Performance of Permeable Friction Courses

NCHRP 9-41

L. Allen Cooley, Jr.
Presentation Outline

- Definition
- Benefits
- Maintenance
- Rehabilitation
- Performance
- Conclusions
Definition

- PFCs are OGFC mixes that are specifically designed to have high in-place air voids
  - Air Void Contents greater than 18%
Benefits of PFCs

- Benefits Were Categorized Based on Three Areas
  - Safety Related
  - Driving Comfort
  - Environmental
Benefits

- Safety Related Benefits
  - Reduced Potential for:
    - Hydroplaning
    - Splash and Spray
    - Light Reflection (Glare)
  - Improved
    - Skid Resistance (Especially During Wet Weather)
    - Visibility of Pavement Markings (Especially at Night)
Benefits

- Safety Related
  - Reduced Wet Weather Accidents
    - Virginia SR 23 – Reduced from 39% of all Accidents to 17%
    - France A7 Motorway – Number of Accidents Fell from 52 (over 6 yrs) to none (over 4 yrs)
    - Canada – Reduced 55%
    - Austria – No Difference in Dry Weather but “Fewer” Wet Weather
    - Japan – 80% Reduction
Benefits

- Driver Comfort Related
  - Driver Confidence in Rain Events
    - Less Splash/Spray
    - Less potential for Hydroplaning
    - Results in Improved Capacity
  - Less Glare at Night on Wet Surfaces
  - Better Visibility of Pavement Markings
  - Improved Smoothness
Benefits

- Environmental
  - Reduced Tire/Pavement Noise (3-5 dB(A))
  - Pavement Smoothness
    - Improved Fuel Economy
  - Use of Waste Materials
    - Ground Tire Rubber
    - Fibers
Benefits

- Environmental
  - Improved Quality of Stormwater Runoff from pavement surfaces
  - Cool Pavement Option to combat Urban Heat Island
Maintenance

- Divided into Two Categories
  - General Maintenance
  - Winter Maintenance
Maintenance

- General Maintenance
  - Cleaning Clogged Surfaces
  - Preventative Surface Maintenance
  - Corrective Surface Maintenance
Maintenance

- General Maintenance
  - Cleaning Clogged PFC
  - Should be Started While Still Permeable
    • Not Being Done in US
    • Some Research in Europe
    • Methods
      – High Pressure Hose
      – Truck Mounted “Suck-Sweep” System
Maintenance

- Preventative Surface Maintenance
  - Fog Seals Have Been Used in the Past
    - Fog Seals will Reduce Permeability
    - Do Not Affect Macrotexture
    - Research In Oregon Concluded that Expected Benefits To Prolong Life Were Not Substantiated.
  - Texas Has Used Seal Coats Over Distressed Areas
Corrective Surface Maintenance

- PFCs Can Be Patched
  - Small Patches Can Be Made with Dense-Graded Mix
    - Rotate 45 deg. (Diamond Shape) So Water Will Flow Past.
  - Large Patches Should Be with PFC
  - When Patching, Only a Light Tack Coat Should Be Applied to Vertical Faces
Winter Maintenance
- Each Agency/Paper Describes Different Techniques
- One Constant – More Deicing Materials Are Needed for PFCs
Maintenance

- Winter Maintenance

  - Quotes From Literature
    - “… no definitive solution for winter maintenance..” Padmos Denmark (2002)
    - “…Since the behavior of the road salts on PFC surface is so different, special locally adjusted strategies are needed.” Griebe ISAP (2002)
    - “…experience is the only true method of developing a winter maintenance program.” Brousseauaud et al France 2005
Maintenance

Winter Maintenance

- Advantages of PFC (Isenring et al, Switzerland, 1990)
  - Ice does not generally form on wet PFC surfaces
  - High level of macrotexture is beneficial
  - Tendency of ice formation within wheel path covered in snow is reduced due to macrotexture, permeability, and limited thaw.
Maintenance

Winter Maintenance

– Disadvantages (Isenring, et al)
  • Need for more deicing salts
  • Use of “grit” to improve friction not viable
  • Snow and ice tend to stick to PFC sooner because the surface is generally cooler
  • Snow and icing rain can form earlier on PFC because deicing salts do not stay on surface
  • Preventative salting is not as beneficial
  • Some icing problems can occur in initial portion of dense-graded surface (lack of salt transport)
Maintenance

Winter Maintenance

  • Monitored Salinity Concentrations on Pavement Surface (Dense-Graded and PFC)
  • Concluded That Rate of Decrease in Salinity Concentration WasGenerally Less on PFC Surfaces
  • Circulation Due to Interconnected Voids and Traffic
Maintenance

- Winter Maintenance
  - Deicing Salts
    - 25 to 100 % more for PFCs (Greibe, 2002)
    - 25 to 50 % more (Litzka, 2002) (Austria)
    - 30 % more (Giuliani, 2002)
    - 100% more in Slovenia (Litzka, 2002)
    - 25% more in Netherlands (Litzka, 2002)
  - Why More?
    - Different Thermal Properties
    - Reaches Freezing Sooner, Stays at Freezing Longer
    - Interconnected Voids
Maintenance

- Winter Maintenance
  - Interesting Observation
    - In Italy, a change from a 20 mm MAS to a 16 mm MAS PFC led to a significant improvement in road conditions during winter events.
Maintenance

- Winter Maintenance
  - Observation
    - Pumping Action Caused by Traffic May Circulate Salt Solution Within Void Structure
    - May Explain Iwata et al Observation About Salinity Concentration
    - Bennert and Cooley (2006) Showed an Influence of Traffic Volume on Friction Test Results – Design Lane = Higher Friction
Rehabilitation

- Typical Distresses
  - Raveling, Delamination, Cracking
Rehabilitation

- Minor Rehabilitation Strategies Similar to Dense-Graded Layers
  - Must Maintain Drainage Characteristics
  - Discussed Under Corrective Surface Maintenance
Rehabilitation

- Major Rehabilitation
  - Replacement of Entire Layer
  - Mill and Replace with Another PFC or Other Layer
  - Georgia Has Expressed Concern with Milling
    - Grooves May Hold Water
    - Investigating Micro-Milling
Rehabilitation

- Major Rehabilitation
  - Inlays Are Not Recommended for PFC
    - Drainage Characteristics
  - Overlaying with Dense-Graded Layer Not Recommended
    - Trapped Moisture – Stripping
  - Some Success with Hot In-Place Recycling
    - However, No Specific Report found
    - Cited in a Paper
Performance

Categories (Huber, 2000)
- Service Life – Length of Time Pavement Maintains Its Frictional Properties and Smoothness
- Service Life Generally Longer
Performance

- Service Life
  - Vast Majority of Reports/Papers Suggest About 10 years.
  - 1998 Survey Indicated 8 years or more
  - Friction Not Followed over Service Life
    - Single Reference (Georgia)
## Performance

**Santa, 1997**

<table>
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<tr>
<th>Test Section Designation</th>
<th>Friction Number (ASTM E274)</th>
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<tr>
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<td>10/27/92</td>
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<tr>
<td>Std. OGFC (d)</td>
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<tr>
<td>Coarse OGFC (D)</td>
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<td>D + Cellulose Fibers (DC)</td>
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<td>D + SB Polymer (DP)</td>
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<td>D + 16% Crum Rubber (D16R)</td>
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</table>

PFCs Tend to Have Low Friction Immediately After Construction. When Binder Wears Off, Friction Improves
Performance

- Service Life
  - Puncher (2004)
    - PFCs Deteriorate Slowly for first 5-10 yrs, Then Deterioration Increases
  - Smoothness Seems To Be Most Applicable Problem
    - Even Clogged PFCs Maintain High Macrotexture
Performance

- Performance Life
  - Larger MAS Maintain Permeability Longer
  - PFCs with Higher Air Void Contents Maintain Permeability Longer
Performance

- Literature Explicit that PFCs Reduce Tire/Pavement Noise
- 3 dB(A) Most Commonly Cited Reduction in Noise
  - Shown By Sound Intensity, Wayside Measurements, and CPX Trailer
  - Some Researchers Indicated Up To 6 dB(A) Reduction
Performance

- Performance Life
  - No Literature Followed Noise Reduction Over Time
  - Thicker Lifts Said To Absorb More Sound
  - Macrotecture Seemed More Important Than Permeability In Sound Absorption
Conclusions

- PFC Layers Have Many Benefits – Mostly Related to Safety
- Design of PFC Contains Four Steps
- Inclusion Within Pavement Design Varies – A Lot Left To Learn
- Construction Similar to SMA
  - Fiber Hoppers and Introduction
  - Draindown
Conclusions

- Method for Cleaning PFCs Needed
- Work is Needed To Determine Winter Maintenance Guidelines
- Mill and Replace Most Common Rehabilitation Activity
- There Are Specific Limitations That Should Be Considered
Thanks!
Questions?

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