Video Conference Agenda and Meeting Notes: Two-Lift Concrete Pavements
27 June 2007
Location: FHWA IA Division Office

Agenda

10:00 am Welcome
Charlie Goodspeed, FHWA's Highways for LIFE Program

10:10 am International Scan on Long Life Concrete Pavements
Tom Cackler, Director National Concrete Pavement Technology Center

10:25 am History of Two-Lift Construction in the US
Dr. James Cable

10:45 am European Experience with Two-Lift Pavement Construction
Dr. Hermann Sommer

11:30 am Two-Lift Construction and Noise Implications
Dr. Rob Rasmussen: The Transtec Group

11:50 am Q&A Session with DOT's planning on constructing a project
In 2007 and 2008

12:50 am Closeout

1:00 pm Adjourn

Meeting notes

Welcome by Tom Cackler, Director National Concrete Pavement Technology Center

Two-lift has been used in the past, but not much in recent years. We are here to learn more about this technique today. Cackler described the agenda and the introduced the presenters:

- Dr. Charlie Goodspeed will introduce Highways for LIFE participation.
- Dr. Jim Cable of ISU will discuss two-lift synthesis.
- Dr. Hermann Sommer will discuss the use of two-lift in Austria. He is recognized internationally as an expert in this technique.
- Dr. Rob Rasmussen of The Transtec Group will discuss the pavement surface characteristics work ongoing at the National CP Tech Center including a link to two-lift concrete pavements including exposed aggregate surfaces.

The end of today's session will include Q&A. Email questions to twolift@cproadmap.com

A partial list of participants (self-introductions):

- FHWA DC Division – DDOT included
- FHWA TX Division – TxDOT too
- FHWA OK Division – Gary Fick too
- FHWA TN Division – Steele
- FHWA HQ – 6 people
- FHWA MN Division – Mn/DOT too
- FHWA FL Division – Jamshid Armaghani too
- FHWA NY Division – NYSDOT too
- FHWA MD Division – Hussein and Noyer from MD SHA and Gary Hoffman (ARA for H4L)
- FHWA Resource Center Atlanta – Rodriguez
- NH DOT (at FHWA NH Division)
- FHWA NJ Division
- FHWA WA Division – Contactor and DOT as well
- FHWA MS Division
- FHWA WY Division
- FHWA NE Division – Frederick
- FHWA OR Division – ODOT too
- FHWA IA Division – IDOT too (in the room)

Highways for LIFE Introduction by Charlie Goodspeed

Why is H4L interested in Two Lift?

- Need for safety – the potential for maintaining good skid resistance.
- Need for recycling is also a driver. This leads to a reduction in congestion during construction.
- Need for Quality – these goals are met with two lift.

In 2006, H4L awarded 3 projects. A number of projects awarded for 2007 – 7 awarded in Phase I, more to come in Phase II.

- VA submitted 2 (one on Rte. 66 with Modular Paving, one a Modular Bridge)
- ME submitted 2 for Modular Bridge
- GA submitted for Perf Contracting
- OR Bridge with Self Propelled System
- MO a Design-Build with a set price
- AZ submitted for a Safety Project through a Tourist Area

2008 Submittals due 7/16. Quality of proposals in 2007 were better than 2006, even better expected for 2008.

If there is interest by anyone on Two Lift concrete pavements, contact the National CP Tech Center at Iowa State University directly: Tom Cackler.

Gary Hoffman putting on workshop for designing and deploying innovation – 4 states have requested this. If interested, call H4L.

Overview of Long-Life Concrete Pavement Scan Tour by Tom Cackler

The mission of the Scan was to identify those techniques used in Canada and Europe that enable them to construct long-life concrete pavements. Some roads carry traffic levels that are high – even by US standards. Some of the design details were therefore surprising. Many slabs were thinner, less joint reinforcement. However, much more emphasis on the system (good foundation, good drainage, etc).

CRCP used as well as JCP. Emphasis on quality of materials – especially in top lift of two-lift concrete. Recycled material use was big – another real potential with respect to two-lift.

Two-lift paving was the first implementation item. Exposed aggregate surfaces was another. Other items include a design features catalog, high quality foundations, mix design components, and geotextile interlayer.

Two Lift Synthesis by Jim Cable

Documented in a report done by Iowa State University. Looked at two-lift in terms of strengths and limitations. Objectives were to look at European practice.

In 2004, a survey was done. Surface courses typically 2 to 5.5 inch. 8.5- to 9.5-inch bottom lift. Problems noted with “stress intensities” on some projects.

Two-lift paving equipment was built and used in Europe. In 1906, there was a patent for two-lift paving was issued. A lot of the Interstate mesh reinforcement was also two lift as a means to efficiently introduce the steel mid-depth.

Changes in 1970 to go to plain jointed pavements (and cost/efficiency) drove us toward the techniques that we use in the US today (single lift). From 1970–1994, 11 projects were documented. Econocrete and/or recycled materials for bottom lift. All of the pavements are still in service. These case studies covered a wide range of traffic levels and climates.

Questions raised include logistics (esp. equipment), and some engineering questions about dissimilar materials being bonded. Is the cost savings there? Recycling, materials, and the benefits of an improved surface all need to be looked at. Will be project specific. The economy can be improved if the lower lift is economized.

In demonstration projects, look at life cycle and get the industry involved. Many of the decisions on how best to do this are best made by the contractors and materials suppliers. Look to them to help innovate based on site-specific goals and restraints.

Two-Lift Concrete Practice by Hermann Sommer

Will describe the technique until 1990, and then exposed aggregate (used since 1990).

Austria carries very heavy traffic on a limited number of corridors given the terrain. It is at the crossroads of modern Europe. Used concrete pavements since the 1950s. Traditionally, concrete pavements have been 9 to 10 inches. Asphalt subbase is used atop a granular or stabilized subbase. To help with studded tire wear, a strong aggregate has been used. Before use of exposed aggregate, the top size was about 1 in. 2 mixing plants and 2 pavers are recommended – no problems with debonding if placed wet on wet. 5-20 years little to no maintenance, followed by joint sealing, local repairs. Later, a HMA overlay is used to fill studded tire ruts. 35-50 year service life (before reconstruction) is not uncommon.

In 1990, noise became a real issue, especially for roads with studded tire damage. Many of the freeways are in valleys, which "trapped" the noise. The loud cars coming from other countries and the increase in traffic made it louder.

Reconstruction of the freeway between Vienna and Salzburg. Reconstruction was necessary, but recycling was needed of the old road. They looked at a comparison of various surfacing options, and when weighing the pros and cons, exposed aggregate was the best (even though it was more costly). Pervious concrete was tried, but was rejected due to ice formation in the layer (and cost and durability issues).

High quality aggregate is critical, however. Very stringent specifications for the top lift. Need high strength to keep the matrix strong enough to retain the aggregate particles. In recycling, the coarser fraction is used in the new concrete. The fines are not used in the new concrete though (used as a stabilizing agent in the subbase instead). New sand is used in the concrete.

There are specific recommendation in crushing and reusing the old concrete. Care must be taken during batching to ensure good moisture control, etc. (Photographs of the various equipment and operation are shown.) The bottom lift mixer limits the daily output. The bottom lift should be very stiff (capable of walking on it without significant depression). Very important is the vibrators – standard poker vibrators may mix the layers. "T-shaped" vibrators will limit the compaction energy to the top lift only. View of paving train shows the distance between paver is typically 12 to 15 ft. (just enough room for inserting joint steel). Retarder and curing is sprayed immediately thereafter. For the last 10 years, there is a single compound that includes both retarding and curing compounds (manufactured by BASF).

The HMA subbase is milled (shallow) to ensure a good bond, and especially if a significant slope or bridge approach. Power broom is like a small grader with 2 brooms – one in front, and one in the middle. Normally done within 8 hrs. Could be as soon as 5 hrs, or later is the weather is cool or the mix has a slower set. The power broom should have low-pressure tires. The brooming is done in short lengths so that sawcutting can be

done shortly thereafter. The latency that is removed from the brushing is pushed to the side by a shovel (careful not to damage the surface). Brooming is done dry. If there is dust during the brooming, then the curing may have been inadequate. The mortar should still be wet.

There are additional details that will not be given on the specific material specification due to the limited time, but we are happy to answer specific questions.

One of the most important aspects is curing. The efficiency should be ensured. A test slab is used to determine the best materials and timing for mortar removal.

Splitting tensile is used for concrete strength – on cores for acceptance and on a rectangular prism for mix design and QC. Strength targets are higher for mix design than used in QC.

Noise is a pay factor. The contractor fought this aspect of the spec, since they also specified texture. However, they have since shown that it can be met. When more than one testing lab (for noise) started to work, however, there were discrepancies. Many were found to be precision and bias issues.

Accidents that occurred were problems of buses and trucks. The additional texture depth was believed to be necessary to avoid this. While noise increases with increasing aggregate size, a compromise of 11 mm maximum aggregate size.

Skid resistance is also a quality requirement. This was shown to be met easily. Measured using a modified trailer that is unique to Austria (the noise is an Austrian standard too).

Change in texture and thus friction and noise is monitored to better understand it. Noise levels of Exposed Aggregate are comparable (and more durable) than SMA of the same nominal aggregate size). Exposed aggregate is a sensitive technique – care is needed.

Segregation due to over compaction must be avoided. To prevent mixing of the two layers too.

Hairline cracks have been found along the vibrator trails (likely due to separation of aggregates, and high paste fraction). Some of these propogate full depth.

Question from Oregon

- How are aggregate supplies identified/operated/regulated?
- Answer: The sources are competitive. The contractor is free to choose any as long as it meets the stringent specifications. Need to continuously take samples from site to ensure it meets spec though.

Concrete Pavement Surface Characteristics Program and Two-Lift Construction by Rob Rasmussen representing the National Concrete Pavement Technology Center

The National CP Tech Center has been working on concrete pavement surface characteristics for years now. A three-part program was established, which is just entering the third part. The objective is to understand the issue of concrete pavements in terms of noise, texture, friction, smoothness. We should learn from what we have done to date, and then model our specifications and procedure to build the optimum surfaces. We should begin by recognizing the variety of concrete pavement textures in use today – from tining of various types, to diamond grinding, drag surfaces, and exposed aggregates (although this technique is used primarily outside of the US). It is clear from the work to date that characteristics like noise, friction, etc are closely linked to texture.

But to control surface characteristics, we need to recognize that those characteristics will change over time. The nominal texture that is constructed will change over time – in most cases, the characteristics will degrade over time, but in some cases there may be a modest improvement (at least, initially). This change over time requires an understanding of the materials – since the quality of the materials will regulate the change in the texture over time.

395 Unique Textures Tested to date:

- 140 Transverse Tining (incl. 12 skewed and 2 cross-tined)
- 104 Longitudinal Tining (incl. 2 sinusoidal)
- 39 Diamond Ground
- 16 Grooved (4 longitudinal, 12 transverse)
- 59 Drag (Burlap, Turf, Broom, Belt, Carpet)
- 10 Shot Peened
- 5 Exposed Aggregate
- 2 Milled
- 20 HMA and Surface Treatments

Over 1000 unique test sections at over 240,000 ft. of total length. Noise, texture, friction, and smoothness are being measured.

There are different types of projects. Type 1 are being evaluated rigorously and numerous times since the time of construction, forward. Type 2 also include a rigorous evaluation, but may or may not have included measurements since “time 0”. Type 3 are one-time-only sites to help build a catalog.

Noise measurements have included on-board sound intensity (OBSI), in-vehicle measurements, and pass-by measurements.

Texture is being evaluated using a new device termed RoboTex (Robotic-based Texture measurement system). This has allowed for 3-D texture information to be collected in a continuous fashion down the road at sub-millimeter resolution.

The catalog of noise data collected to date has allowed for sorting and categorization.

A “Zone Concept” has been developed with three zones. Zone 3 is a zone with the loudest pavements – those that should be eliminated by restoration of the surface – and those we should really never want or need to build. Zone 2 is a zone that contains most of the other concrete pavements we build today. A zone where quality is key in that we should strive for the techniques to build among the quietest pavements in this zone. Zone 1 is for innovation. Only extreme pavements such as porous concrete currently fall in this zone, but it is one that if we put our minds to it, we may find solutions here that are also durable and cost effective.

To find quieter solutions, we must find a link to texture. We know that noise can not be predicted by texture depth. While there appears to be a casual relationship in some cases, there are numerous exceptions that can quickly get us into trouble. We instead know that the “bumps and dips” at 1 to 3 inches affect noise more significantly. We must therefore find what causes these (and other texture features that we know to cause problems). Once we find what causes them, we must find better practices for design and construction that eliminate these sources to the greatest degree possible.

Two-lift construction allows us to build a premium mixture on top – one that otherwise would not be affordable full depth. With that premium mixture, an opportunity to maintain the intended texture over time exists. This could be exposed aggregate, but it could just as well be conventional texture.

Discussion/questions

Texas

- Hua Chen: Texas does a lot of CRCP. What is the applicability of the two-lift in this case?
- In Austria, there is no experience with CRCP. In Belgium, CRCP is used, and two lift has recently been tried. There should be no reason why these can’t be used together.
- With Dr. Cable mentioning a 30-60 minute distance between layers – how is spalling treated? In Austria, there has never been a case of debonding.
- Sommer: It is very important that the bottom lift that does not dry or harden before placement of the top lift. This will likely shorten the distance between the layers.
- How long do you typically wait in Austria between lifts? With a spacing of only 4-6 meters, there is typically no more than 30 minutes between lifts.
- Cable: the 30-60 minutes in his presentation is based on old information. Newer pavers and techniques really don’t push this limit anymore.
- Question: Comparison of ADT and loads in the US versus Austria. An 8-inch slab is used in Austria. Texas uses 15 inches of CRCP. What are the traffic differences?
- Cackler: Truck volumes are possibly 8000 per day in Austria. On the Scan, there were a lot of super single tires and three axle vehicles. There appeared to be a lack of weight enforcement in parts of Europe that likely allow overloads.

- Sommer: Rely on the quality of the subbase to allow for thinner sections. Not just the thickness, but the bond between them. The thickness of the stabilized subbase in the US is very thin compared to Austrian practice.
- Sommer: When recycling, then the material must be stabilized to produce as much bearing capacity as possible. This is more cost effective than thickening the concrete surface.

Florida

- Jamshid Armaghani – Florida Concrete Products
- The interest goes back to 1976, US 41 north of Ft. Meyers – 33 test sections in 5 miles. Been evaluating these since. 3-inch surface on 9 inch Econocrete.
- The joints were cut in the 3 inches, and notched in the 9 inches.
- Working well are doweled joints with 15 ft spacings
- Florida DOT is proposing in 2009 for Highways for LIFE using two-lift based on this experience. Possibly rebuilding sections within this test site.
- Cackler: The upper and lower lifts had the same flexural strength requirement. In the US, a "lower quality" is proposed for bottom lift. Are there cautions with this?
- Goodspeed: Comment on drainage.
- Subsurface drainage is very important, but you won't necessarily see dramatic changes. Problems occur when water is present below the surface. Debonding can occur between the asphalt subbase and the slab when moisture is present. This led Austria to using the flat drains under the joint (8 mm thick, 10 cm wide). Some thought they would clog. They did not. Even if they did, it would extend the life. The problem is the shoulder. It should be pervious.
- Porous concrete can be used. France does this in the shoulder. This may be more difficult in Austria because of the ice.

Georgia

- Cackler: there was interest from Georgene Geary in this.
- Luis Rodriguez: he will capture comments and fwd to GA DOT.

Charlie Goodspeed

- A number of States including Georgia have submitted under "Option 1" in Highways for LIFE. Other States have done Option 2 which allows you to match fed-for-fed money.

Gary Hoffman will represent PA

- PA DOT are currently meeting with ACPA on a field tour
- Central PA there are high quality aggregates that can be transported to Western part of the State.
- Question: regarding the thermal coefficient differences between two layers, is there a rule of thumb about the allowable difference?
- Answer: From practical experience, there is often limestone in the base layer and Basalt in the top layer. There has been no difference in performance. Water

below the concrete pavement may induce more of an effect than the temperature differences. There may be a spec in the UK, however.

Gary Hoffman on H4L workshop

- There is a workshop on innovation that H4L is doing. One day. Could be project specific, or could be generic. State provides facilities.
- Who do they contact for a workshop?
- Answer: Mary Huie at H4L HQ 202-366-3039 Mary.Huie@dot.gov

Bernard Izevbekhai from Mn/DOT

- Interface between two layers. It is possible that this technique will be used soon at Mn/ROAD. Have you instrumented two-lift before? Any advice? Specifically the instrumentation used at the interface?
- Answer: No instrumentation experience.
- Question: What kind of pozolanic substitutions are typical?
- Answer: Austria has always used ground granulated blast furnace slag. This has been beneficial for mitigating ASR. They would like to use more, but this may cause a problem with freeze-thaw durability.
- Question: Do you use maturity to determine the intervals in paving? Or use a tool like HIPERPAV?
- Answer: There is no time interval. Only that the bottom layer does not stiffen or harden before the top layer is placed.

Oregon DOT

- Question: Studded tire resistance. Any progress on a solution to slow down studded tire wear?
- Answer: We have had a significant reduction in the number of studded tires in recent years. Previously, ruts formed in concrete. Even still, this was an incentive to use concrete vs. asphalt since it could resist this damage for longer. It is anticipated that there would be deeper ruts in the concrete with the smaller aggregate. Winter service was improved, however, with increasing traffic levels. Studded tires have fallen out of favor since the roads are better.
- Cackler: Where you have had ruts develop, what is the solution? Sometimes with concrete.
- Answer: Fill the ruts.

Iowa FHWA

- Question: Is two-lift used in bridge construction?
- Answer: Long span bridges normally are not paved with concrete due to dead weight. Short span bridges include asphalt interlayer and concrete pavement on top.
- It is very unusual to drive on the concrete structure in Europe.

FHWA NJ

- Can the layers be different thickness?

- Answer: For economics, the surface should be thinner.

Jim Cable, ISU
- What depth of sawing on transverse joints?
- D/4 of total D for transverse, and D/3 for longitudinal. Regardless of the two layer thicknesses.

Gordon Smith, Iowa Concrete Paving Association
- What is w/c of bottom lift?
- Bottom lift is typically 0.42

Leif Wathne, American Concrete Pavement Association
- Question: It seems that noise and recycling have been drivers in Austria with two-lift and exposed aggregate. Has the cost of two-lift been looked at with other alternatives?
- Answer: The exposed aggregate technique does not add much cost. Calculations were made years ago. The $2/sq.m increase maybe. When life cycle costs are considered, then if the traffic is 8000 heavy veh/day or more, concrete is always more economical than asphalt. Even if traffic is lower, it is still better with concrete if traffic is slow or start/stop. It is this 3000-8000 trucks/day range where competition exists between asphalt and concrete.
- All bus stops in Vienna are concrete, for example.
- All intersections and approaches are the same.

Goodspeed
- Thanks to Tom Cackler at the National CP Tech Center, Bergeron at H4L, and Iowa Division, and Dr. Sommer.

Cackler
- This session has been videotaped, and tapes will be made available to participants and others.
- The National CP Tech Center has been asked by FHWA to provide Scan Implementation including Two-Lift Concrete Paving and Exposed Aggregate.
- Tomorrow we meet with the State of Kansas, and we will be joined by representatives with the State of Washington joining us out there.

Goodspeed
- Gina Ahlstrom/Suneel at FHWA – feel free to call on them
- The Transtec Group has helped too.