

Two-Lift Construction Workshop Minutes  
June 28, 2007  
Hosted by Kansas DOT

**Welcome** by District II Engineer of KDOT – the host district. Cackler introduced the project team on behalf of the National CP Tech Center. Washington State sent representatives since they too will be doing a project shortly.

Cackler provided an **overview of the International Scan on Long Life Concrete Pavements**

- Q: Did we see anything on studded tire and surface wear on the Scan? A: This was one of the drivers to look at higher quality materials in the concrete surfaces in Austria. Sommer will cover this more.

Sommer gave a presentation on the **European experience**.

Austria has always used the two-lift concrete paving technique. Since 1990, they have used two-lift combined with the exposed aggregate surface. The climate and traffic in Austria might be comparable to Midwestern states. The EU increased the maximum axle load limit in Austria, which increased their standard PCC thickness from 22 to 25 inches.

- Q: Is a motorway the same as a freeway in the US? A: The same speed and same traffic – some differences in cross section.
- Q: How this is the granular subbase beneath the stabilized layer? A: Typically 30 cm.

Studded tires and snow chains are used in Austria, requiring a durable surface. Debonding has never occurred as long as the layers are placed wet-on-wet. When ruts occur in the concrete due to abrasion, they are commonly filled using a HMA overlay.

In 1990, two drivers appeared – 1) noise (in large part due to the change in the surface from abrasion of studded tires); and 2) reconstruction (thus a need for recycling). Some wanted to ban concrete pavements because of the noise. However, it was demonstrated that there were options for quieter concrete including longitudinal texture, exposed aggregate, and pervious concrete. Comparing the cost, friction, and durability along with noise pointed to exposed aggregate as the optimal surface. When porous asphalt is used on the motorway, those sections are closed down sometimes due to the icing problem since even the police cannot navigate those sections. Looking at the fundamental mechanisms of what leads to a quieter pavement, an exposed aggregate with a maximum 8 mm size meets this requirement.

- Q: What is the designation of PSV? A: Polished Stone Value – originated in the UK.

The recycled coarse aggregate from an existing 2-lane road is enough for 3 lanes of the new concrete pavement (bottom lift). Sieving of the material should be done wet. The

RCA should be kept wet as much as possible to minimize excess water absorption in the new PCC mixture (for the bottom lift). Diabase is a typical aggregate for the top lift. Compressed air is used for the DBI on the paver. The construction traffic (concrete supply) is on the subbase due to minimal clearance. This requires the DBI (vs dowel baskets). Flat drains are used underneath the joints.

- Q: How are the flat drains kept in place? A: By milling a small strip and using faciners.
- Q: What do the drains drain into? A: Ideally, a pervious shoulder. But this doesn't remain pervious.
- Q: What about pervious asphalt? A: This was just tried. Porous concrete too could be used.

The bottom lift must be very stiff for at least 2 reasons: to keep the dowels in place, and to minimize mixing with the top lift. Standard poker vibrators can often lead to mixing. T-shaped vibrators are used instead. A super smoother is recommended for longitudinal profile. The retarder was previously done independent of the curing. The authority didn't want the retarder on the shoulder, but of course needed curing. Now these are combined. The Belgium (Robuco) exposed aggregate technique was found to be overly sensitive to the time of brushing. It also required a wet brush and plastic that was a logistical problem. The Austrian method uses a different compound that included curing (manufactured by BASF), and no plastic since this seemed to trap heat which led to cracking. The curing must be extremely efficient. The spec is 90% efficient, based on an Austrian standard.

The asphalt subbase is milled prior to placement. The stringline is used to predict what the thickness of the concrete will be. If it looks like it will be too thin, the area will be milled. This helps bonding too – and is necessary on steep grades and on approaches to structures.

Brushing will occur in maybe 5 hours when warm, and maybe 12-16 hours if cooler. It is done in short segments. A loader pushes the latency off the shoulder.

The sawcut is outfitted with a vacuum to pull the slurry out. It is D/4 on the transverse joints, and D/3 on longitudinal (of the entire thickness). The cement used contains 15-25% GGBFS (blended at the mill).

- Q: Is this the same cement for both lifts? A: Yes.

In addition to standard materials tests, a test slab should be constructed for the application rate and timing of the mortar removal. This will be a function of the mix.

- Q: Can you use the maturity meter to determine when to brush? A: Yes, but really it is something that the superintendent will need to make the call on.

Splitting tensile testing of a rectangular prism allows multiple tests to be made on the same specimen. For control.

The contractors fought the requirement for noise and friction, but these were set where they could be easily met as long as everything is constructed reasonably. The only complication was when new laboratories were beginning to measure noise, and there were differences in the measurements between the labs (reproducibility).

The larger aggregate (11 mm) is used in areas that were believed to require more friction – the intent is to have deeper texture that would be more compatible on roads with more trucks or buses. The exposed aggregate surface wears slowly. It is durable. The harder the aggregate and the deeper the texture, the better the noise reduction. Exposed aggregates have been found to be stable in their noise level over time. The porous asphalt was quietest initially, but increased in level quickly over time. Exposed aggregate is a sensitive technique.

- Q: What size vibrators are used? A: 7 cm diameter for the top lift. The first paver uses the standard vibrators (maybe 10 cm). One contractor uses the same T-shaped vibrators for the bottom lift too.
- Brushing is always done dry. If there is dust, however, that means that the curing was likely inadequate.
- Q: What would you recommend to a new contractor? A: Have a contractor that has an attention to quality.
- It took about 2 years to perfect the correct retarder and correct brushing.
- Get samples from Austria.
- Q: Can we get the names of the manufacturers? A: Yes.
- Q: You mention a spread of 300 mm – what is “spread”? A: German fluid table.
- You may be able to use a lower stiff concrete on the bottom, and just modify the process accordingly.
- Cackler mentioned the possibility of bringing the mobile lab down – with the float table, etc.

### **Rob Rasmussen presented on the National CP Tech Center project on Concrete Pavement Surface Characteristics.**

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.

### Andy Wyckoff talked on the **I-70 reconstruction project**

Westbound Rest Area will be location of test section

- \$23.9 million total project cost
- 340 mm dowelled JCP
- 100 mm cement treated base
- 150 mm granular subbase
- Full depth concrete shoulders

Two lift will be done in 2008 on the mainline. The cement treated base was increased to 150 mm and the granular subbase was dropped from the main lanes. \$1.1 million total savings – this will be used to help offset the cost of the two lift.

- Want to know when to best sweep the surface.
- When the slab is strong enough to support the power broom, is it too late.

There will be a limestone aggregate in the bottom – a quartzite or a granite in the top lift. Concern with raveling. Like the test strip to see what will happen. How do we get a consistent 50 mm top lift across the section? At the end of the day, we hope that it has economic value – and that it produces a more durable quiet pavement.

- Q: How is the subgrade going to be constructed given the cross slope breaks? A: It will be an irregular shape.
- Discussion about cross section of proposed pavement.

### Rod Montney – KDOT, **I-70 two-lift construction**

TxDOT is running PSV values. Three aggregates have been found – 300 to 500 miles away: Arkansas (may not meet spec) Granite, South Dakota Quartzite, Wyoming Granite. Mortar sand out of Junction City is OK. Wyoming granite has ASR probs – so 25% ash was used – probs getting air though.

FHWA is doing Mod. Of Elasticity and CTE. C666 being done by KDOT. ASR C-1567 will be run by FHWA. Wet-on-wet bond test undetermined. Euclid is going to do a viscosity modifying admixture allows the PCC to be fluid during placement, but set fast.

In 2008, we may look at recycling existing concrete and HMA into the bottom lift. Exposed aggregate, grinding, drag, long. Tining. May also try an “optimized surface course” with the premium aggregate.

Plasticizer may help with segregation. Fly ash should help with segregation too (compared to just cement). Fly ash seems to be a problem with the air.

## Q & A

- Q: Have you tried both slag and ash? A: Storage may be a problem.
- Sommer says that the quality of the concrete is well described by strength. It would be ideal to have the same modulus of elasticity of both layers.
- Q: What about the CTE between the two layers? A: Not bothered about this.
- Q: The curing efficiency was mentioned – 90% - how is this measured? A: There is a special test using warm air blown over a test slab. The mass loss of the specimen is noted.
- Curing must be applied immediately after floating.
- Q: How do you improve the efficiency? A: Application rate. Time of application (immediately). The efficiency will of course be a function of the material. 250 g/sq.m is typical application rate.
- Q: How does the air temperature of the cure test relate to that of what you find in reality? A: It is just one temperature.
- The National CP Tech Center will obtain and translate relevant test standards.
- The combination of retarder and cure has met the spec.
- The air temperature is about the same as in Kansas.
- Q: What surface retarders are used? A: It is a one-part product: cure and retarder.
- Q: Are these mixed in the field? A: No
- Q: When the curing is followed up, what is used? A: Regular cure – cheaper product.
- There is no compatibility issue with the cure and surface retarders used in the USA
- Q: How sensitive is the application coverage rate of the retarder? A: There is some influence.
- Q: The asphalt subbase used in Austria – how impermeable is it? A: It is dense grade, 11 mm top size.
- Q: What is the limit of HMA as coarse agg in the lower lift of PCC? A: Average of 10% is used, but up to 20% of the coarse aggregate can be HMA.
- The percent of asphalt is not very important, but uniformity is critical. This should be closely monitored.
- Q: In the CTB section, is there milled asphalt? A: 25% typical, but up to 50% can be used.
- Q: Is the CTB mixed at a plant? A: No, it is mixed in place. Largely due to the high production rates – would require a big plant and a lot of trucks.
- Q: What is the strength requirement? A: Low
- Q: What fractions come out of the crushed? A: 0/4, 4/8, 8/16, and 16/32 fractions from recycled concrete
- Q: And it should be kept wet? A: Yes.
- Some problems in Kansas with RCA previously, but it was not kept wet.
- Q: What are the tolerances for thickness? A: No tolerance for total thickness.
- The top lift must have a minimum thickness, and is based on cores. Less than 2 cm is bad.
- Q: Is it a problem to have the surface wrap down the sides? A: No

- Q: What about tie bars? A: Two piece tie bars will be sensitive to stability.
- Q: How long between lifts? A: It is most important that the top lift be placed ASAP before the bottom lift hardens. There is now no minimum time.
- Q: Have you sprayed retarder between lifts? A: No.
- Q: There are retarders that you can spray on the bleed water? A: Yes.
- It is recommended that you start with the Austrian combination cure/retarder.
- Q: Any manual work on the surface? A: Only on the edges (normally).
- Q: Do you use dowel baskets? A: Almost never. Only with hand work (fixed form). This isn't a problem if you have parallel haul roads though.
- Q: What about rain showers? A: This was a concern and why they started with plastic. But this caused more problems due to heat buildup. Plastic is still kept onsite for a sudden rain. Rain on the new concrete may cause it to be a little rougher.
- Q: The mix being proposed for the surface looks like it might have a bad response for air and thus freeze-thaw. A: We too look at air. They do spacing on hardened specimens. They differentiate spherical and irregular voids.
- Q: Any difference in the air system on top and bottom lifts? A: No, the same.
- Q: Modulus checks on the two lifts? A: Not routinely. They want high modulus due to high durability. The modulus was just as high as the bottom lift.
- Q: The extra cement is to hold the aggregates in place? A: It is recognized as a bad mix design, but it works.
- The BASF material has a spec sheet in German language. We can maybe help facilitate acquiring the material.
- Q: Is the DOT writing a spec? A: There will be a change order – at the very least, for the specification.
- The test section this summer will help in finalizing the specification for the mainline section in 2008.
- On the rest area, the risk will be held small in terms of new equipment. The mainline section scope will drive what equipment modifications are made.

#### Afternoon Meeting with WSDOT on **Two-Lift Paving in Washington State**

##### High performance concrete mix that can resist the wear caused by studded tires

- 650 lbs of cementitious material – 125 lbs can be a fly ash
- 0.42 is the spec for w/cm – 0.34 is used now
- 1-1/2" max #467 coarse
- Gap is between #4 and #40
- 60% sand, 40% coarse agg is the current aggregate blend

Using more coarse aggregate helped to increase the wear resistance – 70% coarse aggregate worked best. Even still, this did not prevent rutting... it just delayed it. Now requiring a lightweight stud, and limit the time of year. Reducing the stud protrusion to 1.1 mm helped in Austria. Use a stone with a LA abrasion below 20. The mortar eroded as a result of this, exposing the aggregate. Can a thicker top lift be used – originally, 6 cm was used in Austria.

Increasing from 40% to 70% coarse aggregate could possibly double the life of the pavement. This will likely introduce a noise problem. To keep the noise from being too bad, reducing the maximum aggregate size is a possibility. Reducing the size will lead to more wear. The 4/11 gradation is a good compromise in Austria. 4/12 or 4/13 could be considered possibly. Austria is trying to minimize the thickness of the top layer, but maybe in WA they could use 3 inches.

Forget about the PSV – the studded tires will roughen the aggregate – focus on LA. Alaska has done some studies finding a weak correlation between LA and studded tire wear. There are a number of accelerated wear tests – but these are really for just convincing people. Studded tires in Austria has decreased substantially because of the increased winter maintenance. Other additives seem to have little benefit. Artificial aggregates from chrome slag seem to work but are expensive. Industrial byproducts might be worth looking at. Very minor amount of reactivity. Should find a way to accelerate wear... and maybe a loan of RoboTex for subtle early texture wear.

What kind of modifications to the paver – specifically the vibrators? First do a small area – fixed forms with superplasticizer. Next ensure that there is minimal intermixing on a short pull. Exposing the aggregate is not important if studded tires will be doing this anyway. The consistency of the top concrete should be “softer” than the bottom. Use a modified vibrator (not a poker). “Softer” = more responsive to vibration.

Box vibrator, tamper bars, or a pan vibrator might be alternative to the T-vibrators. Flow table – not only look for response to vibration, but also for segregation during test. Initial texture – carpet drag should be fine.

- Q: Is there a draft spec available? A: There will be stuff posted on the Center’s website shortly including the latest Austrian spec

Room for improvement? Less cement, other vibrators – the current cement content reported is a “conventional.” Is there a minimum cement content in the bottom if there is a lot in the top? Experience has not shown any problems with different materials in both layers. Any damage that was found is not because of dissimilar materials.

Present design matches the modulus of elasticity. Not sure about older pavements. Springenschmid was working on bimetallic effect research. In the lab, they found differences, but not important. There are practical examples. Henry Russell showed that if the moduli are different, there could be problems (NCHRP study). The higher modulus will be compensated for with a higher strength.

- Q: Rob asked Goodspeed about 96 dBA OBSI goal in H4L. If we don’t come close to this, is this a problem? A: Show that you are targeting a benefit over the state of the practice, and that will be judged favorably.