CONCURRENT WORK SESSION
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TRANSPORTATION INNOVATIONS

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T. Scott Shuler

I'm going to talk to you about asphalt and innovations in asphalt technology in the 1990s. This is an interesting subject because asphalt has been used as a paving material for quite a while now and there's been much innovation over the years, especially in the last 10 or 15 years. There is a need for this innovation because of the many changes in the technology, in terms of the kinds of vehicles that are on the nation's highways these days. We've developed very fast from the old days when we simply mixed the materials on-site to the kinds of activities that are going on today, with central plants. This affects how the material behaves in the field. These changes create a need, of course, for the engineering and education and even contracting practices to be able to keep up.

The biggest problem we've seen emerge in the last 10, 15, maybe 20 years, has dealt primarily with the loading on the pavements. Pavements are expected to deliver considerably more than they did in the past. We're not running 60 psi tires or 50,000 lbs gross vehicle weights anymore--the legal limit now is 80,000 lbs and, with special permits, I'm told that in Kentucky we can run 180,000 lbs in some of the coal trucks. We have new loads, a lot more volume, and the technology involved in putting these materials together needs to keep up with these changes.

Currently, wheel track rutting is probably the nation's number one problem with asphalt pavements. It has been a problem for a long time but because of higher tire pressures (which typically average about 105 psi) and the higher vehicle loads, we're asking a lot more of the material that we're using. Consequently, we have to be able to put these materials together and make sure that we verify that the materials we've selected and designed are actually put down in the field. This has become a big problem. It's a safety concern, primarily because water can get into these ruts and not drain out, resulting in hydroplaning. Another big hazard, of course, is that the deeper these ruts become, the easier it is to steer a truck into them. You don't need to use a steering wheel anymore. We're also seeing an awfully lot of truck drivers falling asleep and just letting the truck drive along, and that becomes a hazard.

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Potholes are indicative of some of the problems that we’ve had with asphalt, and front end alignment problems are secondary—you start losing people in these things.

I want to talk about how advanced we are today in asphalt technology. Concerning equipment, in the late 1920s, an old dump truck did really well as far as the service that it provided and the way the material was applied. It was essentially using manual labor. We, of course, can still do this way today (and we do to some extent) using motor graders and we can mix these materials in place. But most of that technology has given way to new technologies. We can produce these materials upwards to 3,000 tons a day, in place. In a recent job in New Mexico, the material was laid out on the grade using 25-ton bottom dumps and windrows picked up by the paving machine then compacted with the rollers behind.

Some of the newer technology involved in that paving activity is actually happening in Lexington as we speak. The contractor doing the work on New Circle Road is using a new piece of equipment called a Material Transfer Vehicle manufactured by Atec Industries. It is a device that allows the individual dump trucks to supply this device with a very large quantity of hot mix. Then the material is continuously supplied to the paving machines so that the machinery does not need to stop during the course of the operation. This saves the contractor a lot of time and at the same time, eliminates the need for the paving equipment to stop and start during construction, which causes bumps.

One of the claims to fame of asphalt pavements is that they are, of course, jointless. There are no construction joints. The stopping and starting of the paving machine that can cause a bump in the pavement is something that we try to avoid. There are numerous ways of tackling that problem. Some hot recycling has been going on now for 10 or 15 years at least. We did a certain amount of recycling, as a matter of fact, on the New Circle Road project. That pavement was cold-milled and approximately an inch to 1-1/2 inches of that pavement was ground off using mining machinery, or a modification of mining equipment, called a milling machine. That material was then removed to the hot plant and could be used again in new paving construction. A device also essentially heats the pavement in place. A series of tines follow along behind this, dig up the softened asphalt pavement, and put it back down in place. This eliminates cracks and other deformities in the pavement and makes for a fairly decent pavement.

This is technology that has actually been around for a while but hasn’t been used a lot primarily because of cost. We’re starting to see more of these for environmental reasons.

Another innovation is a nuclear asphalt gage, which measures the hydrogen-iron concentration of an asphalt mix, or any material that is placed within it using a cesium source. Consequently, no solvents are needed to determine the asphalt content of the paving mix. Many state highway departments currently use a lot of chlorinated hydro-carbon solvents for extracting asphalts from mixes and they are having a very difficult time disposing of these materials. They are becoming a very large environmental concern. Consequently, we are starting to see more and more of this kind of equipment on paving jobs.
What about materials? In terms of equipment, we're in pretty good shape. We've got the means of supplying very high technology in mixing asphalt materials, placing asphalt materials, compacting, and even testing asphalt material. In terms of the materials themselves, we're also fairly advanced. We have a selection of aggregates that we can use, but we haven't found any really good ways of improving mineral aggregates. The good materials that are out there are very good—the bad ones are always very bad and we have to try to avoid those. It's very difficult to try to improve a bad mineral aggregate, so we try to stay away from those materials. However, we do change the way we grade these materials. As a matter of fact, Kentucky is probably one of the leaders in this technology. Termed large mixes, this is a 2" maximum size asphalt concrete mixture. Most asphalt mixtures are in the 3/4 minus sizes, but these mixtures are much larger in size. Consequently, they provide considerably higher shear strengths and we expect higher performance from these mixtures. There is a lot of interest in this now—this is a very, very current research topic. It's something we're working on at the Asphalt Institute, something on which the University of Kentucky has done a lot work—and is one of the world's leaders in this technology.

There are some additives that can be used in asphalt. In most cases the asphalt binder itself is adequate to serve pavement. However in certain special cases there might be a cause for using some sort of polymer or rubber additive to the asphalt to give it increased tensile strength at low temperatures. We have a list of various materials that have been used in a number of states, some are fairly exotic and some not so exotic. For example, ground-up automobile tires can be conveyed up to the top of an asphalt distributor and mixed at a high temperature and then the material is placed after it has been mixed and reacted in this way. The resulting material is not particularly homogeneous, but extremely sticky. In many places where chip seal construction is occurring, there is a need for a very, very sticky binder (primarily in places where we have very high traffic loadings). These materials would serve very well for that. We now can place chip seals on pavements with traffic up to 50 to 60,000 ADT on a four-lane highway. This is a very, very high traffic load for a chip seal. Chip seals are generally extremely cost-effective. The biggest problem has been windshield damage on high traffic pavements, so we've avoided the use of these materials there. Some new binders are allowing us to use these materials on higher traffic locations where in the past it wasn't possible. Here's an example of a pavement that might have needed some preventive maintenance 25 years ago and has been let go. Overlaying a pavement neglected for 25 years can cause a problem with cracks reflecting through to the surface. Now we're doing things like putting geofabrics down over the old crack pavement and putting special elastomeric binders down on top. There are various low-modulus sorts of materials that can be placed on top of the old crack surfaces prior to the application of the asphalt overlay. The idea, of course, is that the stress intensity of crack tip is eliminated in the lower modulus membrane between layers and the crack does not reflect through to the surface—a fracture mechanics trick. Sometimes these fabrics work and sometimes they don't. There is a lot of research going on right now to determine what this mechanism is and how it might be affected.
Our engineering efforts in the asphalt technology areas have a ways to go. This business historically has been very empirical in nature. There are not a lot of places one can go to school to learn about asphalt technology. Consequently, the transfer of the technology takes a long time. It's also a very empirical-related industry so that one does not graduate from college, go right out into the field, and be called an asphalt expert. Most people have worked in this business for 30 or 40 years and don't consider themselves experts because it's a fairly mysterious science. We're making some real inroads in this area though. Primarily in these three areas; the area of materials behavior, mixture, and structural design.

In the area of materials behavior, most of the materials characterization that goes on in asphalt technology is empirical. We test something in a laboratory, measure some empirical property, and then observe how that material works in the field and relate that empirical test to the performance in the field. This is a very straightforward sort of engineering practice. Unfortunately, when it comes to pavements, it takes a long time to develop a cause-effect relationship because these pavements generally don't fail right away.

The other problem we have in the research end is that we're often not allowed to build pavements that fail and, consequently, we can't speed up this process very well. There's an awful lot of work going on right now to try to develop fundamental engineering properties for the materials that we deal with so we can theoretically predict how they will work in the real pavement. This kind of work has been accelerated in the last four or five years with one very major research program that's being sponsored right now. Near the end of that program, we should know a lot more about how to predict performance of pavements based on properties of the engineering materials.

A lot of work is going on in the area of mixture design in an attempt to get away from the empirical types of tests that we run in the laboratory on asphalt mixtures in hopes of getting closer to the fundamental sorts of test that we can more theoretically predict after we have developed sufficient models that can help us do this prediction. In structural design, we are doing a lot of work to try to tie the material properties of the materials with which we are dealing to the structure that we are designing.

Unlike almost every other civil engineering activity about which we know, this particular science is one in which the structural designer often does not know the properties of the materials for which he's designing. You might want to think about that for a minute, but it's very true. Consequently, it's a very difficult discipline with which to be involved.

Material behavior--again we're going to be looking more at fundamental descriptions than material properties so that we can use these in structural designs, so we don't have these empirical relationships that we only have to fall back on.

Mixture design--in a laboratory right now we're doing a lot of work with performance-related evaluations. We are trying to come up with tests that can be performed in a laboratory to actually predict full-scale field performance. Right now those kinds of predictions are all but non-existent.

Probably the most important thing that's happening in the field is to develop verification of laboratory procedures, determine that what we have in the laboratory is what takes place in the field. That's something that would be very important.
have produced in the field is, in fact, something that we designed earlier in the laboratory. Believe it or not, a lot of that verification isn't done and that's the reason why many of these pavements don't work as well as we would like.

Structural design--do some integration with mixture design. There is a lot of activity in this area. The Asphalt Institute is working on some in-house research right now to do this very thing, to try to incorporate the behavior of the mix that we measure in the materials laboratory to the actual structural design when we start coming up with thicknesses.

In terms of education, I'm sorry to say that we're sliding down that line even further than we were for engineering. The reason is because there are very few institutions in the country in which you can learn this technology in a formal way. Probably about four or five universities, at last count, that actually teach this technology at the master's or Ph.D. level.

This is a very difficult science to understand. This is a very complicated thermoplastic material. Unfortunately a smattering of information can be obtained, usually at the baccalaureate level, but it just isn't enough to understand it. The way people have acquired this information in the past, typically, is through highway department experience--counties, cities, and so on. Unfortunately, that process takes a long time. It takes a long time to develop enough experience with these kinds of materials to become a good engineer in this particular field. Currently, we're working very closely with the University of Kentucky to develop some graduate programs in this area so that by the time a student leaves the University he can hit the ground running if he does go to work for a highway department or a consultant.

In construction, we're probably as far down this line as we can get. And when I say construction I don't mean the equipment or the people or anything like that, I'm talking about the contracting practices, the way we actually set up contracts. I'm talking about the legal documents to describe how the work should be done. Unfortunately, right now, many of the contracts that we have set up for contractors, are really designed for the pavement not to do very well. Many times the contractors do not have the incentive to really build a good pavement. There's a lot of work going on right now in the Federal Highway Administration to try to come up with more innovative contracting practices--trying to write contracts that do not lend themselves to poor performance in the field.

So we've got a very highly developed material, and the equipment that we have has been developed very highly. We need to start doing a lot more work with fundamental engineering practices, get the educational system and formal system in touch with this so we have more short courses, more actual courses at the University level, for training engineers and then develop some real contracting systems that contractors can live with so they can build a good product and make some money at the same time.

To summarize, in this particular industry in the future, we're going to be seeing big advances in engineering, education, and construction. Thank you for the opportunity to talk about this. It's an area that I really enjoy and it's an exciting area in which to work. Thank you.