

TECH BRIEF

NM 136 CONTINUOUSLY REINFORCED CONCRETE PAVEMENT

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CONTRACTING OFFICER'S REPRESENTATIVE

Sam Tyson, P.E.
Concrete Pavement Engineer
Federal Highway Administration
1200 New Jersey Avenue, S.E. – E73-440
Washington, DC 20590
202-366-1326 | sam.tyson@dot.gov

AUTHORS

Shiraz Tayabji, Ph.D., P.E.
Advanced Concrete Pavement Consultancy LLC
410-707-4902 | stayabji@gmail.com

Shree Rao, Ph.D., P.E.
Applied Research Associates, Inc.
720-328-7265 | srao@ara.com

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INTRODUCTION

The New Mexico Department of Transportation (NMDOT) rehabilitated about 8.7 miles (milepoint 0.448 to milepoint 9.168) of New Mexico State Road 136 (NM 136) in Dona Ana County, just northwest of El Paso, TX. This four-lane arterial roadway serves as a connection between the Santa Teresa Port of Entry and Interstate 10 (I-10) near the Texas State Line. The roadway serves the Dona Ana County Jetport, the new Union Pacific railroad facility, industrial parks, and the Santa Teresa residential areas. The roadway rehabilitation involved the use of long-lasting continuously reinforced concrete pavement (CRCP) to significantly upgrade the existing asphalt concrete (AC) pavement. The existing AC pavement exhibited significant distress as a result of rutting and cracking.

This is NMDOT's first CRCP project. The CRCP is being constructed over the existing AC pavement and was selected because of its ability to accommodate heavy border truck traffic (up to 96,000-pound vehicle loads), lower life-cycle costs, and less maintenance requirement. The CRCP construction started during April 2018 and was planned to be completed during early 2019. The lengthy construction period included nighttime paving and frequent suspensions of paving operations due to high ambient temperatures and windy conditions.

This Tech Brief provides details related to the planning, design, and construction of the NM 136 CRCP.

CRCP BACKGROUND

CRCP is widely used by several highway agencies in the United States, typically for heavily-trafficked roadways. CRCP has the potential to provide a long-term, "zero-maintenance" service life under heavy traffic loadings and challenging environmental conditions, provided that proper design and quality construction practices are utilized. CRCP differs from other concrete pavements as follows:

1. CRCP has no active transverse joints, except at ends.
2. CRCP provides continuous longitudinal reinforcement, which results in tight cracks in the concrete at about 2–6 feet (0.6–1.8 meters) spacing. Sufficient reinforcement is necessary to keep the cracks tight. In the United States, the longitudinal reinforcement—typically No. 6 bars—is placed over transverse bars to ensure proper placement with respect to depth and transverse spacing.
3. CRCP can extend, joint free, for many miles with breaks provided only at structures (e.g., bridges). Joints, designed as *expansion joints*, are provided at structures or at a terminus of the CRCP.

CRCP design focuses on managing the cracking that develops so as to reduce the structural distress that may develop as a result of traffic and environmental loadings. These distresses include punchouts, steel rupture, and crack spalling. CRCP design involves determining the proper combination of slab thickness, concrete mixture constituents and properties, and steel reinforcement content and location; providing for sufficient slab-edge support; strengthening or treating the existing soils; and providing non-erodible bases that also provide friction, which leads to desirable transverse cracking patterns. Although most of these features are common to all good pavement designs, reinforcement and edge support are particularly critical to a CRCP.

Several highway agencies have implemented the American Association of State Highway and Transportation Officials' (AASHTO's) recommended mechanistic-empirical pavement design procedure and the associated Pavement ME Design software for design of CRCPs (available from AASHTO).



Figure 1. Map overlay showing the NM 136 roadway location details.

(Source: Copyright Google® Earth™. This map can be accessed from <https://www.google.com/earth/>.)

NM 136 CRCP PROJECT DETAILS

Project Overview

In 2014, early planning began for the rehabilitation of NM 136, from the Santa Teresa U.S.-Mexico border crossing. The NM 136 location is shown in Figure 1.

In 2014, the Federal Highway Administration (FHWA) sponsored a workshop in Anthony, NM, to review the applicability of a concrete overlay for the NM 136 project. Based on the site visit, age of the existing asphalt concrete (AC pavement), and anticipated future traffic, a determination was made that an unbonded concrete overlay would be a good rehabilitation alternative, which would make effective use of the existing AC pavement as a base for the concrete overlay.

As of 2014, annual average daily traffic (AADT) on NM 136 was about 5,500 (38 percent of which consisted of trucks). Truck traffic is expected to increase as a result of the North American Free Trade Agreement (NAFTA) between the United States, Canada, and Mexico. Many trucks using NM 136 are oversized multi-modal units that incorporate varying axle configurations and have gross weights in excess of 96,000 pounds (43,500 kg).

During early 2015, NMDOT initiated activities related to development of the preliminary pavement designs, considering jointed concrete pavement, CRCP, and full-depth AC pavement. In

August 2015, FHWA sponsored a workshop in Anthony, NM, to present the latest information on design, construction, and performance of CRCP so as to allow NMDOT to determine if use of a CRCP would be a viable and cost-effective pavement rehabilitation option for the NM 136 project. As a result of the workshop and discussions with FHWA's technical experts, NMDOT decided to proceed with the use of a CRC overlay to rehabilitate NM 136.

Existing Pavement

The existing AC pavement was constructed during 1999 and consisted of 6 inches of AC over a 6-inch granular base. A section at the north end was rehabilitated during 2013 with a 2.5-inch mill and fill with AC. At that same time, the south portion of the roadway underwent a crack-sealing maintenance operation. As of 2015, the pavement was in fairly good condition; however, pavement rehabilitation was under consideration to better accommodate the increase in traffic expected along NM 136 (because of NAFTA) and the growth in the number of intermodal yards near the northern section of the roadway.

The condition ratings for the northbound and southbound roadways (as of 2017) are shown in Figures 2 and 3.



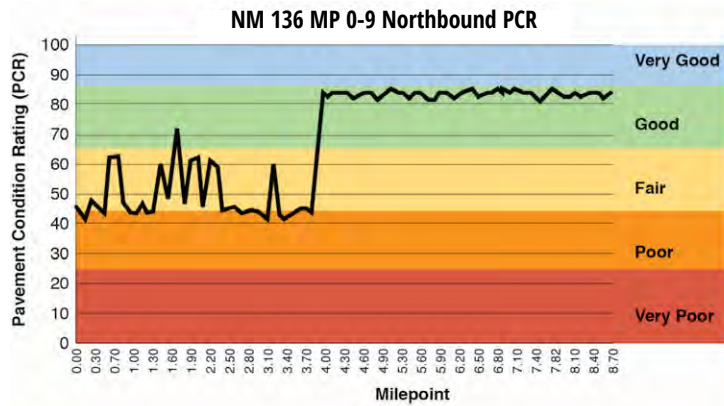


Figure 2. Pavement condition rating along the northbound roadway.
(Source: New Mexico Department of Transportation)

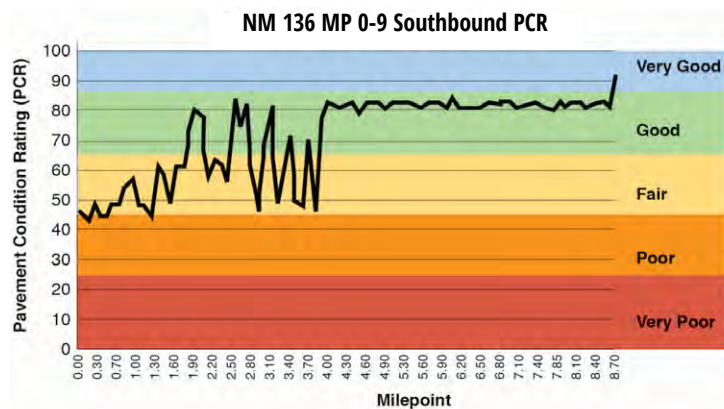


Figure 3. Pavement condition rating along the southbound roadway.
(Source: New Mexico Department of Transportation)

CRCP Pavement Design and Details

The CRCP pavement design was developed by the NMDOT’s consultant charged with developing plans and specifications for the CRCP for use on NM 136. The consultant developed draft CRCP structural design during April 2016 by using the AASHTOWare Pavement ME Design software.

The pavement design was finalized during November 2016. The CRCP design was based on the following specifications:

- | | |
|-----------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| 1. Terminal international roughness index (IRI): 160 inches/mile at 90 percent reliability | 9. Concrete coarse aggregate: Crushed limestone |
| 2. Punchouts: Less than 10/mile at 90 percent reliability | 10. Coefficient of thermal expansion: 4.01 inches/inch/°F (based on test data) |
| 3. Design life: 30 years | 11. Concrete compressive strength: a. 7 day: 3,700 psi b. 28 day: 5,250 psi |
| 4. 2016 Average Annual Daily Truck Traffic (AADTT): 1,730 | 12. Concrete water/cementitious materials ratio: 0.38 |
| 5. Traffic growth rate: 1 percent linear | 13. Average existing AC pavement thickness: 4.75 inches (after milling and infill) |
| 6. Design lane width: 12 feet | |
| 7. Number of lanes: 4 | |
| 8. Base/slab friction: 7.5 | |



Based on the Pavement ME Design software analysis and sensitivity analysis, the following CRCP design details were established:

1. Concrete slab thickness: 9.5 inches
2. Percent longitudinal steel: 0.775 percent
3. Steel depth from the surface: 3.5 inches
4. Shoulder type:
 - a. Outside shoulder: 8-foot-wide CRCP
 - b. Inside shoulder: 4-foot-wide CRCP tide to the median side curb and gutter
5. Existing AC pavement treatment
 - a. Mill: 1.5 inches and apply 1.5-inch-thick AC leveling course

For sections of the roadway that required reconstruction, the pavement details were as follows:

1. Concrete slab thickness and reinforcement details as previously mentioned
2. 3.5-inch hot-mix AC base
3. 6.5-inch aggregate subbase

The pavement sections for the new (reconstructed pavement) and the CRC overlay over the existing AC pavement are shown in Figure 4.

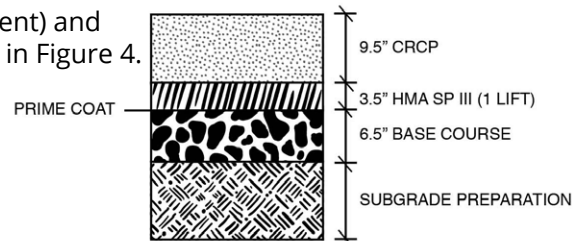
Based on the requirement of 0.775-percent longitudinal steel, the following longitudinal reinforcement details were established for the 9.5-inch-thick slab:

1. Bar coating: None (black steel)
2. Bar size: No. 6
3. Bar diameter: 0.75 inches
4. Bar spacing: 6.0-inch typical
5. Bar depth from the surface: 3.5 inches

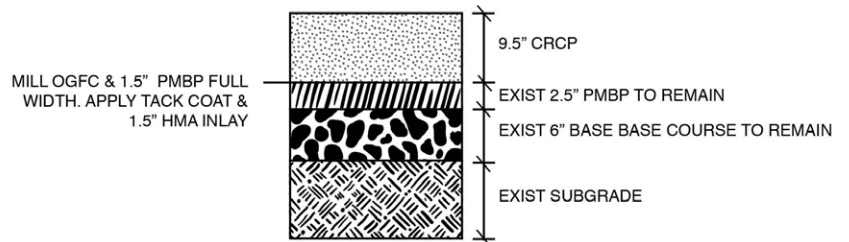
The transverse bar support design was established as follows:

1. Bar coating: None (Black steel)
2. Bar size: No. 6
3. Bar diameter: 0.75 inches
4. Bar spacing: 36.0-inch typical

Tie-bars for the longitudinal joints were designed to be No. 6 bars, 36-inches long, and spaced at 36 inches.



NM 136 Proposed CRCP for Complete Reconstruction



NM 136 Proposed CRC Overlay

Figure 4. Pavement sections for the new CRCP and CRC overlay.

(Source: New Mexico Department of Transportation)



PROJECT SPECIFICATION AND PLANS HIGHLIGHTS

The NMDOT developed a Special Provision (Section 456) for the CRCP. The key items of the special provision are as follows:

1. Concrete mixture: Use of Class F-LS concrete mixture
2. Reinforcing steel: Use of Grade 60 steel
3. Concrete curing compound: Use of two applications of poly-alpha-methyl styrene (PAMS) membrane-forming curing compound that complied with the requirements of *American Society for Testing and Materials* (ASTM) C309, Type 2, Class B as modified below to account for hot, windy, and dry ambient conditions during construction:
 - a. Minimum total solids (percentage by weight of compound): 42
 - b. Loss of water, pounds/square feet in 72 hours (ASTM C156): 0.082 maximum
 - c. Volatile organic content (VOC) content (pounds/gallon): 2.9 maximum
 - d. Vehicle: 100 percent poly-alpha-methyl-styrene
4. Concrete placement: Use of a slipform paver
5. Concrete temperature limitations: 40–90°F
6. Opening to traffic concrete compressive strength: 3,000 psi
7. Surface texture: Longitudinal tining
8. Test strip: Construction of 0.1–0.2-mile test strip
9. Pavement smoothness base on Mean Roughness Index (MRI):
 - a. MRI < 65 inch/mile: Accepted
 - b. MRI 65–80-inch/mile: Pay adjustment
 - c. MRI > 80 inch/mile: Corrective work required

Terminal Joint Details

For the terminal ends, the end section of the pavement was a new CRCP, incorporating simple expansion joints and 10-inch-thick and 10-foot-long sleeper slabs. The expansion joint width was specified to be 1 inch. Use of dowel bars with dowel caps was required at the expansion joints.



Figure 5. Transverse bar support system.

Transverse Bar Support

The transverse bar support system was required to hold the longitudinal reinforcement in proper position in the concrete and within a half an inch of the vertical position shown in the plans. The support system was also required to have sufficient bearing at the base to prevent overturning and penetration into the hot mix asphalt (HMA). The contractor developed the transverse bar support system as shown in Figure 5. The transverse bars are supported by chairs, which are supported on metal plates. The metal plates eliminate the penetration of the chairs into the AC surface.

Transverse Construction Joints

Use of transverse construction joints was required when there was an interruption of 30 minutes or more in the concrete-placing operations. The construction joints were required to be strengthened by the addition of supplementary bars of the same size, strength, and type as the longitudinal bars. Lap splices in the longitudinal bars were not permitted within 3.5 feet of the stopping side or closer than 8 feet from the starting side of a construction joint.



CONCRETE MIXTURES

The contractor developed several concrete mixtures to accommodate varying ambient construction conditions. The project site near El Paso, TX, is subjected to high daytime temperatures, very dry air, and windy conditions throughout the year. In addition, each mixture incorporated Class F fly ash to mitigate alkali-silica reactivity (ASR) in the concrete due to use of locally available reactive aggregates. The fly ash content was 22 percent of the total cementitious materials. The concrete mixture incorporated three aggregate types: a 1-inch maximum size coarse aggregate, a 0.75-inch maximum size coarse aggregate, and sand as the fine aggregate.

CRCP CONSTRUCTION

A 2-day just-in-time training (JITT) was held in February 2018, a few weeks before the start of concrete paving. The training covered the best practices related to the design and construction aspects CRCP and the project-specific specification items and plan details, including quality control/quality assurance requirements. The first day of the JITT was for the NMDOT staff; the second day was open to the NMDOT staff and the contractor's team members, including field inspectors and field testing crew.

Weather Considerations

Because of the challenging weather conditions at the project site, the contract specification required the contractor to continuously monitor the evaporation potential at a height that was not to have exceeded 5 feet above the surface of the concrete. Concrete placement was not permitted if the average evaporation potential over any 10-minute period of time was to be greater than 0.2 pounds per square foot per hour. If the evaporation rate was to exceed the 0.15 pounds per square foot per hour limit, one or more of the following actions were to be implemented to reduce the rate of evaporation, as approved by the project manager:

1. Use an evaporation retarder.
2. Erect windbreaks to reduce the wind velocity over the concrete surface.
3. Place concrete during nighttime or early morning hours.
4. Lower the fresh concrete temperature during hot weather. This was to be accomplished by using cool aggregate and chilled water, by adding ice as part of the mixing water, or by adding liquid nitrogen to the concrete mix after all mix ingredients had been placed into the ready mix truck.
5. Increase the relative humidity at the site with a fog spray maintained over the entire concrete surface until the final finish had been achieved and the curing system had been applied.

The temperature data for 2018 for the El Paso, TX, area is shown in Figure 6. Figure 6 shows that the daytime high temperature at the project site exceeded about 80°F from about mid-March to about mid-September. The contractor elected to use chilled water and nighttime placement of the concrete to minimize the impact of weather condition on concrete placement.

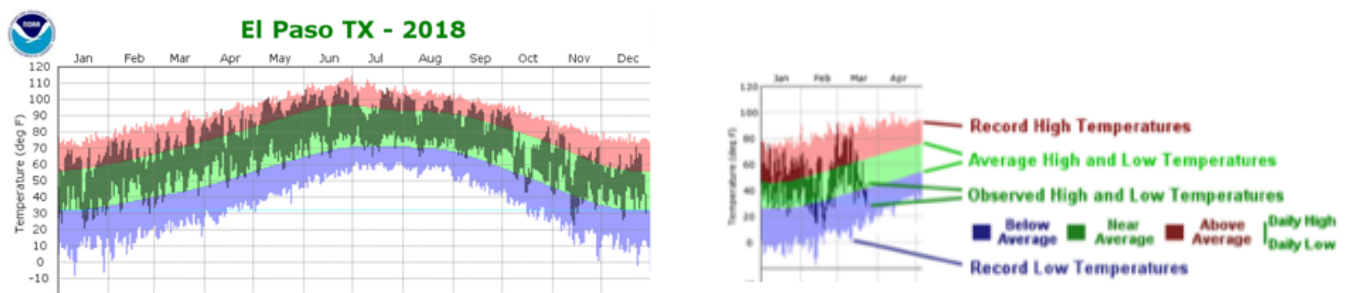


Figure 6. 2018 Temperature data for El Paso, TX. (Source: U.S. National Weather Service)



Construction Staging

The project was designed to be constructed in three segments (stages). Each segment was to be completed before the next segment could begin. The first segment started at the southern end of the project, near the U.S.-Mexico border and went up to just north of Strauss Road. The second intermediate segment started just north of Strauss Road and ended just north of Airport Road. The third segment started just north of Airport Road and ended just west of the Texas State Line.

The project construction (concrete placement) began during early March 2018 with the construction of a short length of a new CRCP section and construction of a CRC overlay test strip. A shoulder section was used for the test strip.

The pavement construction took place along one direction of the roadway, and two-way traffic was maintained along the roadway in the other direction. By the end of December 2018, a total of 14.5 lane-miles of pavement had been constructed.

Construction Details

As indicated previously, this project was designed primarily as a CRC overlay over the existing AC pavement. The project also included a few sections of new CRCP. For the CRC overlay, the construction steps included the following:

1. Construction of the median side curb and gutter
2. Milling about 1.5 inches of the existing AC surface, typically
3. Placing a 1.5-inch thick hot-mix AC leveling course, typically
4. Placing longitudinal bars over transverse bar support system for reinforcement
5. Placing concrete using a slipform paver
6. Finishing, texturing, and curing concrete
7. Longitudinal joint sawing
8. Opening to traffic

Concrete Placement, Finishing, and Curing

The contractor used a new four-tracked slipform paving machine for the concrete placement. The paving width was 38 feet, typically, and incorporated two 12-foot travel lanes, a 6-foot inside shoulder, and an 8-foot outside shoulder.

Base and Steel Placement

Figure 7 shows the prepared AC base, incorporating the AC leveling course, with steel reinforcement ready for concrete placement. Figure 8 shows the longitudinal bar splicing. A diagonal pattern was specified and used to splice the longitudinal bars.



Figure 7. Steel reinforcement placed over the AC base.



Figure 8. Longitudinal bar splicing.





Figure 9. Concrete being discharged in front of the slipform paver.

As previously discussed, because of high temperature and dry conditions, concrete placement was performed mostly at night, typically from about midnight to about 7 a.m. Concrete was delivered in end dump trucks and placed at the paving machine by using a belt placer. Figure 9 shows concrete being discharged in front of the four-track slipform paver by using a side-discharge equipment. Concrete was produced at a nearby concrete plant along the project site. The plant was set up for the project.



Figure 10. Finishing operation behind the paver.

Initial finishing behind the slipform paver was provided by the paver's auto-floats. Concrete finishing was supplemented by use of 12-foot-wide straightedges followed by 10-foot-wide floats. Figure 10 shows the finishing operation behind the paver.

The tining and curing operations on the CRCP were completed by utilizing a four-track texture/cure machine. This is the last machine in the paving train and combines both texture and curing operation into one machine. Figure 11 shows the texturing operation, and Figure 12 shows the curing operation with a side nozzle. Figure 13 shows a view of the completed CRC overlay.



Figure 11. Texturing operation.



Figure 12. Curing operation and use of side nozzle.

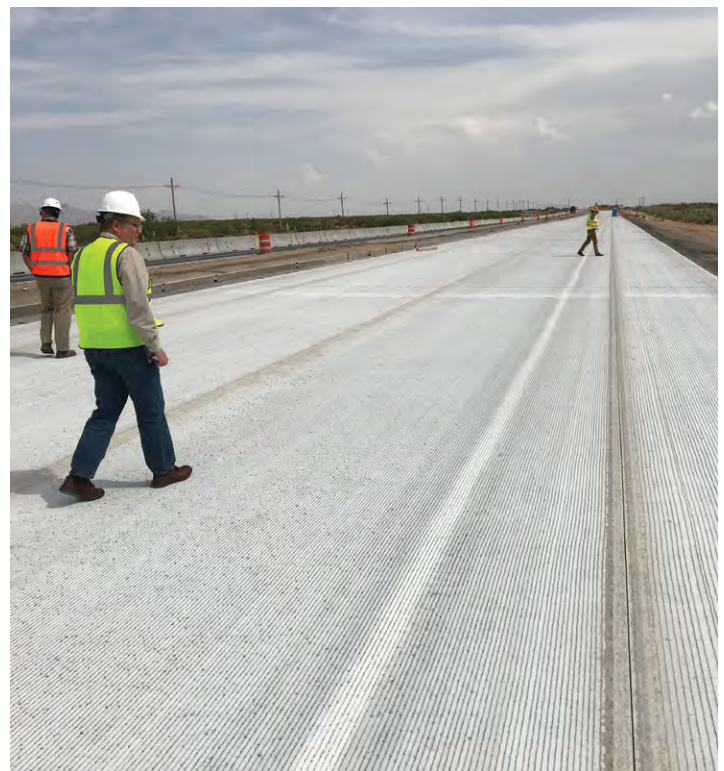


Figure 13. A view of the completed continuously reinforced concrete overlay.



SUMMARY

The NM 136 CRC overlay construction is in progress. Considering the challenging weather conditions (hot, dry, and windy), the construction is progressing well. Early in the project, there were issues related to meeting the project smoothness requirements. The cracking along the CRC overlay developed within a few days. Initial crack spacing, measured after few weeks, ranged from about 8 to 12 feet. It is expected that a close crack spacing will develop after the 2018–2019 winter season.

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PHOTO CREDITS

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