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An objective look at the new polymer-modified asphalt cements

An interview with
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Rutting has always been one of the primary problems that engineers have associated with asphalt pavements. But in recent years, rutting has become the major reason that asphalt pavements lose their smoothness and serviceability, leading to premature replacement. Increased axle loadings and traffic densities are the real culprits, of course. To combat the rutting problem, highway engineers have tried using leaner, stiffer mixes—but this has generally resulted in more failures of another sort: fatigue cracking.

These are not new problems, nor are they limited to the highways of North America. Countries in Europe started experiencing the same sort of problems at about the same time we did.

The European experience with polymers in liquid AC

In Europe, the highway builders were a little bit quicker to respond to the problem than we have been here in the U.S. They have been adding polymers to asphalt cement for 20 or 30 years with a history of good success. So our industry's move toward the use of polymer-modified asphalt cement (PMAC) has a lot of precedent and good research behind it.

Contractors in European countries have used polymers on a larger scale than we have here in the U.S. primarily because they are required in many cases to put guarantees or warranties on their work. When a contractor bids a major job in Europe, he will normally guarantee it for a certain number of years. He is responsible for all maintenance and repair on that roadway during the period of the guarantee or warranty. As a result, the contractor is strongly motivated to build a better road so he does not have to come back and do a lot of premature repairs on it. This is probably the reason why European contractors started using polymers so much earlier than we did here in this country.

I know from personal experience that the Georgia DOT started getting interested in polymers about 15 years ago. As a member of the department, I was involved in PMACs at different stages of our research, from putting down test sections to full implementation of the technology. Georgia was one of the first states to make a major commitment to polymer-modified mixes. They are using polymers now on all of their interstate work, for example.

Perhaps the biggest reservoir of knowledge about polymers in this country is in the engineering departments of the major suppliers of liquid AC. They have people on staff who understand polymers better than almost anyone else in the industry. Some of these engineers came from Europe, where countries like France, Germany, Sweden, and Italy have been using polymers for years. These polymer suppliers are beginning to gear up to meet the future demand for polymers that will be generated by the hot-mix industry in this country.

How polymers affect the performance of hot-mix:

Looking at the research, there can be no question about the potential value of PMACs. It is a fact that polymers can significantly improve the performance of asphalt mixes and substantially increase the service life of highway surfaces. Many industry observers are convinced that there will be a big increase in the use of polymers as the industry implements the Superpave program and the performance-grade binder specifications in this country.

Specifically, there will be a significant improvement in the quality of asphalt pavement with the widespread use of polymers. The asphalt mixes will be more stable at warmer temperatures and more flexible at colder temperatures. This is an important engineering characteristic of pavements made with PMAC.

There are some potential concerns, too. The use of polymers will mean stiffer and harsher asphalt mixes. The mixes are going to be more difficult to work with during the manufacturing, transporting, placement, and compaction processes. It will not be as easy to achieve the desired degree of smoothness. To be successful, we should use all the technology and innovations available. Many of the potential construction problems can be overcome with continuous-paving operations utilizing a material-transfer device like the Roadtec Shuttle Buggy®.

General characteristics of the new PMAC mixes

The term *polymer* can be applied to almost any giant molecule. *(See sidebar story—Editor.)* But not all polymers can be used with liquid AC for road-building purposes. We have found that all polymers do not perform the same. Some polymers have adequate high-temperature properties, others have low-temperature properties, but premium polymers will exhibit both high- and low-temperature performance characteristics.

In addition to rutting resistance, a premium polymer can provide a degree of flexibility or elasticity to an asphalt mix, thereby improving the fatigue characteristics of the mix. A layman's definition of *fatigue* is how many times you can bend something before it breaks. This fatigue-lengthening characteristic of polymers is very important because today's typical asphalt pavement is flexed an enormous amount every day. Can you imagine how many micro–strains a road surface must experience if more than 300,000 vehicles travel over it every day?

There are certain "tricks of the trade" involved with the handling of polymers—and contractors who intend to pave with PMACs will have to learn those tricks. They do not have to know much about the chemical composition of PMACs but they do need to know how to handle the PMAC and the mixture.

Experience teaches that it is the handling of PMAC mixtures that usually has the greatest impact on contractors. There are some very sharply delineated needs that must be met. For example:

❑ There is a need to store the PMAC as a homogeneous fluid prior to mixing it with aggregate;

❑ There is a need to maintain higher mixing temperatures, both for the polymer-modified elements and the mixture;

❑ There is a need for special measures when transporting the hot-mix in trucks;

❑ And there is a need for special procedures during spreading and compaction on the roadway.

In other words, both producers and contractors must know the handling characteristics of the PMACs used in their mixes. As far as chemical compositions and molecular makeups are concerned, there are not a lot of contractors who understand the specifics. For that matter, neither do most of the state-agency people. But there are a lot of things in our society that we use regularly without a full understanding of how they work—everyday things such as airplanes and computers, for example. But we see the end results of those technological marvels and how they can simplify, improve, or impact our lives. We don't avoid things simply because we don't understand them.

An introduction to the handling of PMACs

The day-to-day handling of the PMAC material will be a totally new experience for most people. The polymers and the liquid AC have a tendency to separate, so the real challenge is to keep them stored in a homogenous mixture until they can be used. You can blend the polymers with liquid AC and keep it in special storage tanks for a number of days. Some polymers do have a tendency to settle out or separate. Not all polymers are the same in this regard. When they do separate, the polymers will generally come to the top of the tank and the liquid AC will settle to the bottom. Consequently, the industry is beginning to see a new concept in liquid-AC storage tanks: they are vertical storage tanks that are equipped with mixing paddles.

Heatec has sold a number of tanks that were especially designed to maintain the integrity of polymer mixes prior to mixing with aggregate. Some of their tanks have gone to producers and contractors, while others have gone directly to the suppliers of the basic PMAC product.

Of course, there are some other issues that are certain to arise in connection with the handling of PMACs at asphalt plants. During storage, for example, the *pumpability* of the material can become a problem because it is a much more viscous material than the liquid AC most users are accustomed to handling.

Another potential problem occurs later. Once the PMAC has been mixed with the virgin aggregate, the critical factors become time and temperature. The contractor must be able to keep the mix hot, get it to the roadway quickly, get it spread, and get it compacted—all before it has time to cool down too much.

A polymer-modified mix is stiffer than a conventional asphalt mix because you make a significant increase in the softening point of the binder when you add polymers. In other words, in PMAC mixes, you significantly increase the temperature at which the mix tends to become pliable. Therefore, if you let the mix get very cool after you spread it, it will be very difficult—if not impossible—to obtain adequate compaction and smoothness.

Most contractors and state-agency personnel who have had experience with PMACs report that it is very important to maintain a continuous paving operation and not have a lot of stop-and-go paving. With some agencies, continuous paving is a mandatory procedure to follow. You should also roll the mix immediately after it is spread, while it is still hot.

Another potential problem with PMACs is the stickiness of the material. It will adhere to almost any surface it touches: silos, haul trucks, material-transfer vehicles, pavers—whatever. That is the bad news. The good news is that it is just as sticky when it comes to holding together the aggregate in the hot-mix.

After all, the very stickiness and elasticity of the polymers is the main reason we're going to all the trouble. Most people will probably agree that it is worth all of the trouble to get a good, tight, long-lasting pavement. ▼▲▼

DEMYSTIFYING POLYMERS

In 1846, a Swiss chemistry professor accidentally altered the chemical composition of the cellulose molecule in the cotton of his wife's apron—and the history of the world was also altered.

It took another 60 years, but scientists eventually discovered how to alter molecules more or less at will to create materials that are not found in nature. In 1907, bakelite was invented—a product of the process known as "polymerization". Before long, a parade of polymers followed: rubber, lucite, rayon, polyethylene, nylon, vinyl, styrofoam, polystyrene. . .

A simple, small molecule made up of a group of atoms is called a "monomer" (from the Greek "monos" meaning "one"). When a large molecule is formed from many monomers of the same kind, the result is a "polymer" (from the Greek "polu-" meaning "many"). The term "polymerization" is used to describe the process of linking the small molecules or monomers together.

Polymers are found all around us in nature. Wool is a polymer. So is the starch produced by plants. Lignin is a type of glue produced by trees to hold cellulose fibers together, forming what we call "wood". The DNA in our bodies' tissues and fluids are polymers.

If you use more than one type of monomer to build a large molecule, you have a "copolymer"—and this is the situation with the additives used in liquid asphalt cement (liquid AC). To get one of the additives—typically referred to as "SBS"—the engineers link the monomer of styrene with the monomer of butadiene to form the new, giant molecule: styrene-butadiene-styrene. SBS is a common synthetic rubber that is capable of withstanding high temperatures and extreme tearing forces.

Both of these are ideal characteristics for a polymer that is to be added to liquid AC in order to reduce the rutting and cracking of hot-mix asphalt roads and highways. ▼▲▼