W-h-i-t-e-t-o-p-p-i-n-g spells relief in Iowa

By Gordon Smith

Whitetopping's high standard of performance on Iowa county roads establishes this overlay method as the best solution for rehabilitating aging asphalt

Whitetopping, placing a concrete overlay on deteriorated asphalt pavements, is Iowa's solution to higher maintenance costs. Since 1960, Iowa counties have whitetopped more than 300 miles of asphalt pavement, eliminating potholes, cracks, raveling and rutting surfaces, and loose gravel.

Iowa is a national leader in the use of portland cement concrete for paving, dating back as far as 1918. The Iowa Concrete Paving Association (ICPA) has detailed records documenting outstanding performance of many miles of 6- and 7-inch-thick by 22-foot-wide plain, concrete pave-

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ments. Many Iowa pavements 30 years or older have required only minimal maintenance.

Acknowledging the historical performance of Iowa's concrete pavements, engineers began to examine the recurring costs of maintaining and resurfacing Iowa's existing asphalt roadways at typical 12- to 15-year intervals. The previous success with concrete indicated that a concrete overlay could decrease maintenance costs and lengthen the rehabilitation cycle for asphalt pavements. Cost comparisons of concrete and asphalt overlays showed that a 5- or 6-inch-thick concrete overlay might cost up to 50% more initially than a 2- or 3-inch asphalt overlay, but the concrete would last at least twice as long as asphalt with little difference in maintenance costs. Life-cycle analysis, supported by actual concrete pavement performance records, proved that concrete was the "best buy."

Early projects

As road construction entered the era of rehabilitation, the engineering community and concrete paving industry worked to develop and field test bonded overlays, unbonded overlays, and whitetopping. Iowa's earliest recorded whitetopping was near Sergeant Bluff in Woodbury County in 1960. Woodbury County built another project in 1971. Of course, concrete interstate pavements in Iowa and other states had been built throughout the 1960s on asphalt bases. The performance of these early projects confirmed that whitetopping on Iowa's county roads could be a viable and cost-effective method for rehabilitating miles of asphalt roadway.

In 1977, the whitetopping era began in earnest as Dallas, Boone, and Washington Counties built their first projects. The objective: programmed rehabilitation of asphalt roadways with portland cement concrete overlays. Since that time, 21 of Iowa's 99 counties have constructed whitetopping projects. Dallas County has 50 miles of whitetopping, and Washington and Louisa Counties have covered nearly all their asphalt pavements with concrete.

Several counties that have constructed very little concrete paving in the past are now turning to concrete for relief from the maintenance woes experienced with asphalt. Since 1977, an average of 19 miles of whitetopping has been constructed annually on the farm-to-market roadway system in Iowa.

Iowa Concrete Paving Association

Most whitetopped pavements in Iowa have performed well. This 1990 photo shows a whitetopping completed in Boone county in 1981. After nine years, the pavement shows no deterioration.

Pavement design

Early design procedures for whitetopping on low-volume roads were not precise. Outstanding performance of 6- and 7-inch-thick plain, jointed concrete pavements constructed on earth subgrades caused engineers to conclude that concrete overlays on asphalt should perform equally well if built 5 or 6 inches thick. They were confident that the existing asphalt would contribute some structural support as a subbase.

Based on that conclusion, Iowa counties began to construct many overlays at a minimum thickness of 5 inches. With the introduction of computerized design calculations, early whitetopping designs were verified as structurally sufficient by applying the AASHTO formula for design of rigid pavements. This formula takes into account the condition of the existing asphalt, subgrade condition, projected traffic, and design life (either 20 or 30 years).

Some Iowa overlays with a 4-inch-minimum thickness have required little maintenance during the 10 years they have been in service. However, most engineers prefer the insurance of a 5-inch or thicker pavement, knowing that the additional inch of concrete will nearly double the design axle-load capacity of a pavement for a cost of about $15,000 per mile. Today, there is a trend to require 7- or 8-inch overlays as local government officials strive to optimize spending over a longer design period of 40 years. The assumption that a properly designed concrete pavement can serve longer is supported by hundreds of miles of county concrete pavements that continue to perform well after 25 to 30 years.

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The 1993 edition of the AASHTO *Guide for Design of Pavement Structures* provides specific direction for the design of concrete overlays on asphalt. It recommends that the overlay be designed as a new PCC pavement using an effective modulus of subgrade reaction representative of the existing flexible pavement. Because little long-term performance data was available to the writers of the guide, the concrete paving industry

finds the approach to design somewhat conservative, specifically in low-traffic-volume applications. Regardless, the AASHTO equation provides a point of reference.

Construction details

Whitetopping is the simplest concrete overlay to construct and actually provides some advantages over new construction on virgin subgrade and granular or treated base. Early projects in Iowa specified that the asphalt surface be milled to provide a uniform thickness or correct surface distortions, but it was soon realized placing concrete directly on the asphalt was more effective. Only sweeping of the surface is required to remove loose materials from the slab immediately before overlay placement. The contractor then places concrete directly over potholes and wheel ruts; thicker concrete being placed in the most structurally vulnerable areas. Severe rutting, shoving, or potholes deeper than 2 inches should be corrected by milling or filling. Thermal cracks 1 or 2 inches wide are filled with an emulsion or flowable mortar to prevent keying the old and new pavements together.

Concrete for whitetopping can be either a standard or fast-track mix. Many counties specify the Iowa DOT C-Mix (626 pounds of cement) which reaches sufficient strength to allow traffic in seven days or less. Coarse aggregate resistant to freezing and thawing is required on most Iowa projects. Fast-track mixes using Type III portland cement sometimes are specified where access is required in 24 to 36 hours.

During hot summer days, the contractor should monitor the temperature of the asphalt pavement to guard against heat buildup that might cause severe curling of the overlay. If it's uncomfortable to touch the asphalt with the open palm, water fog the asphalt or apply a lime slurry whitewash to reduce base temperature before concrete placement. Most of the asphalt pavements overlaid in Iowa have sufficiently oxidized or dulled with traffic and weather. These pavements absorb less heat, eliminating the need for water spray or whitewash.

Survey of Whitetopping Performance

In 1989, the Iowa Concrete Paving Association surveyed the performance of more than 238 miles of whitetopping. The objective of the survey was to review general performance and to identify areas of design and construction that might be improved for future projects. A thorough analysis of pavement serviceability confirms that these overlays are performing to a higher standard than many miles of concrete constructed on natural subgrades. The survey made the following observations of whitetopped pavements:

- Little if any maintenance has been required.
- The plain, jointed overlays show no tendency toward faulting.
- Good performance can be partially attributed to thickened-edge construction.
- Rigid concrete bridging characteristics have reduced the occurrence of settlement in the original asphalt pavements.
- Positive drainage and a safer surface is restored with whitetopping. No rutting or other surface distortions develop.
- Concrete provides an all-season surface. There has been no need to restrict roads due to seasonal weakening from spring thaw.
- Edge cracking and cracking at the outside wheel track often caused by lack of subgrade support in pavements on grade was nearly nonexistent on whitetopping.
- Only one pavement blow-up was found. It occurred where pavement thickness averaged 2.75 inches. Bond between the asphalt and overlay exists, reducing overlay movement.
- Only one of 57 projects required unexpected patching. That project, though, was not truly a whitetopping since existing seal coats were removed to a 6-inch-thick rolled stone base, then trimmed to about 5 inches thick before placement of the 5-inch-thick concrete pavement. The pavement was significantly underdesigned for the heavy loading it received.

The ICPA survey also revealed several areas where improvement in whitetopping design or construction can extend pavement performance:

- Minor cracking in overlays was confirmed as a function of several factors: overlay thickness, traffic loadings, condition and quality of the base asphalt, and quality of subgrade support.
- The predominant crack that occurred was at the slab quarter point, and relates to overlay thickness at wheel-track edges. When preconstruction surveys fail to identify the high spot of the wheel rut in asphalt, the minimum overlay thickness may not be maintained. A weak slab results in this highly vulnerable area. Little cracking occurs at the quarter point where minimum thickness has been controlled.
- Although few in occurrence, random transverse cracks were the second most frequent. These cracks were primarily due to long transverse joint spacing (greater than 15 feet) or occasional physical interlocking of overlay and base pavement.

Concrete for whitetopping is mixed and placed as on any conventional project. The contracting authority must establish grades to maintain the minimum thickness across the total cross-section of the pavement. Some contractors use computer programs to calculate grade adjustments. Because asphalt tends to hump outside the pavement's wheel tracks, a cross-section that accounts for wheel track distortions is the best defense against undesired thin slabs.

Often, whitetopping is constructed naturally as a thickened edge pave-

ment, strengthening the pavement where it's most vulnerable in deflection due to wheel loads. Asphalt pavement crowns typically exceed the 2% crown normally specified for concrete. Therefore, the overlay cross-section is thicker at the exterior edges of the slab as the old and new pavement crowns diverge. This design contributes to extended performance of the concrete overlay on asphalt.

Most pavements built for high-speed travel have a transverse-tined surface to improve skid resistance. The concrete is cured with a white liquid-membrane compound applied at the standard rate of 135 square feet per gallon.

The final construction operation is joint sawing and sealing. Transverse joints on Iowa projects have been spaced from 12 to 40 feet apart. The typical spacing is 15 feet, but some 5-inch pavements are jointed at 12 feet. Field surveys of whitetopping performance show a considerable increase in mid-panel cracking when the transverse joint spacing exceeds 20 feet. A longitudinal centerline joint is sawed to one-third of the overlay thickness over #4 deformed centerline tie bars placed on 30-inch centers. Pavement joints are sealed with a low-modulus, hot-poured or self-leveling silicone sealant.

When designing and constructing whitetopping, consider transitions at intersections, bridges, and railroad crossings. Transitions for county road crossings and bridges have varied from 100 to 200 feet. To achieve transition and match existing elevations, plans often specify removal and full-depth replacement of the section or milling and overlay thickening.

Shoulders are specified as earth or granular. On some projects, the shoulders must be widened to meet geometric standards. Unfortunately, current standards require that overlays 4 inches and thicker comply with geometric standards for reconstruction. Because more lenient maintenance standards are allowed for thinner overlays, the issue of shoulder widening has discouraged some counties from whitetopping. Many engineers realize, though, that widening will be required on most roadways at some point in the next 30 years, whether they use one concrete overlay or two asphalt overlays.

Contractors are paid for whitetopping in two parts: by the cubic yard for concrete furnished, and by the square yard for the expense of placement. This payment method accounts for construction variables, and ensures that agencies and contractors are paid for the concrete used. Prices for whitetopping on Iowa county roads in 1993 averaged $36.40 per cubic yard and $2.56 per square yard, or $115,000 per mile for 6-inch pavement.

Other markets

The county road is not the only transportation network that uses whitetopping. Many parking lots have been rehabilitated with concrete, and Iowa's general aviation airport owners find whitetopping to be a highly competitive answer to the maintenance headaches of asphalt runways. In 1971, Storm Lake, Iowa, was first to whitetop the primary runway of its airport. The first maintenance on that 5-inch pavement concrete overlay was performed in 1991, after 20 years, when pavement joints were resealed. Subsequently, eight other Iowa airports have undertaken whitetopping runway rehabilitation projects.

This past summer, a 6-inch concrete overlay on a 59,000-square-yard asphalt runway was competitive in price with a 3-inch asphalt overlay and related runway reconditioning. The concrete overlay was bid at $903,745, and the asphalt rehabilitation bid was $837,470. Unfortunately, a government grant fell short of the amount of money needed for the concrete option and lack of funds at the local level forced the owners to rehabilitate with asphalt. They admitted, though, that concrete was the better buy based on a life-cycle cost analysis.

Advancing whitetopping technology

The future for whitetopping is bright as Iowa continues to confirm the method's success through economic analysis and long-term performance. The Iowa Department of Transportation, Federal Highway Administration, Iowa State University, and the concrete paving industry will cooperate to further advance whitetopping in 1994 on a 7.2-mile test project on Iowa 21 south of Belle Plaine. Sixty-four test sections will be constructed with variable thickness, joint spacings, and base preparation. The research will also include sections with polypropylene fiber reinforcement and three asphalt comparisons.

References

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