Update on Permeable Friction Courses (PFC) in Texas

Louisiana Transportation Conference
Baton Rouge, LA.
January 10, 2011

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Flexible Pavements Branch
TxDOT’s Mission Statement

The mission of the Texas Department of Transportation is to provide safe, effective and efficient movement of people and goods.

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PFC Introduction

➢ TxDOT used Open Graded Friction Courses (OGFC) in the 1970’s and 1980’s
➢ TxDOT discouraged the use of OGFC in the early 1990’s due to durability issues
➢ TxDOT began using Asphalt Rubber OGFC in the 1990’s
➢ TxDOT began using new generation OGFC (termed PFC in Texas) in the 2000’s
➢ PFC is typically placed 1.25 in. to 2.0 in. thick
PFC Introduction (cont’d)

- TxDOT has several versions of PFC
  - PFC – Uses PG 76-22 and fibers
  - PFC-AR – Uses asphalt rubber and aggregate with a “finer gradation”
  - TBPFC – Thin bonded PFC – regular PFC placed with a spray applied membrane – (NovaChip paver)
- TxDOT often bids PFC with an underseal as an alternate to TBPFC
- TxDOT also uses Ultra Thin Bonded Wearing Course (UTBWC) which is better known as NovaChip
Number of PFC Projects in Texas

![Bar chart showing the number of PFC projects in Texas from 1994 to 2010. The highest number is in 2005 with 71 projects, followed by 2010 with 60 projects. Some years have significantly fewer projects, such as 1996 with 3 projects.]
PFC (with PG Binder Only)
Asphalt Rubber PFC (PFC-AR)
Thin Bonded PFC

Total Quantity (Tons) vs. Average Price ($/Tons)

- Quantity (Tons):
  - 2004: 25,000
  - 2005: 70,000
  - 2006: 10,000
  - 2007: 15,000
  - 2009: 10,000
  - 2010: 130,000
- Price ($/Tons):
  - 2004: 0
  - 2005: 0
  - 2006: 0
  - 2007: 0
  - 2009: 0
  - 2010: 150
Ultra Thin Bonded Wearing Course (ie NovaChip)
Why TxDOT Uses PFC

- Enhanced safety
- Reduced pavement noise
- Improved ride quality
- Improved vehicle fuel efficiency
- Improved quality of storm water runoff
THE BIG QUESTION

ARE THEY SAFER?
Highway Safety

- For most people, driving is the most dangerous activity that we are ever involved with.
- By 1950, more Americans were killed in auto accidents then were killed in both world wars.
- A high percentage of accidents happen in intersections and in horizontal or vertical curves.
- Wet weather accidents account for a high percentage of highway fatalities.
How Can PFC Mixes Improve Safety?

- Reduces the risk of hydroplaning
- Drains the water off the roadway quicker
- Reduces spray
- Reduces glare
- Improves visibility of traffic markings
- Coarse macro-texture improves frictional characteristics

Question: Can we prove that these things actually reduce the occurrence of wet weather accidents?
US 183 – Williamson Co.
South Bound near San Gabriel River

Click on image below to show video
RM 1431 – Travis County
WBL – Between Cedar Park and Jonestown

Click on image below to show video
RM 1431 – Travis County – Pictures from Feb 14, 2004
2001 – 2003: 64 Wet Weather Accidents
Note: Project length is only 2 miles long
Safety is a Major Quality of Life Issue
Table 1. Accident Data for RM 1431 (2001-2007)  
(PFC mixture was placed in February 2004)

<table>
<thead>
<tr>
<th>Year</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>AVG 2001 to 2003</th>
<th>AVG 2004 to 2007</th>
<th>% Change in Avg since PFC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total # of accidents</td>
<td>25</td>
<td>48</td>
<td>36</td>
<td>17</td>
<td>6</td>
<td>22</td>
<td>21</td>
<td>36.3</td>
<td>16.5</td>
<td>-54.6</td>
</tr>
<tr>
<td>Dry weather accidents</td>
<td>10</td>
<td>22</td>
<td>13</td>
<td>15</td>
<td>5</td>
<td>21</td>
<td>19</td>
<td>15.0</td>
<td>15.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Wet weather accidents</td>
<td>15</td>
<td>26</td>
<td>23</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>21.3</td>
<td>1.5</td>
<td>-93.0</td>
</tr>
<tr>
<td>Fatalities</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2.0</td>
<td>0.5</td>
<td>-75.0</td>
</tr>
<tr>
<td>Total injuries</td>
<td>25</td>
<td>16</td>
<td>21</td>
<td>6</td>
<td>2</td>
<td>13</td>
<td>9</td>
<td>20.7</td>
<td>7.5</td>
<td>-63.7</td>
</tr>
<tr>
<td>Incapacitating injuries*</td>
<td>6</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>4.3</td>
<td>0.5</td>
<td>-88.5</td>
</tr>
<tr>
<td>Non-incapacitating injuries</td>
<td>19</td>
<td>12</td>
<td>18</td>
<td>6</td>
<td>1</td>
<td>5</td>
<td>4</td>
<td>16.3</td>
<td>4.0</td>
<td>-75.5</td>
</tr>
<tr>
<td>Annual rainfall (inches)</td>
<td>42.9</td>
<td>36.0</td>
<td>21.4</td>
<td>52.0</td>
<td>22.3</td>
<td>34.7</td>
<td>47.0</td>
<td>33.4</td>
<td>39.0</td>
<td>16.7</td>
</tr>
<tr>
<td>Total rain days (&gt;0.1 in.)</td>
<td>57</td>
<td>56</td>
<td>37</td>
<td>70</td>
<td>45</td>
<td>43</td>
<td>72</td>
<td>50.0</td>
<td>57.5</td>
<td>15.0</td>
</tr>
</tbody>
</table>

* Some of these injuries later became fatalities  
Source: Cedar Park Police Department & Austin Mabry Weather Station
Are They Comfortable?

- The average International Roughness Index (IRI) for PFC projects in Texas is less than 60 in./mi. which is considered excellent.
- Many PFC projects are in the 40-50 in./mi. range. Example: Sheldon Hays award winner in Texas had an average IRI of 43 in./mi.
- We have measured noise reductions of more than 8 dB when using PFC as an overlay strategy on rigid pavements.
### Ride Quality Summary (Item 585)

<table>
<thead>
<tr>
<th>Description</th>
<th>Pay Schedule 1</th>
<th>Pay Schedule 2</th>
<th>Pay Schedule 3</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HMA</td>
<td>PCC</td>
<td>Both</td>
<td>HMA</td>
</tr>
<tr>
<td>Number of Projects</td>
<td>92</td>
<td>2</td>
<td>94</td>
<td>139</td>
</tr>
<tr>
<td>Total Bonus Paid ($)</td>
<td>2,392,199</td>
<td>-67,672</td>
<td>2,324,527</td>
<td>3,073,614</td>
</tr>
<tr>
<td>Average Bonus Per Project ($)</td>
<td>26,002</td>
<td>-33,836</td>
<td>24,729</td>
<td>22,112</td>
</tr>
<tr>
<td>Average Bonus Per Lane Mile ($)</td>
<td>1,550</td>
<td>-4,527</td>
<td>1,491</td>
<td>1,338</td>
</tr>
<tr>
<td>Total # of Bumps</td>
<td>1,300</td>
<td>101</td>
<td>1,401</td>
<td>2,747</td>
</tr>
<tr>
<td>Average # of Bumps Per Project</td>
<td>14.1</td>
<td>50.5</td>
<td>14.9</td>
<td>19.8</td>
</tr>
<tr>
<td>Average # of Bumps Per Lane Mile</td>
<td>0.84</td>
<td>6.76</td>
<td>0.90</td>
<td>1.20</td>
</tr>
<tr>
<td>Average IRI (in./mi.)</td>
<td>51.3</td>
<td>71.0</td>
<td>52.2</td>
<td>54.9</td>
</tr>
<tr>
<td>Total Length (miles)</td>
<td>1,544</td>
<td>15</td>
<td>1,559</td>
<td>2,298</td>
</tr>
<tr>
<td>Average Miles/Project</td>
<td>16.8</td>
<td>7.5</td>
<td>16.6</td>
<td>16.5</td>
</tr>
</tbody>
</table>

Data obtained from TxDOT’s Site Manager database. Data represents projects built between 2004 and 2010. Note that numerous other projects have been built under Item 585 since 2004; however, the ride quality data was not provided or was not available in the Site Manager database.
Table 3: Mainlane IRI Values from PMIS

<table>
<thead>
<tr>
<th>Year</th>
<th>Interstate Highways (IH)</th>
<th>United States Highways (US)</th>
<th>State Highway (SH)</th>
<th>Farm to Market (FM)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ACP</td>
<td>CRC</td>
<td>JCP</td>
<td>ACP</td>
</tr>
<tr>
<td>2006</td>
<td>76.8</td>
<td>107.9</td>
<td>125.9</td>
<td>92.6</td>
</tr>
<tr>
<td>2007</td>
<td>75.5</td>
<td>106.5</td>
<td>126.1</td>
<td>92.8</td>
</tr>
<tr>
<td>2008</td>
<td>78.0</td>
<td>112.0</td>
<td>139.9</td>
<td>93.6</td>
</tr>
<tr>
<td>2009</td>
<td>72.4</td>
<td>106.2</td>
<td>124.4</td>
<td>91.6</td>
</tr>
<tr>
<td>2010</td>
<td>70.6</td>
<td>104.4</td>
<td>122.8</td>
<td>90.1</td>
</tr>
</tbody>
</table>
# Tire/Pavement Noise Sound Intensity

## Flexible Pavement Test Sections - TxDOT & CTR

<table>
<thead>
<tr>
<th>Test Section</th>
<th>Overall Level (dBA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>US281/PFC_AR1 10/9/06</td>
<td>94.9</td>
</tr>
<tr>
<td>US281/PFC_AR1 9/3/08</td>
<td>95.7</td>
</tr>
<tr>
<td>US90/PFC</td>
<td>96.6</td>
</tr>
<tr>
<td>IH35/PFC</td>
<td>98.1</td>
</tr>
<tr>
<td>US281/PFC_AR 2 10/9/06</td>
<td>98.1</td>
</tr>
<tr>
<td>FM1431/PFC</td>
<td>98.1</td>
</tr>
<tr>
<td>US290 Y6/PFC</td>
<td>98.1</td>
</tr>
<tr>
<td>IH10 Y5/PFC 8/7/08</td>
<td>98.1</td>
</tr>
<tr>
<td>SH6/PFC</td>
<td>98.1</td>
</tr>
<tr>
<td>FM734/CMHB-C</td>
<td>98.1</td>
</tr>
<tr>
<td>SH130/CRCP 6/2/08</td>
<td>98.1</td>
</tr>
<tr>
<td>US290/CRCP</td>
<td>98.1</td>
</tr>
<tr>
<td>US183/CRCP</td>
<td>98.1</td>
</tr>
</tbody>
</table>

**Overall Level (dBA):**
- Not PFC

**Test Section:**
- US281/PFC_AR1 12/6/06
- US281/PFC_AR 2 9/26/07
- US281/PFC_AR 2 12/6/06
- IH35 NB/PFC
- US281/PFC_AR 2 10/9/06
- IH35 Waco/PFC 9/29/06
- SH6/PFC 9/4/08
- IH35 SB/PFC
- US290 Y1/PFC
- SH146/PFC
- IH45/PFC
- IH30/PFC After
- SH6/PFC
- US290/Y1/PFC
- FM1431/PFC
- IH30/CRCP Before
- US281/CRCP
- SL8/CRCP
- FM1826/ChpSeal

**Not PFC:**
PFC Mixes May Even Be Environmentally Sensitive?

- A study by the Austin district “accidentally” discovered that the storm water quality significantly improved after a PFC mix was placed on Hwy 360.

- Gary Lantrip (environmental specialist) of the Austin district believes the PFC slows the flow and filters the water. More research is under way.
Investigations in the use of PFC for storm water quality

J. Gary Lantrip

Austin District
## Comparison of Average Edge of Pavement Concentrations

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Conventional Asphalt</th>
<th>Porous Asphalt</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSS (mg/L)</td>
<td>117.8</td>
<td>8</td>
</tr>
<tr>
<td>TKN (mg/L)</td>
<td>1.13</td>
<td>0.54</td>
</tr>
<tr>
<td>NO3/NO2-N (mg/L)</td>
<td>0.43</td>
<td>0.40</td>
</tr>
<tr>
<td>Total P (mg/L)</td>
<td>0.13</td>
<td>0.23</td>
</tr>
<tr>
<td>Dissolved P (mg/L)</td>
<td>0.036</td>
<td>0.077</td>
</tr>
<tr>
<td>Total Cu (µg/L)</td>
<td>26.8</td>
<td>5.7</td>
</tr>
<tr>
<td>Total Pb (µg/L)</td>
<td>12.6</td>
<td>0.7</td>
</tr>
<tr>
<td>Total Zn (µg/L)</td>
<td>167</td>
<td>45</td>
</tr>
<tr>
<td>Dissolved Cu (µg/L)</td>
<td>5.9</td>
<td>3.9</td>
</tr>
<tr>
<td>Dissolved Pb (µg/L)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Dissolved Zn (µg/L)</td>
<td>47</td>
<td>34</td>
</tr>
<tr>
<td>COD (mg/L)</td>
<td>64</td>
<td>30</td>
</tr>
</tbody>
</table>
PFC Usage Summary

- Approximately 370 PFC projects have been built/let since year 2000 (avg. 37 per year)
- Approximately 3.8 million tons (approx 8,000 lane miles) of PFC has been placed/let since year 2000. TxDOT has 195,000 lane miles.
- Overall performance has been excellent. Expected life is 10 – 14 years.
- Of the 370 PFC projects, there are 4 known projects (all PFC-AR) that have required heavy maintenance or rehabilitation.
- PFC mixes are unmatched in terms of safety. They are most beneficial on undivided highways with curves, intersections etc.
- PFC mixes are the most complimented of all mixes used in Texas.
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Quality Paving Awards

- TxAPA & TxDOT have a quality paving awards program that recognizes the best HMA paving projects in Texas each year.
- Teams of evaluators rate each HMA project. There are 2 rounds of evaluations with 2 independent teams.
- Over the last 6 years, PFC projects dominated the awards so much so that PFC was placed in a separate category.
- Overlay small & large, full depth small & large, open graded small & large.
Wearing Course Performance

- Approximately 80% of all HMA in Texas is conventional dense graded or Superpave.
- For premium performance, TxDOT uses PFC and/or SMA. Mix of choice on Interstate Highways.
- Future direction of wearing courses
  - Cost reduction
  - Thinner lifts, smaller nominal aggregate size
  - Target mixes that can be placed 0.5 in. to 1.5 in. thick
  - Currently researching all options of thinner SMA, PFC and other friction courses.
Conclusions

- Accident data shows that PFC mixes are effective at reducing the occurrence of wet weather accidents.
- PFC should not be used everywhere but the use of PFC should be strongly considered in areas prone to wet weather accidents such as undivided highways.
- Safety is a very high priority in TxDOT’s mission and vision and the effective use of PFC mixes may have more influence on safety than previously thought.
- PFC meets TxDOT’s vision of Comfort, Safety and Durability and appears to have environmental benefits.
A-R PFC on CRCP
IH 35 San Antonio, Fall 2002
Type “D” Hot Mix

PFC