

Intersection Strategy

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This is the third in a series of four articles detailing the steps to obtain improved performance of HMA intersections. The first article, published in the Winter 1999 issue of *Asphalt Magazine*, described the overall process. The second article, printed on page 8 in this magazine, provides guidance to identifying structural or pavement design parameters, causes of rutting in existing pavements, removing failed courses, and achieving adequate structural thickness. This article gives details on materials selection, mix design considerations, and construction practices. The fourth article, to be published in the Fall of 1999, will track the development and performance of some current intersection test sites.

Recognizing that there is a need to apply an "intersection strategy" using proper materials selection, mix design, and construction techniques is critical to obtaining the improved performance of pavements subject to high shear loading. Perhaps the secret of obtaining improved performance can be summed up as paying attention to the details of the work and being committed to doing the work properly. The ideas discussed in this article are not high-tech secrets but require basic applications of known, good practices.

Materials Selection

Current technology, typified by the

Superpave process, provides materials engineers with several tools for improving the performance of hot mix asphalt (HMA) intersections and other high stress locations. The Performance Graded (PG) binder system offers a variety of binder grades to meet the climate and traffic needs of the local project. One of the provisions for selecting the appropriate PG grade recognizes the need for a stiffer binder for slowed or stopped traffic. This provision, commonly called "bumping the grade," is described as follows in the Asphalt Institute's Superpave Series No. 1, *Performance Graded Asphalt Binder Specification and Testing*:

"For slow moving design loads, the binder should be selected one high temperature grade to the right (one grade "warmer"), such as PG 64 instead of PG 58. For standing design loads, the binder should be selected two high temperature grades to the right or two grades "warmer," such as a PG 70 instead of a PG 58."

Two Grades Stiffer

The design engineer should select a binder for intersections two grades stiffer than that used for conventional applications. If PG binders are available, the process is simplified: use an asphalt binder that is two grades "warmer." If PG binders are not available, check with the local asphalt suppliers, and find a stiffer binder. Most

Materials and Construction Co

suppliers have “heavy-duty” asphalt. As a starting point for binder selection, experience to date has shown that PG 76 provides increased rutting resistance for high shear locations.

Selection of the appropriate aggregate blend is even more critical than binder selection. The aggregate structure carries the load, whereas the asphalt cement binds, waterproofs and gives additional stiffness. The aggregate must have high internal friction to develop the degree of interlock to resist shearing or rutting. Tough, durable aggregate is necessary.

Rounded aggregate must be avoided in both the coarse and fine fractions. The Superpave aggregate consensus properties (coarse aggregate angularity, fine aggregate angularity, flat and elongated particles and clay content) should be used to characterize the aggregate.

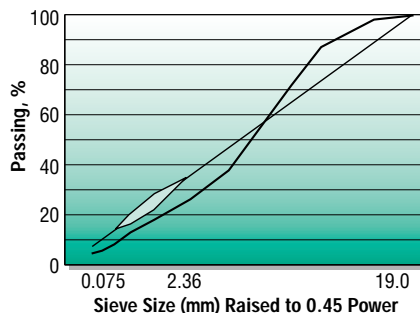
Mix Design

The purpose of the mix design process is to develop an economical and constructable blend of component materials that will satisfy the engineering requirements of the application. For intersection mixtures, it is particularly important to use a mix design system that is capable of achieving compaction that produces stone-to-stone interlock and orientation like that achieved in the pavement—without having the laboratory compactor fracture the stone.

A Superpave gyratory compactor (SGC) is well suited for laboratory mix design compaction since it produces a reasonably comparable aggregate particle orientation to that observed in roadway cores. One of the higher gyratory compactive levels ($N_{\text{design}} = 100 - 125$) should be used. If a SGC is not available, a Marshall compactor may be used. Seventy-five or more blows of compactive effort should be applied.

Current Technology

Current asphalt mixture technology, Superpave and Stone Matrix Asphalt (SMA), provide the designer with some positive means to address rutting. Superpave mixtures having an “S-shaped curve” (that plots above the maximum density line [MDL] for the plus 4.75mm fraction and below the MDL for the fine-fraction) have generally been found to be satisfactory. SMA surface mixes have received a lot of acclaim, but little has been publicized about using SMA-like base mixes. The



SMA concept can be applied to designing a base mixture that can provide excellent intersection performance.

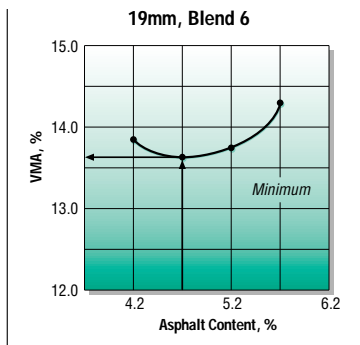
If conditions warrant, the mix designer should consider increasing the design target air voids content from the normally specified 4.0 percent. *The 4.0 percent value was established for high-speed, open-highway applications rather than for slowed or standing traffic.* This adjustment is particularly valid for Marshall designs where additional compactive effort may break the stones. A target air voids level of 5 to 5.5 percent is suited for Marshall mixes placed in extreme shear locations. Similarly, SGC-designed mixtures can be targeted for 4.5 to 5 percent air voids. Mixture having these voids level will produce lower voids-filled-with-asphalt (VFA) which, in turn, provide additional room for elastic deformation under loads.

VMA

A word of caution is in order regarding a potential concern about the VMA of the designed mixture. It is possible to develop an aggregate structure that has too much VMA. The gradation may be gap-graded, or there may be insufficient filler. This condition can exist with either Superpave gradings or SMA blends. The extra space between aggregate particles may be filled with asphalt binder to meet the air voids and VFA requirements. This unusually

Concerns for Improved Intersection Performance

heavy asphalt film coating provides lubrication between the stone particles. Most practitioners advise against using mixtures having VMAs that exceed the minimum value by 2 percent or more. That limit is valid for normal, high-speed applications, but for intersection applications, the user might be well advised to limit the maximum VMA of the plant-produced mixture to 1 percent above the minimum specification value. The binder content should be selected to stay away from the high asphalt content side of the VMA curve.



In addition to volumetric design, proof testing or strength testing to evaluate the mixture's resistance to rutting is strongly recommended. Several devices are available to perform this evaluation. One of the best, and the least common, is the Superpave Shear Tester (SST). This machine is capable of performing several tests to characterize the mixture's resistance to permanent deformation. Other equipment that can be used includes the Asphalt Pavement Analyzer, the Hamburg Wheel Tracking device, and other loaded wheel testers. Whether or not strength testing equipment is available, the designer should give careful thought to the candidate mixture. Some questions to ask include:

- Do I have experience with a mixture similar to this one?
- What was the performance of similar mixes?
- Does the asphalt content seem appropriate?
- Does the mixture seem too wet or too dry?
- How hard was it to coat the aggregate in the lab design?

Questions such as these may not guarantee performance, but they are intended

to cause the mix designer to think about how this mix should perform. Information on performing mix designs can be found in the Asphalt Institute's MS-2 (Marshall) and SP-2 (Superpave) manuals.

Construction

The construction focus of high performance intersection work must be geared to achieving density and durability. In order to carry the loads without showing or rutting, the mix must be densified to the point of achieving stone-to-stone contact. The aggregate must develop interlock to resist shearing. Avoiding segregation, constructing dense joints, and producing an impermeable mat enhances durability. See *Compacting Superpave Mixes* below.

Avoiding segregation is important in achieving a pavement having uniform load-carrying capability. Segregating the aggregate particles creates a weaker, and less durable pavement. Segregation management practices are well documented, but they have to be followed closely in intersection work to avoid problems. Similarly, proper joint construction techniques have been well publicized, but these techniques must be executed or air and water will enter the pavement and start

to cause deterioration.

A final construction consideration for intersection paving is to keep traffic off of the mat until it has gained sufficient strength to resist early rutting. This requires enough time for the mat to cool to 150 to 175°F. The hot mat is most susceptible to rutting.

Conclusion

The principles that are involved in selecting the materials, designing the mix, and placing and compacting the mix are fairly straight-forward. The difficult part is in the execution. Quality control is important. Placing test strips to fine-tune the mixture and to tailor paving operations makes a difference.

The commitment required to produce a well-performing intersection pavement is not completely painless. Intersection work is not high production paving. Many contractors do not like to slow down and optimize all the points in the process. The unit cost of paving an intersection for optimal performance is higher than for conventional applications. Many agencies do not want to spend the extra money, but there is no shortcut. If you want good intersections, you have to do all the little things that add up to gaining the performance.▲

Compacting Superpave Mixes

By Dwight Walker, Associate Research Director, Asphalt Institute

By now, most users of Superpave mixes are aware that the coarser mixtures tend to be more difficult to compact than finer, conventional mixes. However, what may not have been fully recognized is the critical nature of getting proper compaction with these mixes. The stony texture of coarse Superpave mixes can produce different voids structures than finer mixes.

It has commonly been accepted that conventional mixes are practically impermeable when compacted to approximately 7% air voids or 93% of theoretical maximum, or solid, density (TMD). Coarser Superpave mixes, at

the same (7%) in-place air voids content, will tend to have larger and more interconnected voids. This situation makes the resulting pavement more permeable and, thus, more susceptible to durability concerns such as oxidation, stripping, raveling, etc.

Those agencies that currently require a 92-93% minimum TMD may find that they need to increase the specification minimum to 94% of solid in order to improve durability. Achieving 94%, or more, of TMD requires optimizing the compaction process. It may be necessary to increase the nominal maximum aggregate size to a lift thickness ratio of 3 or 4 to 1. If this is not practical, it may be necessary to reduce the aggregate top-size. In order to optimize the compaction process, a test strip is highly recommended.▲