Efforts to Improve the Life of Concrete Pavements in Virginia

Celik Ozyildirim, Mohamed Elfino, and Shabbir Hossain

ABSTRACT

The Virginia Department of Transportation has been active in improving the service life of concrete pavements in new construction and repairs. Several new technologies and practices have been successfully tried in the past decade. This paper addresses recent developments in design, materials, and construction practices and provides examples from newly constructed and repaired pavements. Some of these advancement areas are attention to foundation support, use of continuously reinforced concrete pavement (CRCP) along with its thickness and steel amount, new innovative construction practice using precast and prestressed slabs, use of wider slabs (truck lanes) to reduce edge stresses, use of large-size aggregate and pozzolanic materials in the mixture, implementation of trial batches and trial pavement sections, and attention to consolidation and curing during construction. These practices are expected to provide longer life. Recent projects have incorporated these practices. Examples included are the Route 288, Madison Heights Bypass, and Battlefield Boulevard Interchange CRCP projects for new construction and the I-66 precast and precast prestressed pavements for rehabilitation.

INTRODUCTION

Concrete pavements have been constructed in Virginia since 1913. Initially, plain jointed concrete and then reinforced jointed and continuously reinforced concrete pavements were built. Most of the concrete pavements have performed satisfactorily during their intended service life and beyond. There have been some instances where the concrete pavements have exhibited less than desired performance. Pavement performance is dependent on the foundation support and pavement design, selection of materials and proportioning, and the construction practice used. The following sections summarize the initiatives undertaken by the Virginia Department of Transportation (VDOT) to improve the performance of pavements in Virginia. Examples are

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included from three recent new pavement projects with CRCP and a rehabilitation project using precast prestressed pavement slabs on I-66.

FOUNDATION SUPPORT

Many pavement distresses occur due to poor foundation support, which includes selection and preparation of subgrade, subbase, and base along with proper subsurface drainage. For example, edge punchouts or midslab cracks may occur under variety of conditions including lack of support, which may also be associated with drainage issues.

The pavement base provides additional load distribution, contributes to drainage and frost resistance, and provides uniform and stable support. In Virginia, cement-stabilized soil or aggregate bases are common. In addition, an open-graded drainage layer (OGDL), 2 to 3 inches (50 to 75 mm) thick, is used for drainability under the slab. With time, the importance of stability was recognized, and an asphalt concrete mixture meeting the gradation shown in table 1 was used that has both stability and the needed drainability. A coefficient of permeability of at least 1,000 ft/day (305 m/day) was required (VDOT 2007). Also, most pavements are constructed with an edge-drain system for proper subsurface drainage. An inspection program has been established using video camera to ensure that the drainage system functions properly during the pavement’s service life.

<table>
<thead>
<tr>
<th>Table 1. Gradation of Asphalt-Treated OGDL</th>
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<tbody>
<tr>
<td>Sieve</td>
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<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>1 inch</td>
</tr>
<tr>
<td>¼ inch</td>
</tr>
<tr>
<td>½ inch</td>
</tr>
<tr>
<td>No. 8</td>
</tr>
<tr>
<td>No. 200</td>
</tr>
<tr>
<td>Asphalt cement content 4.3 ± 0.3% (PG 70-22)</td>
</tr>
</tbody>
</table>

1 inch = 25.4 mm

BRIDGE APPROACH SLAB

Sags at bridge approaches, as shown in figure 1, have been a continuous problem for many agencies including VDOT. Therefore, VDOT modified the requirement for constructing the backfill behind the backwall of bridges. The depth of select material used behind the footing must provide a minimum of 6 ft (1.8 m) under the pavement end of the approach slab. Select material Type I, with a minimum California bearing ratio of 30, must be used. In addition, the minimum compacted dry density of the select material must be 100 percent in the top 3 ft (0.9 m), 98 percent from 3 to 6 ft (0.9 to 1.8 m), and 95 percent below 6 ft (1.8 m). The use of two plain jointed slabs spaced at 20 ft (6.1 m) were changed to one reinforced concrete slab with a tapered depth from 15 inches (380 mm) to a depth matching the CRCP in the mainline. Two
expansion joints, one on each side of the reinforced slab, are used. This change, in addition to the compaction requirements, is expected to provide a bridging effect in the presence of inadequate support in the bridge approach area. Long sags resulting from inadequate consolidation of a thick and soft subsurface layer are avoided by requiring the primary consolidation of the fill to be complete before the pavement placement.

Figure 1. Faulting between the approach slab and the bridge backwall.

PAVEMENT

In concrete pavements, the desired performance is dependent on the proper design, selection of concrete materials, and construction practices.

Design

Considering the harsh environment, the high traffic volumes and loads, and the extended service life requirements, continuously reinforced concrete pavement (CRCP) has been the desired pavement type for VDOT. CRCP provides a solid base for an overlay (for both concrete and asphalt) when the pavement reaches the end of service life. The use of asphalt concrete overlays on CRCP is also not prone to problems observed on jointed pavements such as reflective cracking or faulting. The first CRCP was built in late 1966 and early 1967 on I-64 around Richmond (McGhee 1969).

Use of a wider travel lane of 14 ft (4.3 m) while keeping the delineating white line at 12 ft (3.6 m) ensures proper edge support for the pavement. This approach provides an economical way to provide edge support equal to a full-width tied shoulder without the joint, and it reduces the chances for punchouts and eliminates the joint at the critical location near the driving edge. Joints at this critical location usually allow water penetration and subsequent softening of the soil support under the wheel path.
In the past, based on the Portland Cement Association design method, CRCP with a thickness of 8 inches (200 mm) on a stabilized base was acceptable compared to 9 inches (225 mm) of concrete pavement on unbound aggregate. The thinner pavements showed cracking more than desired. It was found that the traffic predictions underestimated the truck loadings. Therefore, traffic projection and axle loading information was improved, which led to thicker pavements and better performance. In estimating the axle loading, each axle of trucks is assumed to be fully loaded, resulting in higher equivalent single-axle loading (ESAL). This, in turn, results in thicker pavement. For example, a 13-inch-thick (330 mm) pavement was used at Battlefield Boulevard with a single mat of reinforcement. The amount of reinforcing steel was increased from 0.65 percent to 0.70 percent to improve the crack spacing with the goal to have the transverse cracks spaced at 4 to 6 ft (1.2 to 1.8 m) while maintaining tight crack opening. Also, transverse steel spaced at 4 ft (1.2 m) was used to support the longitudinal steel and to keep the longitudinal cracks tight in the event of their occurrence. CRCP shows many cracks on the surface. Although they are usually tight, sometime they may facilitate the intrusion of deicing solutions. However, if the crack width is narrow or cracking does not exist near the reinforcement, corrosion concerns are diminished. Even if corrosion occurs, it is expected to be in isolated small anode locations at the cracks.

Material Selection and Proportioning

Material selection may include use of supplementary cementitious material (SCM) such as Class F fly ash or slag cement. SCMs are used to lower the permeability of concrete and to resist chemical reactions such as alkali–silica reactivity (ASR). VDOT specifications require non-polishing aggregates for the wearing course. Therefore, siliceous aggregates are used, and cements available generally contain alkali contents that can cause the ASR. Another proposed change has been to permit 2-inch (50 mm) nominal maximum-size aggregate (NMSA) and blending of aggregate sources to achieve well-graded distribution. The strength of the concretes is tested to verify design requirement. Rather than testing the design flexural strength, the compressive strength test is conducted after a correlation with the flexural test is established for a particular mix.

Supplementary Cementitious Material

Harmful solutions penetrate through high permeability concrete and through the cracks. Water and solutions can lead to distress due to cycles of freezing and thawing, ASR, sulfate attack, and corrosion if there is reinforcement especially near the surface. SCMs such as Class F fly ash and slag cement provide reduced permeability, hence increased resistance to freezing and thawing and to chemical attack. Since the early 1990s, VDOT has been specifying pozzolans (Class F fly ash) and slag to inhibit ASR.

Alkali–Silica Reaction

ASR has been observed in some pavements built before the introduction of SCMs. For example, in the late 1980s, 6 mi (9.7 km) of pavement on I-64 near Charlottesville, Virginia, were replaced because of ASR. Alkali solutions can react with the siliceous aggregates, causing a gel around the aggregate. When the gel absorbs water, expansion occurs that can lead to cracking. A typical ASR-damaged concrete is presented in figure 2. Most of the available alkalis come from the
cement. A VDOT study found that the amount of alkali necessary to cause an excessive expansion is 0.45 percent (Lane and Ozyildirim 1999). ASTM C 150 recognizes 0.60 percent as the dividing line for low-alkali cement. The difference is probably attributable to changes in fineness over the years. Others have also found that an alkali limit of 0.60 percent does not provide protection in all cases (Lane 1994).

SCMs such as Class F fly ash, slag, silica fume, metakaolin, or similar types of products are effective in inhibiting ASR (Lane and Ozyildirim 1999). The amount of SCM is determined by the amount necessary to limit the expansion of the mortar bars tested in accordance with ASTM C227 and using Pyrex glass as the reactive aggregate. Producers can test and propose the amount of SCM needed for ASR protection. However, they can also use the table provided by VDOT (VDOT 2011) that shows the amount of SCM (Class F fly ash, slag cement, or silica fume) needed to inhibit expansion for cements with different levels of alkali content.

![Figure 2. ASR damaged pavement section.](image)

**Aggregate Maximum Size and Grading**

VDOT is interested in minimizing the crack width and increasing the spacing of cracks in the CRCP. Moisture loss causes shrinkage, and temperature drop produces contraction. When the movement due to shrinkage or contraction is restrained by the base or the reinforcing steel, cracking of concrete results.

In general, separate coarse and fine aggregates are used in concrete production. When combined, they exhibit missing materials in intermediate sizes, which produce void spaces needing more paste to fill the voids. On the other hand, a well-graded aggregate produced through blending could minimize the voids leading to reduced paste requirement.

Before the introduction of slip-form pavers in the 1960s, a 2-inch (50 mm) NMSA was used. With the introduction of the slip-form paver, the aggregate size was reduced to 1 inch (25 mm) because it was claimed that the paver could not place larger aggregates. The smaller size also
minimized segregation in aggregate stockpiles. However, recent pavement construction with slip-form pavers indicates that placement with 2-inch (50 mm) NMSA is not an issue. With larger size aggregates along with well-graded distribution, reductions in the water, cement, and paste contents are expected, which would lead to reduced shrinkage. Larger aggregates are also expected to provide better aggregate interlock. If cracks form, a vertical movement between two sides is restrained through the bridging with larger aggregates. Old pavements in Virginia with 2-inch (50 mm) NMSA have performed well, which supports the soundness of the recommendation to increase top-size aggregate. The core from an old pavement section in figure 3 shows the presence of a 2-inch (50 mm) aggregate in the concrete. With 2-inch NMSA, larger specimens with a minimum dimension of 6 inches (150 mm) were used—6 x 12-inch (150 x 300 mm) cylinders and 6 x 6 x 20-inch (150 x 150 x 500 mm) beams for quality control/quality assurance.

![Figure 3. Presence of 2-inch nominal maximum size aggregate in a core from an old pavement.](image)

**Strength Testing for Quality Control/Quality Assurance**

The flexural strength of concrete is used in design of the pavement. It is determined using beams subjected to third-point loading (ASTM C 78). Beams are bulky and exhibit a lot of variability. Therefore, a relationship between compressive strength and flexural strength is developed at the beginning of a project. The acceptance tests are then based on the compressive strength of the concrete. Also, maturity method is accepted to estimate the strength of the concrete for opening to traffic.

**Construction Practices**

Construction issues such as correct steel location, concrete handling and placement, consolidation, and curing are important for satisfactory performance of concrete pavement.
Longitudinal reinforcing steel should be placed in such a manner that it stays in the middle depth of the pavement. This can be accomplished by placing steel on chairs, as shown in figure 4, rather than using the feed-tube system. The chairs provide the proper positioning of steel with attached clips. This method also allows for the slab to be poured monolithically, which reduces the probability for cold joint leading to delamination at the reinforcing steel, which has resulted from pouring two layers in the feed-tube system. The feed-tube installation has caused steel to be close to the surface in many locations, as shown in figure 5.

![Figure 4. Chairs to keep reinforcing steel at the correct height.](image1)

![Figure 5. High steel caused by feed-tube installation.](image2)

Concrete handling and placement requires monitoring the supply of concrete with continuous quality control during mixing, hauling, placing, and finishing. Concrete delivered must be
workable with an adequate time of setting. Early stiffening of the concrete can lead to difficulties in placement and finishing (Gress 1997).

The porous and segregated concrete shown in figure 6 did not have proper consolidation. Adequate concrete consolidation is essential to attain the strength and durability desired. Also, proper curing ensures the development of desired properties and minimizes volumetric changes. Pavements are generally cured using curing compounds (CC). The quality, time of application, and uniform coverage with CC are important. VDOT is stringent in CC requirements (VDOT 2007). White-pigmented, membrane-forming compound is applied immediately following the texturing operation at a rate of coverage close to 100 ft² per gallon (2.45 m²/L) to achieve a solid white appearance. In cold weather, proper insulation of the pavement is also needed during curing.

![Figure 6. Lack of consolidation at the header.](image)

Initial sawcutting of the longitudinal joints needs to be done as soon as the concrete slab can support sawing equipment so that the cut can be made without undue raveling. The use of tape to form longitudinal joints is still allowed in Virginia, but not for slabs greater than 9 inches (230 mm) thick.

Smooth ride is emphasized and achieved through incentive and disincentive as part of the contract. Surface is routinely textured using metal tines. To reduce noise and achieve smoother pavements, next-generation grooving is being explored in experimental sections.

**Prepaving Conference and Trial Section**

Before the start of any construction activity, a prepaving conference between the contractor and department personnel is recommended. In this conference, matters related to the construction are discussed for successful construction. This conference is very helpful in identifying potential areas that may require special attention.
Another important improvement has been the use of trial sections. This change has enabled the evaluation of the mixture and the available equipment to determine if any changes are warranted for successful construction of the pavement. Figure 7 shows one such trial section for the Madison Heights Bypass construction. This trial section provided a lot of insight into the base preparation, reinforcement placement, concrete mixture, and the impact of paving speed on the consolidation. Based on this trial construction, steps were planned and used successfully for the mainline paving. These steps involved the use of proper admixtures, adequate paving speed, and the continuity of paving operation without frequent stop and go.

Figure 7. Trial section at Madison Heights Bypass.

Precast Technology

Precast panels can be used in large-scale pavement construction as well as a viable alternative to cast-in-place patching. Precast panels can be cast at a convenient location with minimal weather restrictions and better quality control. When adequate strength is gained, they are placed in the pavement in a short period of time. The slabs can be pre-tensioned in the transverse direction and post-tensioned in the longitudinal direction to extend the service life. Prestressing the panels enables increased durability, reduced slab thickness, and efficient load transfer. It reduces the chances of cracking and controls crack and joint widths in both the transverse and longitudinal directions.

CASE STUDIES

The implementation of the plan of actions involved the pavement design engineers, materials engineers, researchers, and the industry. Collectively, their efforts complement one another, and a sound product is expected. VDOT has already implemented these actions on several projects. The following sections provide examples from three recently constructed new CRC pavements (State Route (SR) 288 in Chesterfield, Madison Heights Bypass in Lynchburg, and Battlefield Boulevard in Hampton Roads) and one rehabilitated pavement (I-66 precast prestressed slabs in...
Northern Virginia). All of these pavements were constructed within the past decade. These projects had different base materials to complement the subgrade condition leading to a stable and uniform support. A high-speed inertial profiler with single point laser was used to measure the ride quality in terms of the International Roughness Index (IRI). Current performances of these sections as indicated by IRI along with their age are presented in table 2 below; a narrow band laser was used to measure IRI. VDOT assumes IRI values below 70 inches/mi (1.1 m/km) as desirable. It is important to note that both Battlefield Boulevard and the I-66 precast sections were diamond ground to improve the smoothness of the surface immediately after construction. Diamond grinding usually creates small ridges and depressions; a narrow beam laser can easily travel in and out of pavement grooves, ridges and depressions, thereby yielding a higher IRI value. Visual observation indicated no major distresses on any of these sections, and their IRI values also did not show any significant deterioration over years of traffic. In general, the crack spacing in these pavements ranges between 3 and 8 ft (0.9 to 2.4 m), as desired.

Table 2. Average Ride Quality in Terms of IRI Values

<table>
<thead>
<tr>
<th>Pavement Section</th>
<th>Year Constructed</th>
<th>Length and No. of Lanes</th>
<th>Age at Latest IRI (years)</th>
<th>IRI (in/mi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Route 288</td>
<td>2003</td>
<td>5 mi and 4 lanes</td>
<td>7</td>
<td>74–86</td>
</tr>
<tr>
<td>Madison Height Bypass</td>
<td>2005</td>
<td>11 mi and 4 lanes</td>
<td>5</td>
<td>60–72</td>
</tr>
<tr>
<td>Battlefield Boulevard</td>
<td>2007</td>
<td>1 mi and 10 lanes</td>
<td>2</td>
<td>60–70</td>
</tr>
<tr>
<td>I-66 precast prestressed slabs, Northern Virginia</td>
<td>2009</td>
<td>0.2 mi and 4 lanes</td>
<td>2</td>
<td>70–99</td>
</tr>
</tbody>
</table>

1 mi = 1.609 km; 1 in/mi = 0.0158 m/km

SR-288

A CRCP section was built as shown in figure 8 on SR-288 with 10-inch (250 mm) thickness (Ozyildirim 2007). In each direction, there were one 12-ft (3.7 m) lane and one 14-ft (4.3 m) lane of CRCP, with 2 ft (0.61 m) of the 14-ft (4.3 m) lane striped as part of the shoulder. Placement started in 2000 and was completed in 2003. In some places, the difficulty of providing a level base course resulted in varying thicknesses of the concrete slab, generally on the high side of the slab, drawing attention to the need for proper base preparation. Underneath the CRCP, Section 1 had a 3-inch-thick (75 mm), Type 1, asphalt-treated OGDL over a cement-treated aggregate (CTA) subbase. The CTA was between 6 and 8 inches (150 and 200 mm) thick. The OGDL consisted of No. 57 aggregate stabilized with 2.5 percent asphalt cement. Section 2 had a similar structure, but the OGDL was composed of No. 8 and No. 68 aggregate stabilized with 4.3 percent asphalt cement. To assist in drainage, a longitudinal underdrain near the edge of the lane was placed to a depth of 4 inches (100 mm) below the subbase/subgrade interface.
Inside the CRCP, reinforcing steel was placed at mid-depth in the longitudinal direction to control cracks and aid in load transfer. The reinforcing steel comprised No. 6 bars covering 0.7 percent of the pavement cross section and No. 5 bars spaced every 4 ft (1.2 m) running in the transverse direction. The steel was kept at the proper height by steel chairs that locked the bars in place.

Larger NMSA (2 inches (50 mm)) was used in this project. A well-graded aggregate was attempted through blending. Improvement in water reduction was achieved. However, large improvement was not obtained due to missing intermediate sizes. Initially, a high cementitious material content was used (590 lb/yd³ (350 kg/m³)) with 20 percent Class F fly ash, and segregation was observed during spreading due to high spreader speed and consolidation. Then, the cementitious material content was reduced to 541 lb/yd³ (321 kg/m³) with 20 percent Class F fly ash, and the water-to-cementitious material ratio (w/cm) was kept the same, eliminating the segregation problem.

Special attention was also provided for curing. Curing timing and coverage were monitored, and a solid white appearance was obtained with the curing compound.

**Madison Heights Bypass**

This four-lane divided highway was built in 2004 and 2005. A section of the 11-mi (17.7 km) highway during construction is shown in figure 9. Instead of a CTA subbase, an 8-inch (200 mm) cement-treated soil subbase (12 percent hydraulic cement by volume) was constructed, primed by a thin layer of liquid asphalt, and then covered with No. 8 aggregate (Ozyildirim 2007). In lieu of an OGDL, an asphalt concrete base course (BM-25.0) was placed. This layer was designed to provide drainage and stability. The top layer was 12 inches (300 mm) of CRCP. One 12-ft-wide (3.7 m) lane and one 14-ft-wide (4.3 m) lane were built in both the north and south directions. The lanes themselves were 12 ft (3.7 m) wide, and the additional 2 ft (0.6 m) on the outside lane was striped as part of the shoulder. The remaining shoulders were asphalt concrete. To assist in drainage, a longitudinal underdrain near the edge of the lane was placed to a depth of 4 inches (100 mm) below the subbase/subgrade interface.
Steel reinforcement in the longitudinal direction consisted of No. 7 bars at 0.7 percent of the concrete cross-sectional area. It was placed at mid-depth and held by chairs that kept the bars at the correct height. In the transverse direction, No. 5 bars were placed 4 ft (1.2 m) apart.

Total cementitious material content was 564 lb/yd³ (334.6 kg/m³) with 25 percent Class F fly ash. The coarse aggregate was No. 57 with an NMSA of 1 inch (25 mm).

**Battlefield Boulevard**

The Battlefield Boulevard Interchange Project in the City of Chesapeake included 1 mi (1.6 km) of 13-inch-thick (330 mm) CRCP with five lanes in each direction on I-64. It was constructed in 2007. Traffic was moved to the outside lanes, allowing for construction to take place in the center lanes. An onsite batch plant provided the concrete, uninterrupted by traffic. This project also had widened outside shoulders.

The existing 8-inch-thick (200 mm) jointed reinforced concrete pavement was recycled and used as an aggregate for the CTA base. Figure 10 shows onsite crushing and storage of recycled aggregate. The aggregate was also mixed with the cement at the batch plant on site. Recycled concrete aggregate was placed with no major problems, similar to regular CTA. Recycling of the existing pavement enabled sustainability, eliminated disposal concerns, and provided cost savings.
I-66 Precast Prestressed Slabs

Precast prestressed concrete pavement (PPCP) was used to repair all four lanes of a 1,020-ft (310.9 m) section on I-66 with 5,780 yd² (4,833 m²) of concrete pavement consisting of 102 panels. This was a nighttime-only construction project with lane closures from 9 p.m. to 5 a.m. because of the high volume of traffic; in 2008, average daily traffic was 184,000 vehicles per day with 5 percent truck traffic. The lane closures for PPCP started for two lanes at 9 p.m., and for a third one at 10 p.m.; all lanes were opened to traffic at 5 a.m. The existing concrete thickness ranged from 9 to 11 inches (230 to 280 mm). The new slabs were 8-¾ inches (222 mm) thick. First the two left lanes were removed and two slabs, each 12 ft wide and 10 ft long (3.7 by 3.0 m), were placed. Then the right lane and the auxiliary shoulder were replaced with monolithic 27-ft-wide (8.2 m) precast sections, each 10 ft (3.7 m) long. Slabs contained conventional reinforcement, but were supplemented by bonded prestressed strands in the transverse direction during production and post-tensioned strands in ducts during installation, as shown in figure 11. The lanes were also tied together by transverse strand which was grouted in-place without any post-tensioning. Nonshrink grout was used to fill the post-tensioning ducts, and base grout was used to fill the voids underneath the slabs.

The existing pavement structure was built in the early 1960s with 6 inches (150 mm) of plain aggregate subbase and 6 inches of cement-stabilized subgrade. Attempt was made not to disturb the base layer during the removal of the existing slabs. After slab removal, a layer of No. 10 aggregate was compacted as a leveling course before placement of the PPCP. Then a nonwoven geosynthetic fabric was used as separation layer to minimize friction.

The total cementitious content of the panels was 752 lb/yd³ (446.1 kg/m³) with 20 percent Class F fly ash. A low w/cm of 0.36 was used to enable fast turnaround time in the forms. Release strength of 3,500 lbf/in² (24.13 MPa) was achieved overnight using radiant heat.
Careful attention to base preparation, use of low w/cm concrete with low permeability, and prestressing the slabs are expected to provide longevity in this highly traveled roadway.

Despite the tight dimensional tolerance during casting and placement, it was difficult to match the successive panel elevations that resulted in rough ride. To improve ride quality, the precast slab areas were diamond ground.

**SUMMARY**

VDOT has implemented many measures to extend the life of newly constructed concrete pavements. Some of these practices are summarized below:

- Stable base material with adequate drainage to provide firm, uniform, and dry condition for better support.
- Thicker pavements to meet anticipated truck loadings.
- Wider outside lanes (travel lane) to provide edge support and reduce punchouts.
- Reduced cementitious material content for reduced shrinkage and more stable mixtures (rich mixtures tend to segregate at handling and super-elevation).
- Supplementary cementitious material for reduced permeability and improved resistance to chemical attack.
- Larger NMSA and well-graded aggregate through blending for reduced water, cement, and paste contents.
- Emphasize consolidation to eliminate large air voids that can compromise strength and durability.
- Proper curing to enable hydration and to control temperature and moisture variation.
• Use of prepping conferences and trial sections to establish proper communication with the contractor, explain any special features on the project, and avoid any potential problems by putting the contractor’s paving plan to a test before the actual paving.

• Use of precast prestressed slabs for accelerated construction, with high-quality slabs.

These improvements in design, material selection and proportioning, and construction practices have led to successful applications in the field. Even though these pavements have not been in service for a long time, their current condition along with initial test results (strength, permeability, IRI, etc.) project a long and durable service life.

ACKNOWLEDGMENTS

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