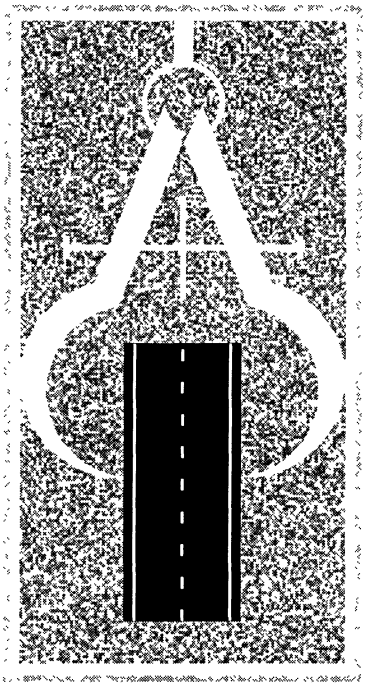
TECHNICAL ASSISTANCE
REPORT

THE JOURNEY TOWARD END RESULT SPECIFICATIONS FOR ASPHALT CONCRETE



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ABSTRACT

The Virginia Department of Transportation has been working to replace traditional asphalt concrete specifications with end result specifications since the mid-1960s. The type of end result specification that is most possible is the performance-related specification where product quality characteristics and life-cycle cost relationships are correlated with performance. The development of tests for quality characteristics and the development of reliable life-cycle cost relationships present challenges.

The identified asphalt concrete quality characteristics were degree of compaction, thickness, smoothness, segregation, strength, and durability. Each characteristic is discussed, and an estimate is given with regard to when each characteristic could be used in a specification. It was estimated that a performance-related specification for asphalt concrete may be possible in Virginia by the year 2005.

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INTRODUCTION

The Virginia Department of Transportation (VDOT) has worked toward an end result specification (ERS) for hot-mix asphalt since the mid-1960s, although evolution has changed the destination. When first embarking on this journey, only the most prophetic could envision the ultimate goal as being a true ERS, i.e., a specification in which the final in-situ properties can be measured, related to quality and performance, and paid for relative to anticipated longevity. Since VDOT, the Federal Highway Administration (FHWA), and other state transportation agencies have been working toward this goal for almost 40 years, surely the objective must be in sight. This paper attempts to show where this effort stands and why the end, although getting closer, is still some way off.

For a true ERS to have meaning, it must assess the fundamental properties necessary to produce a long-lived pavement and be able to relate these properties to pavement life. This brings to bear a performance-related specification (PRS) and a performance-based specification (PBS), which are more specific types of an ERS. The difference between the two is that a PRS contains quality characteristics and life-cycle cost relationships that are correlated with product performance whereas a PBS contains fundamental relationships that are associated through performance models. Since these models are not well developed at present, a PBS for portland cement concrete and hot-mix asphalt are still in the future. But what about a PRS?

CHALLENGES

Two challenges face Virginia and any other state that wish to implement a PRS. The first is to develop the tests for quality characteristics that are truly related to performance. The second may be more difficult than the first and that is to develop life-cycle costs that relate the level of the quality characteristic to performance.

The asphalt industry is close to being able to write a PRS. In fact, a prototype is under development based on results of WesTrack testing, which was a large-scale testing program of

Superpave mixtures on an oval test track in Nevada. Several other ongoing national studies are attempting to develop acceptance tests that will provide the necessary knowledge that will feed a PRS.

QUALITY CHARACTERISTICS

For a PRS to be functional, the quality characteristics must be measured simply, practically, and quickly. Although there is no consensus on which quality characteristics are critical, the following properties are considered a minimum in the national ongoing studies:

- degree of compaction of the pavement and longitudinal joint
- thickness
- smoothness
- segregation
- strength
- durability.

Although the necessary technology is close to being available to measure these properties, there are still gaps that need to be filled. The following paragraphs discuss each of these properties as it stands nationally and, specifically, as it relates to VDOT.

Compaction

One of the properties that are possible and practical to measure and assess is the final in-place compaction. However, there is controversy over how to measure this property. Most technologists agree that to obtain the most accurate measure of air voids, which is the physical in-place property most related to performance, cores must be cut from the pavement. This is viewed by some as creating a point of weakness and as being esthetically unpleasant. However, the alternative to cutting cores is using nuclear density gage readings. Although this measurement device has advantages, it has the disadvantage of providing a relative density that requires correlation with cores. This correlation creates an inherent weakness in accuracy. Adding to the complexity of the problem is measuring the compaction at the joint. Early joint deterioration is a problem not only in Virginia but also nationwide. But cutting sufficient cores from the pavement and the joint is not likely a feasible option because of the number of cores required to estimate the compaction levels on both the pavement and at the joint. However, it may be feasible to use a combination of air voids determined from cores for the pavement and the nuclear density gage for measuring relative compaction at the joints. Thus, the property of compaction can be determined for a PRS, with a well-written specification. Thus, for VDOT, a test procedure and specification for this quality characteristic are feasible by 2002.

Thickness

The most straightforward way to measure thickness is to measure cores. Another alternative is to measure yield, but the variability of the thickness cannot be measured with this method. Nondestructive devices are being tested, but none has been proven effective at present. The ground-penetrating radar system has been used, and there are claims that results are comparable to core measurements, but the cost of a small system is $100,000 plus. But, as with compaction, this quality characteristic can be determined for inclusion in a PRS now with cores, and possibly later with the ground-penetrating radar if funds and personnel are made available.

Smoothness

There is much research being done on smoothness measurement because DOTs have come to realize how important a smooth pavement is to the traveling public. VDOT is in the midst of revising a rideability specification that can be incorporated into a PRS. At present, the specification is in the form of the improved rideability provided by an overlay, but with additional work, it can probably be put in the form of an absolute ride specification by 2002.

Segregation

Segregation has been identified as separation of aggregate particles of different sizes or differential cooling of adjacent areas of a pavement mat more commonly known as thermal segregation. Both types of segregation result in shortened service life. Some means other than visual observation will be required in a PRS to measure segregation. Particle size segregation is a problem on many pavements, particularly on base courses and coarse-graded surface courses.

The problem of measuring this pavement defect has resulted in a National Cooperative Highway Research Program (NCHRP) study that offers potential solutions to the measurement problem. The ROSAN device that is mounted on a vehicle was identified as a tool to measure particle segregation. The Virginia Transportation Research Council (VTRC) needs to investigate the feasibility of using this device in a VDOT PRS specification. It is estimated that measurement of particle size segregation may be possible for a specification by 2004. Although measurement of thermal segregation is possible through measuring density, it may be infeasible because of the large number of measurements that would be required. Thermal segregation would be partially controlled by enforcement of an effective density specification.

Strength

Strength is a property that is, at present, problematic to include in a PRS (ERS). Because hot-mix asphalt is a thermoplastic material, defining the strength under the proper loading and temperature conditions is necessary. A practical measurement system for determining in-place strength has not been agreed upon. Measuring the strength of the as-produced mixture is much

more feasible, but it conflicts with the desire to have a true ERS based on in-place field measurements.

In a recent NCHRP panel meeting concerning which quality characteristics to include in a PRS, it was decided to try to refine a dynamic modulus test to measure the strength of the hot-mix asphalt. Although the panel wanted the measurement to be made in-situ, there does not appear to be a test available to do that at present. Current procedures for determining dynamic modulus on extracted pavement cores require the cores to be glued together to be of sufficient thickness to accommodate the test device. This is not a practical procedure to use in a PRS, and other solutions are being sought. The NCHRP study is leaning toward laboratory-compacted specimens for the measurement of dynamic modulus. It is estimated that a procedure will be available by 2005. When fully developed, this procedure will be available for implementation by VDOT.

Durability

Durability is another property that is not easily measured in-situ. Although closely controlling air voids is the best way to impede oxidation and slow binder hardening, the initial stiffness of the binder and several mixture properties also play a part in the durability of asphalt concrete. Once again, currently, this property can be measured only under laboratory conditions. For use in a PRS by VDOT or other agencies, the measurement of this quality characteristic is still some years away.

Two additional durability characteristics are concerned with fatigue and moisture damage. The fatigue test is a time-consuming test that would be difficult to implement on a routine basis. The potential for moisture damage can be measured with the permeability test and stripping test. The stripping test is a standard test that could be performed on field cores, and the field permeability test currently being developed at the National Center of Asphalt Technology shows promise. Measures for moisture damage could be available as a result of the center's work and additional work by VDOT by 2004.

PAY FACTORS, LIFE CYCLE COST ANALYSIS, AND OTHER FACTORS

The other impediment to implementing a PRS is the lack of a method to combine the individual quality characteristics into a comprehensive life-cycle cost analysis or pay factor schedule that reflects the quality of the product. Several intuitive procedures are used by several DOTs, but there is no universally accepted combination. The prototype PRS uses "as-design life-cycle cost" as a ratio to "as-built life-cycle costs." The prototype PRS will have model relationships that may be useful to VDOT. A recent national forum in Florida estimated that the elements of a PRS, which would include these basic relationships, would be in place by 2005. These relationships will have to be tuned to Virginia conditions.

NATIONAL EFFORTS

Several NCHRP and FHWA projects are concerned with a PRS for hot-mix asphalt. Consideration should be given as to how best to combine these resources. The pertinent ongoing national studies are:

- NCHRP Project 9-15, *Quality Characteristics and Test Methods for Use in Performance-Related Specifications of Hot-Mix Asphalt Pavements*
- NCHRP Project 9-16, *Relationship Between Superpave Gyratory Compaction Properties and Permanent Deformation in Service*
- NCHRP Project 9-18, *Field Shear Test for Hot Mix Asphalt*
- NCHRP Project 9-19, *Superpave Support and Performance Models Management*
- NCHRP Project 9-20, *Accelerated Field Test of Performance-Related Specifications for Hot-Mix Asphalt Construction*
- NCHRP Project 9-22, *Beta testing and Validation of HMA PRS.*

THE NEXT STEP

It is apparent that work needs to be done to develop the type of ERS that VDOT desires. The question as to which efforts are best undertaken by the VTRC and which should be left up to the national studies must be considered. The effort necessary to develop the tests for the quality characteristics is considerable. The status of efforts to complete the PRS may be summarized as follows:

- A density specification that efficiently measures air voids and joint density is critical. Research is in progress at VTRC comparing density measured by the nuclear device, the PQI capacitance device, and coring. The results should lead to the development of a proper specification by 2002.
- The smoothness specification now in place needs to be tweaked to be applicable to new and rehabilitated pavements as well as overlays. Work is in progress by VDOT.
- The ROSAN device needs to be obtained and used to develop a segregation specification for VDOT. It is hoped that this work will be an extension of the smoothness specification work by VTRC.
- A test that measures strength needs to be developed or refined. After the test is identified in the NCHRP study, it must be investigated, confirmed, and adapted for use by VDOT.

- Some measure(s) of durability such as those for binders and/or mixtures needs to be developed. Such a measure could probably be handled best by a national study(s); completion is not anticipated soon. It might be possible to incorporate a moisture-damage quality measure in the near future with some additional work by VDOT.

- A protocol or model that combines the individual quality characteristics into a single pay factor or life-cycle cost equation needs to be developed. This can be done on a rational basis only after most of the tests and measurements of the quality characteristics are developed. It is anticipated that VDOT can develop a life-cycle cost equation and refine it as life-cycle cost data become available. Consideration should be given as to how to proceed in gathering life-cycle cost data that will be needed to input into and refine the prototype PRS.