I-80- PDR, Concrete Overlay, and Sustainable Concrete Mix Design

T. Laker[1], M. McIntyre[2], P.E, C. Preston[3]

Abstract

Constructing, maintaining and reconstructing interstate highways can be accomplished in a sustainable, cost effective manner. Sustainability is an increasingly important element in the design and construction of transportation infrastructure because of limited dollars and natural resources. Construction materials and methods can contribute greatly to the overall sustainability of a pavement. Concrete, as the most widely used construction material on the planet, has been proven time and again as one of the most sustainable and longest lasting pavement media. Other intrinsic benefits of concrete include light reflectance and reduced rolling resistance which results in improved fuel economy for the traveling public. In this paper these attributes will be explored through the experience gained during the reconstruction of a section of Interstate 80 near Park City, Utah. This section of highway was originally constructed with asphalt but after years of repair work the section has been repaved with concrete pavement. This project utilized multiple sustainable practices including partial depth recycling of the existing asphalt which was treated with cement, and a concrete overlay. I-80 proved that many pavement challenges can be solved with concrete overlays, while economizing taxpayer dollars, saving natural resources, recycling existing materials, and providing a long design life.

Background

Since its creation in 1956, the Interstate Highway System "has been a part of our culture as construction projects, as transportation in our daily lives, and as an integral part of the American way of life." (FHWA) Salt Lake City is considered to be the crossroads of the West with the intersection of two major Interstate Highways, Interstate 15 (I-15) and Interstate 80 (I-80). These interstates make the transportation of goods and services from the east to the west and the north and the south possible and are vital to Utah's growing economy. Insuring that these assets are built correctly and are well maintained is one of the Utah Department of Transportations (UDOT) major focuses. Utah's climate, varying elevations, and increasing population growth can make this a challenge. One hundred ninety-seven miles of I-80 exist in Utah and were first constructed in 1956. The 7.55 mile section of I-80 addressed in this paper was first paved with asphalt pavement but given the increasing amount of truck traffic and the winding mountain elevations of the roadway, the

[1] Senior Technical Service Engineer, Mountain Sales Group, Holcim (US) Inc., 801-829-2178, todd.laker@holcim.com

[2] Executive Director, Utah Chapter, American Concrete Pavement Association, 801-556-9561, mcintyre@utahacpa.com

[3] Concrete Paving Manager, Geneva Rock Construction, 801-765-7800, cpreston@genevarock.com

asphalt pavement was in need of maintenance more frequently than the Department desired. Therefore a rigid pavement design was selected to ensure a longer life for this reconstruction of a vital transportation corridor.

Introduction

The I-80 reconstruction project from Silver Creek Junction to Wanship, UT embodies the true spirit of sustainability and environmental stewardship. I-80 is the major East/West Corridor for truck commerce across the State of Utah. With over 45% average daily truck traffic, the existing asphalt pavement was failing to withstand the loads and environmental conditions of this mountain area. Repeated surface failures caused UDOT to repair this section of highway early and often. This project utilized MEPDG to design a 40 year concrete pavement that would withstand the mountain elements: this section of highway is located at about 6,400 feet in elevation and is subject to drastic weather changes. The project is 7.55 miles long with 2-12 foot lanes in each direction with 4 foot interior shoulder and a 10 foot emergency lane. A total of 377,500 SY of concrete was placed.

Construction

This project was awarded by UDOT based on combined lowest price bid and shortest construction schedule. This pushed Geneva Rock to perform the work under an accelerated schedule. The project schedule required the eastbound lanes to be constructed in the fall of 2014 with the westbound lanes being constructed in the spring of the following year. A late bid date (May 2014) provided a very short window to complete the eastbound work before winter traditionally set in. The partial depth reclamation (PDR) was completed ahead of schedule which allowed the Portland cement concrete pavement (PCCP) crews to maintain their construction schedule in spite of an unseasonably wet fall. All lanes in both directions had to be opened in the normal configuration during the winter months. Construction of the westbound lanes resumed with PDR construction in April of 2015. PCCP construction began shortly thereafter and was completed in September of 2015. In addition to the PDR and PCCP, there was a substantial bridge along the westbound lanes that had to be demolished and reconstructed during the 2015 construction season. The construction schedule of the bridge was critical to the success of the project, as final paving operations could not be completed until the bridge was finished. Geneva Rock and the bridge sub-contractor involved were able to work together to maintain the bridge and paving schedules.

Design and Planning

A durable, long lasting concrete pavement was designed to cap the PDR providing a great highway surface for years to come. Mainline concrete pavement design consisted of 12 inches of PCCP placed over 4 inches of the PDR. Off ramps consisted of 10 inches of PCCP on 4 inches of PDR. One and a half inch diameter by 18 inch long dowels were specified across transverse joints throughout the project for load transfer. Four bars per wheel path were placed in the concrete using a Gomaco IDBI. Number five (#5) by 30 inch tie bars were used in all longitudinal joints with spacing at 15 inches on construction joints and 30 inch spacing on contraction joints. A central batch plant was set up at west end of the project on UDOT property and produced concrete for the entire project including paving and barrier wall construction. Geneva Rock selected the Gomaco IDBI paver and a Gomaco Zero Clearance paver along with a material belt placer for the concrete paving of both the east and westbound lanes. Traffic was switched head-to-head with a temporary barrier down the middle to speed the construction and insure safety to the traveling public. This gave the contractor one entire direction at a time to pave. The permanent concrete barrier wall was constructed by a concrete sub-contractor. The narrow canyon provided concrete paving

PCCP Mix Desgin			
Material	Type	Weight (lbs)	Volume (ft^3)
Cement	ASTM C1157 Type GU/MS	458	2.33
Fly Ash	ASTM C618 Type F	153	1.066
Water		234	3.75
Fine	ASTM C33	1180	7.056
Coarse	ASTM C33 #67	1015	6.535
Coarse	ASTM C33 #467	742	4.776
Air Content	5.5%		1.485
		OZ/CWT	OZ/Yard
Air Entraining Admixture		4	24.44
Water Reducer		4	18.33

Figure 2: Westbound PCCP Mix Design (Envirocore)

PCCP Mix Desgin			
Material	Type	Weight (lbs)	Volume (ft^3)
Cement	ASTM C150 Type II/V	458	2.33
Fly Ash	ASTM C618 Type F	153	1.066
Water		234	3.75
Fine	ASTM C33	1180	7.056
Coarse	ASTM C33 #67	1015	6.535
Coarse	ASTM C33 #467	742	4.776
Air Content	5.5%		1.485
		OZ/CWT	OZ/Yard
Air Entraining Admixture		4	24.44
Water Reducer		4	18.33

Figure 2: Eastbound PCCP Mix Design

challenges with its limited access to the project and limited to no track grade. The accelerated schedule and the unpredictable mountain weather also proved somewhat challenging.

Concrete Mix Design

Due to the accelerated construction season in 2014, the eastbound lanes of I-80 were constructed with a traditional concrete paving mixture (see Figure 1) The hydraulic binder selected was an ASTM C150 Type II/V Portland cement. The concrete mixture included 25% Class F fly ash.

The westbound lanes were constructed with a concrete mixture that was designed with sustainability in mind. This mixture utilized Holcim Envirocore cement as the hydraulic binder. Envirocore cement has a lower carbon foot print due to the incorporation of un-calcined high grade limestone, interground with the Portland cement clinker. The limestone lowered the CO_2 associated with clinker production and helped the concrete by providing nucleation sites of hydration products. Thelimestone cement is also engineered for use with other supplementary cementitious materials (SCMs) such as fly ash. (Laker, et al) This concrete mixture also included Class F fly ash used in conjunction with the limestone cement increasing the CO_2 reduction by an additional 25%.(see Figure 2) The Envirocore concrete mixture significantly lowered the environmental impact from traditional concrete mixtures by utilizing blended cements and SCMs.

The two concrete mixtures performed similarly and meet all concrete strength requirements for the project. Concrete batching and placement crews did not see a noticeable difference between the two concrete mixtures. Concrete results of the two mixtures are provided in Figure 3.

Lane	28 day Concrete Strength (PSI)
Westbound	4980
Eastbound	5110
Total Project	5050

Figure 3: Average 28 day Compressive Strength

PDR

Another sustainable construction technology utilized on the project was that of partial depth reclamation of a portion of the existing asphalt. Four inches of the existing asphalt was recycled by pulverizing it with a percentage of Portland cement to create a durable paving platform. This was the first project in the history of reclamation, where only a portion of the existing asphalt was used, leaving the other portion in place. The original PDR design specified 9% to 11% Portland cement in the reclamation mixture. UDOT required strength values were between 300-500 PSI in 7 days. Geneva Rock however, performed value engineering to optimize the cement content of the PDR. Test strips of PDR were constructed at 7%, 8%, and 9%. It was determined that 7% cement was adequate to meet the UDOT strength requirements. This reduction in cement saved money and reduced the raw materials needed on the project.

The existing asphalt was profile milled to where the bottom of the PDR layer would be. Excess tailings from the milling process were used to fill in areas lacking sufficient material. The shaping of the grade was accomplished by 3D-guided equipment. The cement for the PDR was delivered in bulk pneumatic trucks and then transferred to a spreading vehicle that spread the dry material. A rotomill then mixed the dry cement into the milled asphalt and added the specified water content. The PDR was shaped by the use of a sheep foot roller, a 3D-guided grader, and a smooth drum roller. Per UDOT specification, moist curing with water for 72 hours (or until prime coat application) was required. No construction traffic was

allowed on the newly mixed PDRfor 72 hours. A product called Enviroprime was used for the prime coat. After proper curing, the PDR was then ready for its PCCP overlay. Lessons learned during the construction of the PDR included that it wasnecessary to drive on the treated sections sooner than 72 hours. Also the longer the contractor waited to place the prime coat, the less ruts that wouldform however, after 2 days, there waslittle chance of shaping the PDR.

There were many benefits to using the PDR under the PCCP. The PDR proved to be a superior paving base material, holding up well during construction activities and reducing yield loss compared to an aggregate base. However, it was somewhat problematic to adjust the grade easily. Because the existing materials were utilized on this project very little waste was created and subsequently landfilled, thus reducing fuel and hauling and disposal costs which have negative impacts to the environment.

Innovation

In addition to the use of Envirocore cement and PDR, the westbound lanes of this project utilized stingless technology. The eastbound lanes paved in 2014 utilized a string line for equipment navigation. This proved to be cumbersome and forced increased haul truck transit time to accommodate the limited openings in the string line. String line opening and transitions can also affect pavement smoothness. Therefore in 2015, Geneva Rock paved the westbound lanes utilizing stringless technology. This was the contractors first project with the stingless system. The stringless navigation system reduced the transit time of haul trucks and increased the construction speed and efficiency. Pavement smoothness was maintained with the incorporation of this navigation technology.

Smoothness

The smoothness required by UDOT on I-80 was a 5 inch per mile using a 0.2 inch blanking band. The final profile measurements achieved for the project are shown in Figure 4 and required minimal grinding efforts. This exceeded the requirements of UDOT and a smoothness bonus was awarded to Geneva Rock. The use of the PDR under the concrete pavement provided a solid base for consistent and continuous paving operations which played a major role in achieving this superior smoothness.

Lane	Inches per Mile
Westbound	2.37
Eastbound	3.29
Total Project	2.83

Figure 4: Average Profile Measurements

Barrier placement

Cast in place concrete barrier was placed along the majority of the inside shoulder as well as a few locations along the outside shoulder. The barrier was placed using a Gomaco paver with a barrier mold. There was a total of 57,300 LF of barrier placed from concrete produced at the jobsite concrete plant utilizing similar concrete mixtures as in the paving designs. Concrete was delivered to a Gomaco RTP-500 concrete placer that transferred the concrete from the concrete haul trucks to the barrier paver. This process allowed for the barrier to be placed at higher, more efficient production rate than being supplied from a ready-mix concrete truck.

Rumble strips

Due to the use of eastbound lanes being used for head to head traffic during the construction of the westbound lanes, rumble strips were not installed until all paving was complete on both eastbound and westbound. The rumble strips were ground in prior to the roadway being open to traffic in its final configuration. The rumble strips improve the safety of the roadway by alerting drivers when they leave the drive lane.

Public Relations

As with any construction project on an interstate highway, there are many stakeholders affected by construction activity. Several communities were affected by some of the required ramp closures, therefore Geneva Rock and UDOT worked closely with these communities to provide updates on the closures and to identify alternate routes during construction. With I-80 being a major truck route connecting the western United States to the east, UDOT and Geneva Rock regularly updated the Utah Highway Patrol to make sure notices were being sent out on the lane width restrictions and ramp closures, so as aid in logistics planning.

Conclusion

The reconstruction of Interstate 80 near Park City, Utah is a great model of sustainable construction and design. This project utilized state of the art materials and technologies to deliver a long lasting, low maintenance pavement on one of the interstate highway systems most crucial corridors. In addition to the intrinsic benefits of PCCP including light reflectance and reduced rolling resistance which results in improved fuel economy for the traveling public, this project also incorporated energy and CO_2 conserving materials and methods including Envirocore cement and PDR base construction (Van Dam, et al.). The use of Envirocore cement on the westbound lanes helped further reduce the carbon footprint of these lanes while maintaining all specified plastic and hardened concrete properties. The PDR base construction proved to be more stable and durable than traditional aggregate base material and helped reduce the waste typically associated with milling asphalt. Innovative construction technologies such as stringless navigation and concrete barrier wall concrete delivery also improved the efficiency of this project.

The Interstate 80 reconstruction proved that many pavement challenges can be solved with concrete overlays, while economizing taxpayer dollars, saving natural resources, recycling existing materials, and providing a long design life. UDOT is extremely pleased with the speed of construction, the reuse of materials, and the cost-effective construction of PCCP on this project. UDOT intends to use the PDR capped with PCCP in future projects.

ACKNOWLEDGEMENTS

Appreciation is extended to the Utah Department of Transportation and Geneva Rock for their commitment to using innovative paving technologies to improve sustainability and willingness to share their experiences.

REFERENCES

Federal Highway Administration (2015) "History of the Interstate Highway System" <http://www.fhwa.dot.gov/interstate/history.cfm> (Oct 8, 2015)

Harrington, D; Fick, G. (2014) *Guide to Concrete Overlays: Sustainable Solutions for Resurfacing and Rehabilitating Existing Pavements (3rd edition),* National Concrete Pavement Technology Center, Ames, IA.

Laker, T. Smartz, B (2012). Use of Portland-Limestone Performance Cements in Colorado and Utah: Laboratory Durability Testing and Field Case Studies. Presentation made at TRB 2012 Conference, Washington DC.

Luhr, D.R.; Adaska, W.S.; Halsted, G.E. (2008) *Guide to Full-Depth Reclamation (FDR) with Cement*, PCA, Skokie, IL.

Van Dam, T; Taylor, P; Fick, G; Gress, D; VanGreen M; Lorenz, E. (2012) *Sustainable Concrete Pavements: A Manual of Practice*, National Concrete Pavement Technology Center, Ames, IA.