Intersect Strategy

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This article is the first in a series on obtaining better performance from asphalt pavement intersections. It discusses why intersections require special attention and what steps are necessary to establish an "intersection strategy." Future articles will deal with pavement structure considerations, causes of rutting, materials selection and control, and proper construction of asphalt intersections. We will also describe case histories and performance of trial sites and will provide an update on what is being done to improve intersection performance.

Asphalt pavements typically provide excellent performance and value. They are smooth, quiet and durable. They do not require long construction times and they are easy to maintain—resulting in minimum traffic delays. Never is this more apparent than at our intersections, which can be opened to traffic minutes after placing asphalt. This minimizes the impact to local businesses and motorists, who dread lengthy lane closures and traffic rerouting.

The Challenge

While asphalt has continually proven to have superior life-cycle cost benefits, special attention should be focused on intersections to ensure the same outstanding performance. Some mixes that have a history of good performance in posted-speed applications may not perform well in intersections, climbing lanes, truck weigh-stations, and other slow-speed areas. The slow moving or standing loads occurring at these sites subject the pavement to higher stress conditions that can be enough to induce rutting and/or shoving. As pavement engineers, we often don't recognize the fact that these lower frequency load applications are much more severe, nor do we typically have a formal way of addressing the phenomena.

Superpave binder and mix lab tests offer the advantage of measuring fundamental material properties. One of the Superpave accelerated mix performance tests, called the Frequency Sweep at Constant Height (FSCH) test, brings to light just how dependent asphalt stiffness is on load frequency. FIGURE 1 illustrates the reduction in mixture stiffness as the loading time is increased, or the frequency of load application is reduced. With this FSCH test, the mix's complex shear modulus (a fundamental measure of stiffness) decreased ten-fold when the duration of the loading cycle went from .1 seconds (10 Hz) to 100 seconds (.01 Hz). A frequency sweep test on the binder

Developing a Strategy for B

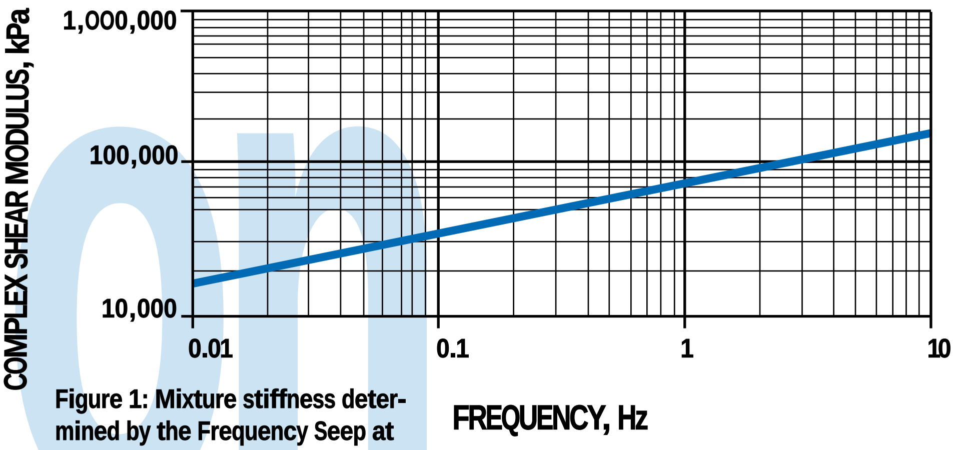


Figure 1: Mixture stiffness determined by the Frequency Seep at Constant Height test.

using the Dynamic Shear Rheometer (DSR) will reveal a similar frequency dependency. This explains why asphalt pavements that have sufficient stiffness to resist rutting in posted speed traffic areas may not perform so well in the slower or static traffic areas.

The lower frequency loads are not the only reason that intersections are more prone to rutting. Braking, accelerating and turning movements that occur put additional stresses on the pavement surface. Engine fluid drippings and heat exhaust increases with slower traffic and has a softening effect on asphalt. In addition, load repetitions at intersections are sometimes double that of mainline pavement due to the cross flow of traffic. Together, these efforts constitute the reason that asphalt intersection pavements need to be treated differently.

A Strategy

Recognizing that some traditional mixes may not always be successful at meeting this challenge, the opportunity exists to implement a strategy for ensuring good performance at slow-speed applications, namely intersections.

The key to achieving this desired performance for asphalt intersections is recognizing that these pavements need to be treated differently than regular open road pavements. Specifically, the pavement must be designed and constructed to withstand more severe conditions.

The intersection strategy consists of these steps:

▲ Insuring structural adequacy
▲ Selecting and controlling materials
▲ Following proper construction practices
▲ Implementing the plan.

Structural Adequacy

To perform well, an intersection pavement must first have adequate thickness to provide the structural capacity or load-carrying ability to meet traffic needs. For new pavements, the thickness design must account for the normal factors—such as subgrade strength and traffic, and also allow for the loss of paving materials stiffness at the slow speeds occurring at intersections. For existing pavements, it is critical that the structural adequacy of the in-place material be evaluated. Both the thickness and quality of the existing layers must be checked. There must be enough structure to carry the loads, and any failed or weak layers must be removed. If the existing pavement has rutted, the cause or source of the distress must be identified and addressed. Simply paving over existing failed material will likely result in reoccurring ruts. *(The next article in*

this series will offer additional detail on evaluating the structural adequacy of an existing intersection pavement and identifying the cause of any rutting.)

Materials Selection, Mix Design and Control

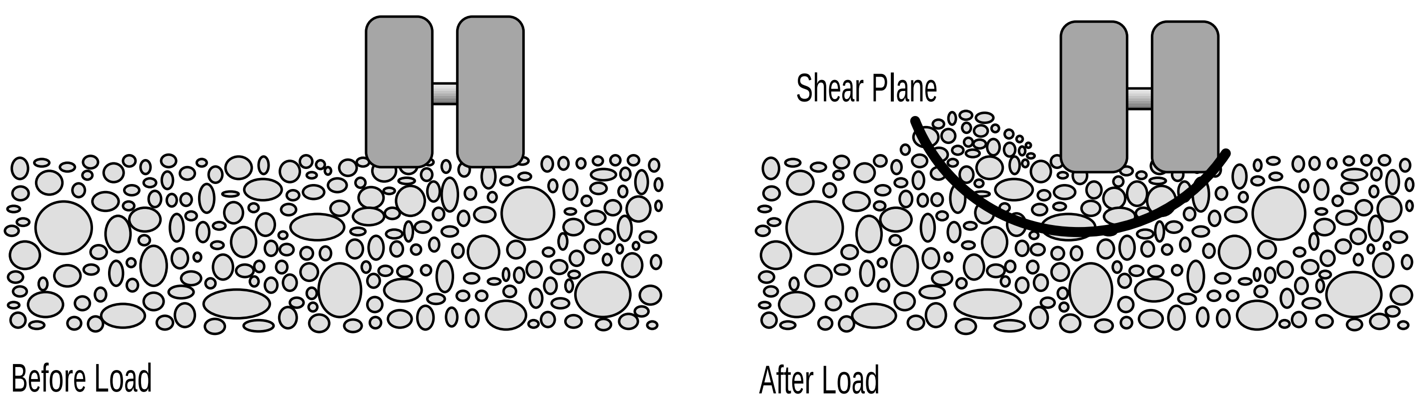
The materials available today offer the designer many choices in attaining improved performance. Careful selection of the asphalt binder and the aggregate combination will go a long way toward providing optimum performance.

The use of Superpave's Performance-Graded (PG) asphalt binder specifications (AASHTO MP-1) is highly recommended. This system has the advantage of the binder being selected based on the climate in which it will serve. Recognizing that a more rut-resistant binder is needed at intersections, Standard Specification for Superpave Volumetric Mix Design (AASHTO MP-2) requires that the high temperature grade be increased by two grades for standing traffic (<20km/h) and by one grade for slow traffic (20 to 70 km/h). Experience at numerous sites across the U.S. has shown that PG 76s have performed well in intersection-type installations. These higher-graded binders may be new to some users. It is recommended that the binder supplier's representative be contacted for information regarding handling guidelines (temperature, agitation, etc.).

Like the asphalt binder, the aggregates used in intersection mixes must be carefully selected. The aggregate structure must be capable of carrying the load and developing a high degree of stone-to-stone interlock that will resist shearing. Certain aggregate properties are critical to delivering this performance. The need for consistent gradations is well recognized, but there also must be consistency of particle shape, texture and absorption.

Both the coarse and fine aggregate must be angular to provide the interlock required for rut resistance. Superpave's Coarse and Fine Aggregate Angularity Tests or similar AASHTO procedures are recommended for evaluating the aggregate. Obviously, limiting the use of rounded particles and uncrushed sands is essential. In many cases, washing, crushing or other means of process-

Figure 2: Shearing Behavior of Rounded Aggregate



ing can improve marginal, local aggregates. FIGURE 2 illustrates how weak aggregate structures can displace under loads.

In addition to materials selection, the mix design procedure is important in achieving desired performance. The goal of the mix design process is to select the appropriate asphalt content for an aggregate structure that can carry the load and resist rutting.

Asphalt mixes are designed at a specific level of compactive effort. The Superpave Gyratory Compactor (SGC) can provide a higher compactive effort than the Marshall Hammer, better simulating the actual traffic conditions present at intersections. Mixes meeting Superpave volumetric criteria, or Stone Mastic Asphalt (SMA) mixes, are good candidates to use at intersections due to their ability to resist rutting.

VMA

Experience has shown that voids-in-mineral-aggregate (VMA) property of the mix is particularly important. Mixes with marginally low VMA can be sensitive to relatively small changes in the total fluids content (asphalt binder, moisture, and fine filler). Small increases in fluids can then cause these mixes to be subject to rutting or shoving. On the other hand, mixes with too high VMA will produce thick asphalt coatings on the aggregate particles which can act as a lubricant, allowing the particles to reorient themselves under traffic, which leads to rutting, shoving or bleeding.

After selecting the materials and performing the mix design, the contractor must deliver a mix to the intersection project with the same laboratory properties. Quality control of the asphalt mix is critical and initial trial runs are required to identify any needed volumetric adjustments. As a minimum, verification of asphalt content and gradation, and laboratory air voids is essential in the field-produced mix. Since intersections normally involve fairly small quantities of hot mix asphalt, there is little time for making changes. The contractor's process control must already be geared to producing the mix as designed.

Construction

The next step to achieving optimal performance is the construction phase. The secret of construction operations at intersections is to follow well-established "good practices" and to pay attention to details. Examples include:

Milled areas need to be thoroughly cleaned. Removing all the "crumbs" at the edges of the milled area is particularly important. All debris must be removed and a uniform tack coat applied to the surface and vertical sides of the milled pavement.

Proper joint construction is important to prevent water from entering the structure. The stiffer, stonier mixes that generally offer the best rutting resistance typically require careful joint construction efforts.

Proper handling to avoid segregation is also important. To carry the traffic loads, the mix must be uniform and not have varying density or texture.

Achieving proper compaction is critical. The stiffer Superpave mixes may require extra effort to achieve the necessary density (93 to 96 percent of maximum theoretical density).

Other "good practice" precautions, such as not over-heating the mix, avoiding the use of diesel fuel in truckbeds, etc., still apply. Poor construction practices have negated a lot of good materials and mix design work.

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Intersection Strategy

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Implementation Plan

As part of developing an intersection strategy, one of the decisions to be made is how much of the pavement should be treated differently. This involves many factors. One of the barriers to implementing an intersection strategy is that the typical volume of hot mix asphalt needed on an intersection project is relatively low.

Many engineers are reluctant to write a special specification for an intersection, and many contractors do not want to do a small volume project that requires special attention and possibly different materials. Nevertheless, the key to constructing a successful intersection is recognizing that they may need to be treated differently, depending on the performance of the typical mix being used for the mainline road.

Solutions

One solution to the low-volume project barrier is combining many intersections into one project. This may require several districts or jurisdictions getting together and combining intersections that need rehabilitation into one project.

For many roads with a series of closely spaced intersections, it would be logical to use the improved mix for the full length rather than alternate with a series of intersection strips and regular strips. For existing intersections, the full length of any problem area needs to be included in the specification.

Increased Performance

Evaluating the performance history of your intersections and other similar high-stress areas needs to be a key part in deciding whether changes should be made to the normal procedures. Even though the initial unit cost of building these improved asphalt intersections may be higher than the unit cost of regular asphalt pavements, the performance life will be dramatically increased, reducing the overall life-cycle cost.

This life-cycle cost will typically be less than half that of using concrete in the intersection.

Improved asphalt intersections can be constructed with minimal motorist delays, avoiding lengthy lane closures and traffic re-routing that is necessary with concrete construction and curing. The final product will be a long lasting, cost-effective, smooth asphalt intersection that is constructed or rehabilitated in minimal time.

Future articles will offer additional detail on structural considerations, materials selection, mix design, quality control and construction details. They will also provide examples of successfully constructed asphalt intersections.▲

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