Effects of Aggregate Size, Shape, and Surface Texture on the Durability of Bituminous Mixtures

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•VIRGINIA has been using bituminous mixtures as its major construction and maintenance material for more than 30 years, having started with liquefier-type "cold" mixes. The varying terrain ranging from the Atlantic coastal plain through the Piedmont area to the Appalachian Mountains offers quite a variety of aggregates including sand, gravel, granite, trap rock, dolomite, and limestone. In the interest of economy, every effort has been made to use locally available aggregates in bituminous mixes. With the emphasis on skid resistance during the past 10 to 12 years, it has been necessary to import aggregates for the wearing course in some areas of the state, but the thickness of these courses has been held to the practical minimum.

This discussion of the effect of aggregate size, shape, and surface texture on the durability of bituminous mixtures is based on a review of the maintenance records of the Virginia Department of Highways. For design and estimating purposes, we usually use an average life of 10 years for surfaces of bituminous pavements, realizing, of course, that many factors influence the life span of any specific treatment. In the western area of the state where limestone is prevalent, many pavements exceed 10 years in service. However, it has been necessary to place on major routes a safe, skid-resistant wearing surface incorporating silica sand, slag screenings, or similar nonpolishing aggregate after from 2 to 5 years. Now the design provides for a nonskid wearing surface as a part of the original application.

These skid-resistant surfaces are laid down in thin applications of approximately 30 lb per sq yd, and they frequently have to be replaced in 3 to 6 years depending on the volume of heavy truck traffic. We believe, however, that, other factors being equal, the coarse aggregate mix, 1 in. down, will wear longer than the sand or fine-aggregate mix. Aggregate mixes do not tend to wear away as rapidly as the fine mixes, particularly silica sand. The sand treatment will, in the process of wearing, continually present a sharp angular particle face for tire contact.

The durability of these sand mixes can vary greatly, depending on the aggregate source. For example, one bituminous concrete producer has a plant located adjacent to a sand and gravel supplier from whom he obtains crushed sand produced as the supplier crushes gravel. This crushed sand was used on US-1 in a sand-asphalt mixture that did not require resurfacing for 13 years, whereas similar mixes from other suppliers under similar traffic conditions required resurfacing from 3 to 7 years. This sand showed equally good performance in other places where it was used. Isolated local sand deposits produce mixes that give comparable performance, but these are the exception rather than the rule.

In localities where nonpolishing coarse aggregate is economically available, bituminous concrete surface mixtures are now used with a maximum-size coarse aggregate of either $\frac{3}{4}$ or $\frac{3}{8}$ in. The local sand mixes may allow aggregates up to $\frac{3}{8}$ in. top size; however, most of the mixes are manufactured from aggregates with 75 to 100 percent passing the No. 4 screen. The deslicking mix, which is applied at approximately 30 lb per sq yd, has from 95 to 100 percent passing the No. 8 screen and may have as much as 95 percent passing the No. 30 screen.

It seems, therefore, that the local sand mixes wear away the fastest, but they always provide a skid-resistant surface. The "weardown" in some cases is sufficient for the driver to notice an elevation difference immediately adjacent to the pavement

marking. The very fine deslicking mixes wear down less rapidly than do the local sand mixes, and the coarse aggregate mixes give the greatest length of service. These are general statements, however. The durability of any particular bituminous mixture is dependent on many factors, such as characteristics of the aggregate, mix design, plant procedures, application procedures, temperature and atmospheric conditions, and traffic types and volumes. Chances of securing a long-wearing pavement are greatly enhanced if the best aggregate available is used.

In addition to durability, economic factors must also be considered, and durability may be sacrificed for economy. For example, two applications of a cheap mixture may cost less and last longer than one application of an expensive mix. This was the consideration for the eastern shore of Virginia where there is an abundance of sand, but where it is impossible to secure mixes with adequate stability in accordance with normal standards. Even when used in limited proportions, 25 percent or less, the sand caused troubles with control and subsequent pavement failures. A review of traffic weights and volumes on secondary roads led the Virginia Highway Research Council to consider a design for this type of service. Utilizing this local material with a small amount of mineral filler and strict controls on asphalt content, the Council produced a bituminous mixture that costs 25 percent less than mixtures manufactured from commercial materials and provides comparable service on all but major routes. Certainly, in this case, particle shape has a great effect on service and durability, but durability can be related to traffic types and volumes. It is not enough to be limited to standard mixes, that is unless there are unlimited funds, and certainly operational people are not in this position.

In closing, it is appropriate to acknowledge the value of research to the operating divisions of the Virginia Department of Highways. The Virginia Highway Research Council developed the deslicking mixes and pioneered in the use of local materials and local sands for particular applications. It has currently recommended that changes be made in gradation of base mixtures to provide greater durability and is developing statistical specifications that the Department hopes to adopt shortly.