means a heavy void concentration can weaken the membrane.

Summary

Roof testing laboratories need good samples with which to work and as much information as possible from the consultant.

The ASTM test standards provide test procedures for use but cannot be used to predict performance as they currently stand. Make sure the testing lab has experienced personnel. Testing of weathered roof samples requires experience and knowledge along with patience. Hopefully this article has given insight on factors to consider when future roof testing and evaluation needs arise. ■

About the Author



René M. Dupuis, Ph.D., P.E.

René M. Dupuis, Ph.D., P.E. is a principal and president of Structural Research, Inc., consulting engineers. He is a licensed professional civil engineer with a structural engineering and material background. During his more than 25 years of experience with roofing systems, he has worked in research, testing, design, product development, and roof performance assessment with numerous building owners, manufacturers, trade associations, and roofing professionals. René serves as chairman of the ASTM Committee D-08.20 task group on Roof Performance among other roofing industry activities.