AMERICA RIDES ON US

Asphalt.

HIGH-PERFORMANCE INTERSECTIONS

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Asphalt.

THE UNITED STATES HAS OVER 2 MILLION MILES OF PAVED ROADS, OF WHICH FULLY 94% ARE SURFACED WITH ASPHALT. INTERSECTIONS PLAY AN INTEGRAL ROLE AND MUST BE GIVEN SPECIAL ATTENTION TO HANDLE THE UNIQUE STRESSES TO WHICH THEY ARE EXPOSED.

Pavement designers and contractors have learned that some intersections need special attention. Heavy, slow-moving vehicles that are stopping, turning, or accelerating expose intersections to some of the highest stress levels found on pavements. High-stress locations also include climbing lanes, truck weigh stations, rest areas, and other slow-speed areas. Giving special attention to these areas can ensure that high-stress areas deliver the same outstanding performance as other asphalt pavements. Pavement engineers have adopted a four-point strategy to ensure good performance for intersections and other high-stress applications.

A basic intersection strategy consists of four steps:

- Assess the situation.
- Ensure structural adequacy.
- Select high-performance materials and confirm the mixture design.
- Use proper construction techniques.

THE KEY TO ACHIEVING THIS DESIRED PERFORMANCE AT HIGH–STRESS INSTALLATIONS IS RECOGNIZING THAT THESE PAVEMENTS MAY NEED TO BE TREATED DIFFERENTLY FROM REGULAR, POSTED-SPEED PAVEMENTS.

» ASSESS THE SITUATION

Two types of pavement evaluations are normally conducted: a functional evaluation and a structural evaluation. A functional evaluation considers the surface characteristics of a road, including certain types of cracking, surface smoothness, noise, and surface friction characteristics. A structural evaluation is used to determine the ability of the pavement structure to carry current and future traffic. A structural evaluation typically requires detailed information about pavement layer thicknesses, paving layer material properties, subgrade support conditions, traffic, and the response of the existing pavement to loading.

» ENSURE STRUCTURAL ADEQUACY

To perform well, an intersection must first have adequate thickness to provide the structural strength to meet traffic needs. For new pavements, thickness 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 in-place material be evaluated. Any failed or weak layers must be removed. Simply paving over existing failed material will likely result in reoccurring failure.

» SELECT HIGH-PERFORMANCE MATERIALS AND CONFIRM MIX DESIGN

Current technology, known as the Superpave process, provides engineers the necessary tools for improving the performance of asphalt intersections and other high-stress locations. The performance-graded (PG) binder system is used to select the proper type of liquid asphalt to bind the aggregate particles together in the finished pavement. This selection is based on each project's expected climatic and loading conditions. One of the provisions for selecting the appropriate PG binder recognizes the need for a stiffer binder for slowed or stopped traffic associated with intersections. This provision, commonly called "grade bumping," rounds up one grade higher for slow-moving traffic or two grades higher for standing or stopping traffic.

FOR SLOW-MOVING TRAFFIC, THE BINDER SHOULD BE SELECTED ONE HIGH TEMPERATURE GRADE HIGHER THAN CLIMATE CONDITIONS ON THE PROJECT CALLED FOR, SUCH AS A PG-70 INSTEAD OF PG-64.

FOR STANDING OR STOPPING TRAFFIC, THE BINDER SHOULD BE SELECTED TWO HIGH TEMPERATURE GRADES HIGHER, SUCH AS A PG-76 INSTEAD OF A PG-64.

While the asphalt binds the pavement together, waterproofs, and gives additional stiffness, it is the aggregate structure that actually carries the load. This makes aggregate selection and blending a critical step. The Superpave aggregate requirements (coarse aggregate angularity, fine aggregate angularity, flat and elongated particles, and clay content) are used to characterize the aggregate being considered. As the expected traffic loading on the pavement increases, the aggregate and aggregate blend must meet higher standards. A successful blend of aggregate must have high internal friction to develop the degree of interlock needed to resist shearing or rutting. Tough, durable aggregates are necessary. Rounded aggregate must be avoided in both the coarse and fine fractions.

The purpose of the mix design process is to develop an economical and constructible 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 that produces stone-to-stone interlock and orientation — without having the stone fracture. The Superpave gyratory compactor is well suited for the mix design process because it "kneads" the mix to simulate traffic action on the roadway. With higher traffic stresses, higher numbers of gyrations (typically over 100) are used to confirm how well a mix will perform in a high-stress installation. For intersection applications, additional laboratory performance tests of the mixture, such as the Hamburg wheel test or the asphalt mix performance tester, should be performed.

» USE PROPER CONSTRUCTION TECHNIQUES

Use of proper construction techniques is of course important for all pavements, and it is critical for high-performance intersections. Three aspects are worth special mention here: proper compaction, avoidance of segregation, and excellent joint construction.

Proper density is vital for long-term durability. The mixture must be properly compacted to resist additional compaction under heavy traffic. **Proper compaction** also reduces air and water intrusion that could cause accelerated aging and reduce the long-term durability of a pavement.

Segregation occurs when different-size aggregate particles separate in the mixture during handling and placement, creating a weaker, more open-textured pavement that is less durable. Best management practices to

prevent segregation must be followed closely in intersection work; otherwise, problems may occur.

Proper joint construction techniques must be executed to prevent the intrusion of air and water at the construction joints.

» CONCLUSIONS

Using this four-step strategy, high-performance intersections have been routinely constructed for years. Documented proof can be found in three case studies from three different states where exposure to intensive high-stress loading had required annual rehabilitations. After the intersections were rebuilt using this four-step strategy, all three have provided superior performance without additional maintenance or rehabilitation expenditures in the intervening years.

World's Strongest Intersection

The sign on the corner of Williams and Margaret Streets in downtown Thornton, Illinois, reads "Thornton Quarry, Largest Limestone Quarry in the World." The quarry produces up to 50,000 tons of stone each day. The only way in and out of the quarry is through the intersection of Williams and Margaret Streets, the site of the "World's Strongest Intersection." The Thornton Quarry provides the majority of the mineral aggregates used throughout south Chicago and northwest Indiana. Aggregate from the quarry gets trucked as far away as Michigan because of its excellent quality, inherent to a quarry formed from a coral reef. The vast majority of this aggregate is shipped by truck and passes through the intersection of Williams and Margaret Streets.

» BACKGROUND

The pavement endures around-the-clock pounding of thousands of fully loaded semi-trailers hauling stone and asphalt pavement material to construction sites and material producers throughout the greater metropolitan area. The pavement never fully relaxes; this leads to additional distresses. Over 1200 heavy trucks per day enter the intersection, most of them stopping at the traffic light or making turns in 11-foot-wide lanes, heavily channelizing the load applications. On several previous occasions, the intersection had been paved, repaved, and even reworked to the sub-base. Until the intersection's rehabilitation in 1998 however, the performance of the pavement surface continually fell short of Illinois Department of Transportation (IDOT) expectations. Typically, it required maintenance or rehabilitation even before a year had passed.

» 24-HOUR REPAIR WINDOW

One of the significant challenges facing IDOT was how to repair the intersection in a cost-effective manner within a 24-hour period. Neither the quarry owner nor the customers wanted the intersection shut down, even for a few hours, in the height of construction season. Meeting the time-constraint challenge required extensive analysis and a true collaborative effort between experts from IDOT and the asphalt industry. The partners became known as the "tough mix team." The team met for numerous technical discussions and analysis sessions to develop the pavement design. The surface mix and the intermediate layers would have to handle the torture of the extraordinarily high traffic loads in order to meet the mix team's high expectations.

IN A HEAD-TO-HEAD PAVEMENT COMPETITION WHICH BEGAN IN 1994, THE ASPHALT SECTION IS STILL GOING STRONG AFTER 16 YEARS. THE CONCRETE SECTION BARELY SURVIVED THE FIVE-YEAR EVALUATION PERIOD AND WAS REMOVED AND REPLACED WITH AN ASPHALT PAVEMENT SIMILAR TO THE SECTION THAT WON THE COMPETITION.

» SOLUTION

As a result of the analysis, the experts determined that a previously placed stone-matrix asphalt (SMA) overlay had not failed, but the older mix below the SMA showed signs of serious deformation to a depth of approximately 6 inches. After extensive analysis, the team recommended using a properly applied SMA mixture over a completely restructured foundation. IDOT decided to mill the existing intersection pavement full-depth to ensure that the SMA would be placed on a solid foundation. IDOT specified that an SMA dolomite binder course be placed directly on the milled surface, then topped with a 2-inch SMA surface mix. The aggregate for the SMA was steel slag, a by-product of the steel manufacturing in the region. The steel slag SMA mixture was specified for the surface course to provide a high-friction surface and the necessary stone-on-stone contact needed to handle the high stresses of the heavily loaded, slow-moving trucks.

» CONCLUSION

An evaluation of the 1998 pavement fix was performed in 2010. After 12 years, and the application of almost 10 million equivalent single axle loads (ESALs), the intersection of Williams and Margaret Streets has required essentially no maintenance and quietly continues its amazing performance as the “World's Strongest Intersection.” The steel slag mixture has performed so successfully that it has become the mix of choice whenever IDOT needs to overlay an expressway in the Chicago area.

Asphalt Wins a Maryland Intersection Contest

A Maryland intersection project, begun in 1994, was unique in that it set up a direct performance comparison of asphalt and concrete pavements on adjacent intersections along U.S. Route 40 in Elkton, Maryland. The official evaluation period ended in 2000. The asphalt intersection, built six months earlier than the concrete intersection, is still in service in 2010. After more than 16 years, the asphalt has shown some distress but is still in good condition after years of outstanding service. The concrete section barely survived the evaluation period, and after only five and a half years of service, the badly cracked concrete pavement had to be removed. It was replaced with the same material and cross-section as the asphalt intersection.

» BACKGROUND

In 1993, the Maryland State Highway Administration (MD SHA) decided that they did indeed have a problem with intersections. They formed a team within their own department in order to identify solutions. After meeting for a year and not finding any solutions, they developed a plan to establish a competition between the asphalt and concrete industries.

In 1994, two adjacent intersections, US 40 at MD Rt. 213 and US 40 at Landing Lane, were assigned to the two industries. The MD SHA team told the industry representatives that they could use any technology available and could ignore the current Maryland Department of Transportation (DOT) specifications. The only requirement was to work within a given budget for each intersection. The winner would be determined based on pavement performance — the best performance would win.

The first step was a forensic analysis of the existing roadway to determine what was wrong. Maintenance records showed that the existing US 40 eastbound intersection had rutted at approximately 1 inch or more per year. As part of the forensic analysis, a trench was cut across the width of the slow lane. The trenching revealed 8 inches of asphalt over an existing concrete roadway. Rutting was evident in the top 6 inches of the 8-inch asphalt pavement. Four-inch-diameter core samples were taken from various areas of the roadway in order to confirm that the depth was consistent. Two 10-inch-diameter cores were also cut. Examining these cores showed that, even in the coarse mixes with large aggregate, very little stone-to-stone contact existed. A Hamburg wheel tracking device was used to test the existing cores and the new proposed mixture for rut resistance. The Hamburg wheel tracking device passes a steel wheel over a sample for up to 20,000 applications. If 20 mm of rutting occurs at any point less than the 20,000 passes, the mixture is considered to be a failure. The two large cores taken from the existing intersection failed at fewer than 4,000 passes.

» ASPHALT PAVEMENT DESIGN AND BINDER SELECTION

Based on the evaluation, the decision was made to mill and replace all 8 inches of the existing asphalt pavement with the new, tougher mixtures designed in the laboratory. Traffic data for this intersection showed 12.8 million ESALs in a 20-year period, with 12 percent of the traffic being trucks. The standard asphalt grade in Maryland is a PG 64-22, which was increased to a grade of PG 76-22 with the addition of SBS polymer to account for high summertime temperatures and for heavy, slow-moving traffic. The new proposed mixes actually accumulated no more than 4 mm of distress at 20,000 passes in the Hamburg wheel tracking device.

» SPEED OF ASPHALT CONSTRUCTION

The contractor established a night paving schedule, in which all work was performed from 7 p.m. to 6 a.m. In only eight nights, the complete milling and paving of the intersection was accomplished, and the project was completed prior to Labor Day 1994. As a result of this schedule, there was little or no disruption to the motoring public or to the businesses adjacent to the intersection. In contrast, the concrete intersection, built in the spring of 1995, took 12 days and nights to construct, even though the total surface area of concrete paving was only 1,700 square yards. The concrete construction schedule included 24-hour lane closures for four consecutive days for each of three consecutive weeks while the concrete cured and gained enough strength to open to traffic.

» CONTINUED PERFORMANCE TESTING

When the project was completed, performance of the intersection was assessed annually for a five-year period. A profilograph was used to measure ride quality for both the asphalt and concrete intersections one year after completion. Test results in the fall of 1995 showed a substantial difference in ride. The one-year-old asphalt tested at 13 inches of bumps per mile while tests of the concrete, which had been in service for less than six months, showed 41 inches of bumps per mile. Using a transverse profilograph, rutting has been examined every fall since the project was completed. In fall 2000, after six years of testing, only 1/16 inch of rutting was found in the asphalt intersection.

» CONCRETE INTERSECTION

When the concrete industry started construction in the spring of 1995, their existing intersection had the same original pavement section as the asphalt industry's intersection, 8 inches of asphalt over an existing concrete pavement. Their new pavement design called for milling off 6 inches and leaving 2 inches of asphalt pavement as a bond breaker, then placing 6 inches of whitetopping. By late 1999, the concrete pavement showed severe cracking and open joints. In spring 2000, a failed area had to be patched. By July 2000, the condition of the concrete intersection was so poor that the MD SHA decided to remove the concrete pavement. It took the concrete industry 288 hours (12 days) to install the original pavement, but it was removed and fully replaced with asphalt in just 22 hours (less than one day).

» COSTS

Initial cost comparisons of the test sections showed that it cost $36 per square yard to mill and replace the existing intersection with 8 inches of asphalt. In contrast, it cost $92 per square yard to mill and replace the existing intersection with 6 inches of concrete whitetopping.

» CONCLUSIONS

Sixteen years later, the asphalt pavement is still in place and still providing excellent performance. It shows only minor distress — reflective cracks from the concrete pavement below. The result of this competition proves once again that asphalt pavements provide excellent solutions for high-stress intersections at substantial cost savings, while reducing disruptions to traffic and businesses.

Kentucky Intersection Competition

In 1998, after years of dealing with excessive pavement distress, the Kentucky Transportation Cabinet initiated a head-to-head competition between the concrete and asphalt industries at an intersection in Somerset, Kentucky.

The intersection, connecting US 27 and KY 80 with Cumberland Parkway, carries a high volume of traffic with a high percentage of trucks. The distresses caused by the heavy, slow-moving trucks as they were stopping or turning required almost yearly maintenance. This led the Kentucky Transportation Cabinet to challenge the paving industries to a competition. The contest, initiated in 1998, required both industries to use their best technologies in order to solve the distress problems that the intersection had experienced over time. By allowing each industry to pave on either side of the busy intersection, the durability of both asphalt and concrete could be tested under identical weather and traffic loading conditions. The asphalt industry chose to pave the intersection with a stone-matrix asphalt (SMA) mixture for its strength and rut resistance during the summer months and its ability to resist thermal cracking during the cold winter months.

» THE PROJECT SCOPE AND TIMELINE

- The asphalt overlay was completed over the course of seven nights, without the need for daytime lane closures disrupting traffic.
- The concrete industry took 28 days to complete its work with full-time lane closures as the concrete cured and gained adequate strength to open to traffic.
- The asphalt portion of the pavement was completed at a cost of $25.25 per square yard.
- The concrete portion of the project cost nearly $50 per square yard to complete.
- Early in 2001, after three years of service, data from the Kentucky Transportation Center (KTC) at the University of Kentucky indicated that the minor depressions in the wheel paths were well within acceptable limits and the asphalt pavement was performing extremely well.
- At the same time, KTC noted that many concrete slabs had cracked and faulted, with some faults nearly 2 inches deep. Some sections of the concrete pavement had failed completely and some panels were rocking severely under traffic.
- In May 2001, Kentucky Transportation Cabinet maintenance crews removed the severely failed sections of concrete slabs and replaced them with asphalt pavement.

» CONCLUSION

Twelve years after the Kentucky intersection competition began, the condition of the pavement itself declared a winner in the competition. The concrete pavement required frequent lane closures for repairs to address the extensive cracking and deterioration and was completely replaced with asphalt during the 2007 construction season. The rehabilitation of the intersection connecting US 27 and KY 80 with the Cumberland Parkway marks a clear victory for asphalt in a head-to-head battle with concrete. Not only is asphalt a more durable pavement than concrete, but it is also the less expensive material to install and repair while providing a safer, smoother surface on which to drive. In other words, asphalt is miles ahead of the competition.

Overall Conclusions

» ASPHALT INTERSECTION PAVEMENTS

Cost Less

- Asphalt pavements cost less to build and maintain.
- Asphalt is 100 percent recyclable.

Cause Fewer Delays

- Asphalt pavements take far less time to construct, a critical requirement when rehabilitating intersection pavements.
- There is no need for 24-hour lane closures.
- Lane closures can be limited to overnight or off-peak traffic hours.
- Intersections can be opened to traffic as soon as the rollers have finished and the pavement has cooled.
- Motorists and merchants benefit from this fast turnaround and less disruption.

Provide a Ride That is Much Smoother and Quieter

- Asphalt intersections can be economically maintained to preserve ride and acoustic qualities over longer periods.

Allow Easy Maintenance

- Utility repairs are much quicker and less costly to make in asphalt pavements.

Safer

- Asphalt provides superior visibility of pavement markings for drivers.
- Asphalt provides better skid resistance with quiet surfaces.

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