Somerset Intersection Project
US 27 & KY 80 in Somerset, Kentucky
Aggregate Gradation and Mix Design Details

Description	**3/4-inch Base Mixture**	**1/2-inch Surface Mixture**
Aggregate Type/Size	Limestone #57 Limestone #8 Unwashed Limestone Sand Washed Limestone Sand	Limestone #68 Dolomite #78 Unwashed Limestone Sand Washed Limestone Sand
Aggregate Gradation Sieve Sizes	**Job-Mix Formula (Percent Passing)**	**Job-Mix Formula (Percent Passing)**
1.00 in.	100	100
0.75 in.	91	100
0.50 in.	71	94
0.375 in.	57	70
No. 4	35	43
No. 8	20	25
No. 16	12	16
No. 3	09	11
No. 5	06	7
No. 10	04	5
No. 200	3.1	4
Percent Asphalt Content (PG 76-22)	4.5	4.8
Percent Air Voids	4.4	4.4
Percent Voids in the Mineral Aggregate	13.8	14.3
Maximum Specific Gravity	2.507	2.495
Number of Gyrations (Nmax)	174	174
Number of Gyrations (Ndesign)	109	109
Construction Information		
Design Traffic Load	12,500,000 ESAL	12,500,000 ESAL
Asphalt Quantity (tons)	1447	1045
Lift Thickness (inches)	3	2
Nights to Complete Work	2	3

Asphalt Costs Less: At nearly half the cost, asphalt pavements are more economical.
Asphalt Causes Less Delay: The asphalt contractor worked only seven nights (not 28) to complete the HMA paving.
Asphalt Rides Much Smoother: Measurements taken by the Kentucky Transportation Cabinet on Kentucky roadways confirm that asphalt is 20 percent smoother.
Asphalt Allows Easy Maintenance: Repairs are much quicker and less costly with asphalt pavements.
Asphalt is Safer: With superior skid resistance, asphalt pavements are safer.

PAIKY

Plantmix Asphalt Industry of Kentucky

Depot Place • West Broadway
P.O. Box 286 • Frankfort, Ky 40602

Tel (502) 223-3415
Fax (502) 223-2370

e-mail PAIKY@aol.com or www.paiky.org

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Summary

The asphalt industry has proven it is possible to design and construct intersection pavements to meet even the most severe loading conditions. However, it requires special attention, careful planning and high-quality materials. The development of successful asphalt intersections in Kentucky and our sister states offers outstanding value for the taxpayer.

When designed and constructed properly, hot mix asphalt intersections are the most cost effective pavement solution and can perform extremely well under the most severe loading conditions. We welcome the opportunity to discuss with you further why hot mix asphalt is the best choice for your next intersection paving project. Please call the Plantmix Asphalt Industry of Kentucky for additional information on your specific project needs.

References

High Performance Hot Mix Asphalt Intersections, Asphalt Institute 2000.

Corum, Ron: "High-Performance HMA Intersections," Hot Mix Technology Magazine, pp. 37-43, January/February 2001.

Rosenberger, Carlos, and Mark Buncher: "Structural Adequacy in Asphalt Intersections," Better Roads Magazine, pp. 29-31, August 2000.

Walker, Dwight: "Intersection Strategy (Parts 2 & 3)," Asphalt Magazine, Volume 13, No. 2, Summer 1999.

HOT MIX ASPHALT INTERSECTIONS

The Challenge

Although asphalt has continually proven to have superior life cycle-cost benefits, special attention, in some cases, 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-weighing stations and other low-speed areas.

Slow-moving or standing loads occurring at these sites subject the pavement to higher stress conditions (starting and stopping movements, increased temperatures, turning movements, etc.), which may be enough to induce rutting and shoving. In addition, the increase in the number of trucks and heavier wheel loads also can play a significant role in the premature failure of some pavements.

Pavement specifiers often do not consider the fact that these slow-moving load applications need special attention. Consequently, there hasn't been a plan for addressing the situation. Typically, the same hot mix asphalt designs are utilized for mainline pavements and for high-stress intersections.

There is a need to give special attention to many high-stress intersections, and the Plantmix Asphalt Industry of Kentucky (PAIKY) wants to assist in designing hot mix asphalt (HMA) intersections that will perform well under even the most severe loading conditions.

PAIKY, with technical assistance from the Asphalt Institute, the Kentucky Transportation Cabinet Division of Materials and the Kentucky Transportation Center at the University of Kentucky, has compiled this document as a guideline for the design, construction and rehabilitation of HMA intersections in Kentucky. The Divisions of Highway Design and Operations within the Kentucky Transportation Cabinet, as well as city and county public works officials from across the state, are encouraged to utilize this document.

With major advances in technology, the asphalt industry has met the intersection challenge with the added benefits of cost savings, less construction time and smooth and safe pavements.

When to Apply This Strategy

Determining whether or not to use a high performance HMA intersection design versus a conventional mixture design should be determined on a project-by-project basis. As a guideline, utilize this intersection strategy when the 20-year traffic loading is greater than 3 million ESAL. However, other factors may necessitate the use of a high-performance intersection. The strategy should be implemented where the existing pavement has not performed well, where extreme loads are routinely encountered or when traffic will be queued for a significant period of time.

If troublesome intersections are within one-quarter mile of each other, the entire roadway should be designed using this strategy. Acceleration and deceleration lanes, areas with sharp turning movements, and areas of slow-moving traffic should be included with the intersection design as well. Utilize this design strategy at least 300 feet from either side of the intersection and extend this distance beyond 300 feet if specific project conditions (queue lengths, etc.) warrant an increased distance.

Intersection 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. An intersection strategy should consist of the following steps:

- Assessing the problem (if a rehabilitation project is involved);
- Ensuring structural adequacy;
- Selecting materials and designing/controlling mixtures; and
- Practicing proper construction techniques. (This step is absolutely critical to the success of the entire effort.)

The key to achieving this desired performance at high-stress installations is recognizing that these pavements may need to be treated differently than regular, posted-speed pavements. Specifically, the pavement must be designed and constructed to withstand more severe conditions.

Assessing the Problem

The primary concern at asphalt intersections is rutting due to the higher-than-normal stress conditions. Rutting in an asphalt pavement may be due to mechanical deformation, or it may be related to the HMA properties. Rutting in the HMA may be a result of plastic flow or consolidation. Rutting in the asphalt layer typically occurs during the summer months when pavement temperatures are high. The three primary failure mechanisms for intersection pavements in Kentucky are indicated below.

- Mechanical deformation typically occurs due to the lack of structural capacity (weak or rutting subgrade or inadequate HMA thickness) and may be accompanied by alligator cracking.
- Plastic flow could occur due to high pavement temperature, poor material selection, poor mix design or from inconsistencies in the mix production.
- Consolidation in the wheelpaths occurs because of insufficient compaction of the asphalt mat at the time of construction. Some further consolidation can occur in well-compacted pavements.

For existing pavements that require rehabilitation, the key to finding a solution is to perform a forensic investigation and determine the root cause of the problem. A forensic investigation should initially include a physical assessment of the problem by a pavement engineer with experience in identifying typical distresses in asphalt pavement. The investigation also may consist of coring or cutting trenches in the existing asphalt pavement and testing the base stone and soil subgrade materials. The investigator should distinguish between insufficient subgrade support versus problems within the asphalt mixture.

In addition to identifying the type of rutting, the physical assessment of the intersection also needs to provide the location limits and depth of rutting. The information will be needed to determine the depths of milling or undercutting necessary to remove the weak or failing materials.

Ensuring Structural Adequacy

To perform well, an intersection pavement must first have adequate thickness to provide the structural capacity to meet the traffic needs. For new pavements, the thickness design must account for normal factors such as subgrade strength, base thickness and traffic. For existing pavements, it is critical that the structural adequacy of the material in place be evaluated. Any failed or weak layers must be removed. Simply paving over existing failed material likely will result in recurring failure. Likewise, if an asphalt mixture is failing in its current application, replacing that asphalt with the same type of mixture also will result in recurring failure.

Selecting Materials

Selection of the proper liquid asphalt binder, as well as appropriate aggregates, plays a critical role in the long-term performance of an asphalt intersection. The liquid binder should be stiff enough to help resist rutting and should be combined with aggregates that are angular in nature and provide strength from stone-to-stone contact.

Research has shown that the liquid binder grade plays a significant role in the rut-resistance of an asphalt pavement. With the implementation of Superpave in 2000 for all state projects, Kentucky has adopted the Superpave performance graded (PG) binder system. The base asphalt grade typically used in Kentucky is a PG 64-22.

However, for intersection applications, it is appropriate to “bump” the liquid grade by two high temperature grades to a PG 76-22. Use of a PG 76-22 liquid binder ensures a stiff asphalt binder and provides better rut-resistance than a softer asphalt grade. In some very severe cases, higher grades of liquid binder are used to stiffen the mixture.

The aggregate used in an intersection mix plays an equally important role in the rut-resistance and performance of the mixture. Coarse and angular aggregates with multiple crushed faces provide better aggregate interlock than smooth, rounded particles.

Aggregate interlock and stone-to-stone contact create an aggregate matrix that resists the shearing action that results in rutting. The Superpave aggregate-consensus-property tests should be utilized for selecting aggregates for intersections. Intersection mixtures should limit the quantity of rounded particles, such as natural sand, and replace these materials with crushed particles and manufactured (crushed) sand. To adequately address troublesome intersections, it is recommended that the HMA mixture utilize 100 percent crushed aggregate.

Mix Design

The mix design process brings together the liquid binder and aggregates into a blended mixture that will satisfy the engineering requirements for the application. The Superpave method of mix design now implemented in Kentucky has led to asphalt mixtures better suited for intersection applications. These Superpave mixtures utilize the PG binder grades recommended for intersection applications. These new mixtures also require a gradation band, resulting in mixtures with angular aggregates providing stone-to-stone contact.

Some common reasons for mix instability are too much asphalt and insufficient air voids, too much rounded aggregate, or too high of a minus-#200 content. Careful attention to these mix design recommendations and strategies, combined with close quality control and assurance, should result in an asphalt mixture capable of performing well in intersection applications.

Another option to consider for an intersection application is a stone matrix asphalt (SMA) mixture. These mixtures, often referred to as gap-graded Superpave, rely heavily on stone-to-stone contact and have proven to be extremely rut-resistant.

When performing a mix design for an intersection application, utilize the methods and procedures outlined in the Kentucky Transportation Cabinet's "Standard Specifications for Road and Bridge Construction," along with any "Supplemental Specifications." The mix design should be completed using a Superpave gyratory compactor in accordance with state specifications with the following exceptions.

High-performance intersections should be designed in accordance with Class 3 or 4 mixtures based on the "Standard Specifications." The asphalt binder content may be designed based on air void contents slightly higher than those used for posted-speed pavements (design for 5 percent rather than 4 percent). In addition, the voids in the mineral aggregate (VMA) should not exceed the minimum specification value by more than 1 percent. If the VMA is too high, it may result in a thick asphalt coating that can cause excessive lubrication between the aggregates, leading to rutting.

For high-stress intersection applications, the designer should consider performance testing of the asphalt mixtures. Rut-testing devices, such as the Asphalt Pavement Analyzer (APA), may be used for this purpose. Currently, Kentucky has three APAs in the state (KYTC Division of Materials in Frankfort, Frankfort Testing Lab in Frankfort and Scotty's Contracting in Bowling Green) that may be used to test the performance of a specific asphalt mixture.

Proper Repair Techniques for Existing Pavements

Once the assessment of an existing pavement is complete, the appropriate repair alternative must be selected. Selection of a repair solution is primarily based on the type of distress observed during the assessment.

For rutting caused by structural failure, the failed and cracked asphalt pavement should be removed. Paving over existing asphalt that suffers from alligator cracking will likely just delay the same structural problem. Structural failures are often a result of poor drainage. Existing drainage should be evaluated, and, if the drainage is found to be inadequate, sufficient drainage treatments should be included in the rehabilitation plans.

If the assessment determines that rutting in the pavement is caused by consolidation and not from plastic flow, the pavement may be stable. If rut depths are shallow, it may not be necessary to mill the surface or remove pavement (unless required for a curb or other elevation restraints). However, if the ruts are deep, it may be difficult to achieve compaction in the old ruts, and milling the surface would provide a uniform base for an overlay.

If rutting is caused by plastic flow, it is important to identify the extent of the rutting (in terms of both location and depth) by coring or trenching. Those layers that exhibit plastic flow should be removed, typically by milling. Determining the proper depth of milling is critical and must extend below the depth of the existing ruts. Any exposed subgrade or gravel base should be recompacted prior to placing the HMA.

Proper Construction Techniques

In order for an asphalt intersection to perform well, proper construction techniques must be employed. Poor construction practice can overshadow the good work performed as part of the assessment, structural adequacy, mix design and materials selection, resulting in an intersection pavement that will not perform. As a general rule, follow the guidelines set forth in the "Standard Specifications" along with any "Supplemental Specifications."

Prior to an overlay, be sure that milled surfaces are thoroughly cleaned. Also make sure to provide an adequate (but not excessive) tack coat to create a bond between the old and new asphalt layers. During production, do not overheat the mixture and take the steps necessary to avoid segregation. Segregating the aggregate particles creates a weaker and less durable pavement and should be avoided.

In order for an intersection pavement to carry the loads without shoving 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.

Compaction of Superpave mixtures should begin as soon as the mat is stable enough to support the rolling equipment. Compacting the material to achieve the necessary density is critical to the desired performance. These stiffer mixes may require extra effort to achieve the specified density (typically a minimum of 94 percent of the maximum theoretical density for intersections).

Keep traffic off the mat until it has gained sufficient strength to resist early rutting. Since a hot mat is most susceptible to rutting, the mat should be allowed to cool to 150 degrees to 175 degrees F prior to allowing traffic on the mat.

For signal control, the designers should consider use of pole-mounted cameras instead of traditional traffic loops cut into the pavement. Because traffic loops are typically installed along the wheel paths near the stop bar, they may have an adverse impact on the performance of the pavement.

US 27 and KY 80 in Somerset, Kentucky

As a result of the rutting problems encountered at the intersection of US 27 and KY 80, the Kentucky Transportation Cabinet initiated a head-to-head competition between the concrete and asphalt industries in 1998. The intersection was originally constructed of asphalt and suffered excessive rutting due to high traffic volumes, high truck percentages and grade variations across the intersection. The asphalt in this intersection had to be milled and replaced several times due to repeated rutting in the wheelpaths. The Kentucky Transportation Cabinet wanted a better solution and challenged the industries to a head-to-head competition. The intersection was divided in half, with a portion of the intersection paved with hot mix asphalt and the other portion paved with Portland Cement Concrete pavement (PCC). The asphalt industry evaluated the existing pavement and decided to mill out 5 inches of existing asphalt pavement and replace it with a Superpave mixture. The mix design included a very coarse mixture, 100 percent crushed aggregates and a PG 76-22 binder. The aggregate gradation was actually outside the Superpave gradation limits and was between a coarse Superpave and a SMA mixture.

The designers purposely used the intersection mixes coarse in the direction of SMA to enhance strength and rut-resistance. However, these mixes were not as severely gap-graded as SMA in a hope to enhance workability and minimize the potential for segregation.

The mix design was performed as a collaborative effort between the KYTC Division of Materials and Hinkle Contracting Corporation with additional input and testing from the Asphalt Institute, PAIKY and Koch Materials Company. Copies of the gradation and mix design details have been attached to this document as an example. The PCC industry chose to utilize a 4-inch-thick "whitetopping" overlay for its portion of the project.

The asphalt overlay was completed in seven nights at a cost of $25.25 per square yard. In contrast, the PCC industry took 28 days to complete its work at a cost of $50 per square yard. After nearly three years of service, the HMA pavement is performing very well. Minor consolidation was noted immediately following construction at isolated locations, but these areas are now stable and performing very well.

Based on observations made in early 2001, many PCC slabs have cracked, and some sections of the PCC pavement have failed completely. Some of the failed slabs had faulted nearly two inches and were rocking severely under traffic. On May 17, 2001, state maintenance crews used a backhoe to remove sections of failed PCC slabs on eastbound KY 80 near the stop bar at the US 27 intersection. The excavation exposed the original asphalt pavement, which appeared very stable and relatively dry. With adequate structural support beneath the slabs, failure of the PCC sections can only be attributed to the PCC pavement itself. Based on observations of the intersection, other PCC sections will require removal and replacement in the coming months and years.

The Somerset intersection project illustrates the advantages to HMA intersection applications.
(see page 5)