BUILT-UP ROOFING: AN HISTORICAL PERSPECTIVE

BY CARTER SLUSHER

A long way from its crude beginnings in the 1870s, built-up roofing (BUR) systems have grown in use and protect many of the nation's commercial buildings. In its nearly 140-year history, the BUR industry has continued to evolve and set the bar for performance criteria in commercial roofing.

Today, the industry faces several new challenges. Petroleum refiners are able to extract more from crude oil residuals, an act that impacts the quality of the asphalt produced. At the same time, changing economics have caused refiners to turn from asphalt production to more lucrative end products, threatening the availability of asphalt for roofing.[1] Also, the price of asphalt is expected to rise as the United States government implements plans to spend millions of dollars repairing roads and bridges.[2] All of this is taking place while the commercial roofing industry is facing a shortage of trained BUR installers.

Two critical changes – raw material asphalt quality and the shortage of trained installers – have reduced the latitude of application conditions necessary to produce a quality BUR. These factors have increased the need for a registered roof consultant to ensure a proper BUR construction.

HISTORY AND DEVELOPMENT

History demonstrates that failure to account for mistakes of the past can produce devastating results. In the late 1800s, BUR materials were used to replace lead sheets on commercial wooden buildings.[3] BURs were constructed *in situ*, using alternating layers of jute and tar or lake asphalt. These constructions, though crude, used largely unrefined bitumen that was rich in natural constituents and provided an improvement over conventional roof constructions of the time.

Documented use of asphalt for roofing, in preference to coal tar, began in the 1870s. However, its use became prevalent as petroleum refining technology improved in the early twentieth century. Asphalt gained preference because it was easier to handle and had a wider functional temperature range than coal tar.

The fluid catalytic cracking process, developed in 1942, established the foundation of modern petroleum refining. Using a catalyst in the cracking reaction increased the yield of high-quality products. Several complex reactions are involved but principally, the long-chain hydrocarbons are cracked into lighter products.

Changes in reinforcements for BUR impacted performance, but the asphaltic bitumen that formed the waterproofing agent retained much of its chemical composition.[4] Since failure mechanisms have been described as a function of asphalt's basic molecular or intermolecular chemistry, the changes imparted by the refining process determine the quality of the asphalt produced.[5]

AIR BLOWING

Air blowing has been employed through one technique or another to harden the flux sufficiently to make it useful as an interply adhesive for built-up roof construction. Many use the term "oxidized" when they think of air-blown asphalt. The process is actually "dehydrogenation" and "polymerization," where hydrogen atoms are split off from the parent hydrocarbon chains, and smaller chains attach (polymerize) to form larger-chain molecules. Most of the oxygen that reacts with the asphalt in the blowing process forms water vapor. Only 5% to 15% of the oxygen introduced into the process remains bonded in the asphalt. The amount of oxygen in the finished product increases with augmented aromaticity of the feedstock. Thus, highly aromatic crudes produce an asphalt that is chemically different from those produced from crudes with low aromaticity.

Investigators do not agree on the identity of all compounds in which oxygen is bound during air blowing, and the reaction mechanisms that take place in the process are still being investigated.[6]

LESSONS LEARNED

In the 1960s and 1970s, paper and asbestos felts were being offered. Some of the more interesting events occurred when conventional "tried-and-true" four-ply BUR constructions made with asphalt-saturated, 15-pound paper "rag" felts were replaced with two or three heavier paper felts. Advertising slogans such as "One Plus One Equals Four" that promoted two-ply applications were abandoned when those constructions experienced widespread failure.

BUR REQUIREMENTS DEFINED

As a result of the extensive failure of various BUR designs, Bob Mathey and Bill Cullen of the National Bureau of Standards (NBS, now NIST) traveled across the country obtaining samples of installed BUR

membranes of all types of felts available at the time. They transported the samples to their laboratory for testing and produced the first industry-accepted comprehensive work that described the minimum properties needed for a BUR system to perform effectively.

Their results were reported in 1974 in NBS's *Building Science Series 55*, a document that defined the minimum performance attributes of a completed BUR membrane. The study gave the industry a means to determine the minimum performance of any BUR membrane, regardless of construction. The popularity and application of NBS 55 criteria resulted in the development of ASTM D 2178 Type IV and Type VI fiberglass felts used today in the construction of BUR roof membranes.[7]

CHANGES IN ASPHALT

Among the more significant changes in asphalt that impact roofing is that today's refineries can extract more fractions from crude oil. Many refiners possess the technology to rearrange the structures of one fraction from crude oil to produce a different fraction. Cracking takes large hydrocarbons and makes them into smaller ones, which can be recombined to make the desired product. Catalysts speed up the process.[8]

Additionally, Congress has mandated production of low-sulfur fuels, which are accomplished in the refining process by a coker. Vacuum bottoms (the leftovers of petroleum distillation) are used as feedstock to produce either asphalt or coke. If low-sulfur fuels are in demand, the vacuum bottoms will be dedicated to fuel production and not asphalt.

All of this means that today's refinery technology can eliminate asphalt production from slate and remain profitable. It also means that the quality of asphalt varies according to the crude slate and the products the refinery is making. Ultimately, asphalt quality will be decided by the refining companies.

Once the quality of the roofing materials has been established, BUR quality is a function of the accuracy of the applicator to construct the roof membrane. Variations in asphalt quality decrease the latitude of application conditions, particularly the application temperature of the asphalt that forms the waterproofing layer.

Based on these observations, it is apparent that the best BUR systems will be constructed under the guidance of a registered roof consultant who will ensure that good roofing practices are observed. BUR systems have come a long way, weathered many storms, and remain an important tool for roof consultants.

FOOTNOTES

1 Julia Poppen, "Drivers Face Bumpy Ride—Blame It on Asphalt," *The Rocky Mountain News*, July 15, 2008.

2 Mike Pesce, Erin Phalen, Joel Rose, Kai Ryssdal, and Ben Teplitz, "Asphalt Shortage Makes Recovery Tough," *Marketplace*, American Public Media, January 6, 2008.

3 Paul Morgan and Alan Mulder, *The Shell Bitumen Industrial Handbook*, Shell Bitumen, Riversdell House, Chertsey, Surrey, England, 1995.

4 "Petroleum Refining and Catalytic Cracking," *The Encyclopedia Britannica* Online, June 7, 2009.

5 Raymond E. Robertson *et al.*, *Asphalt Behavior as a Function of Its Chemical Constituents*, 1991.

6 John J. McKetta and William A. Cunningham, *Encyclopedia of Chemical Processing and Design*, CRC Press, 1977, p. 496.

7 William C. Cullen and Robert G. Mathey, *Preliminary Performance Criteria for Bituminous Membrane Roofing*, November 1974, U.S. Department of Commerce, Center for Building Technology, Institute for Applied Technology, National Bureau of Standards, Washington, DC.

8 Craig Freudenrich, PhD, *How Oil Refining Works*, January 4, 2001, www.HowStuffWorks.com.

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WIMBLEDON'S CENTER COURT NO LONGER SUBJECT TO RAIN DELAYS

Having to wait for the rain to stop before play can resume at Center Court, Wimbledon, England, is now a thing of the past, thanks to a new retractable roof inaugurated May 17. If it starts to rain, play is suspended until the roof is closed and the court surface and bowl have reached optimum conditions for players and spectators. The 30,000-ton concertina-style retractable roof can be deployed in complete silence in wind speeds up to 43 mph. It closes in a maximum of ten minutes, and the air management system stabilizes within half an hour. If wind speed increases above 43 mph, the roof will lock to ensure maximum strength and stability. The air management system controls humidity of the court and prevents condensation on the inside of the roof or sweating of the grass.

The roof is constructed of 5,2000 m^2 of tensile and durable Tenara fabric, concertinaed across the span of the ceiling. Both 20% and 40% translucent types were used to avoid shadows or bright spots. Held up by ten 77-meter roof trusses, each weighing 70 tons, the fabric deadens the sound of falling rain. The main contractor was Galliford Try. The lifespan of the roof is expected to be around 50 years. One hundred percent of the material used is recyclable.

By the way: if a player whacks a ball hard enough to hit the 16-meter-high roof and it comes back down on the court, the player loses the point. Just in case you had to know.

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