PCCP/ABC Combinations For Lower Volume Routes

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Design Principles

• Roadbeds for a concrete pavement structure should:
  – Should be uniform and constructed of a material that will provide requisite stability over the life of the pavement
  – Resist erosion
Design Principles

- PCC pavements are rigid
- Vehicle loads are distributed over large areas (beam strength) (15-20 ft)
- Minor deflections
- Low subgrade pressures
- Subgrade uniformity is more important than strength
Design Principles

- Asphalt pavements are flexible
- Distribution of loads depends largely on pavement thickness
- Load on subgrade is more concentrated
- Deflections are much higher
- Subgrade strength/stiffness is very important
Design Principles

- Concrete pavement design thickness is relatively insensitive to support stiffness (modulus of subgrade reaction)
Design Principles

• Overzealous engineering of a roadbed could have a negative effect once all loads are considered.
**Case 1:** The foundation is perfectly rigid.

Applied Load

- **Ematerial = \( \infty \)**

Due to the perfectly rigid foundation, no deflections or flexural stresses develop.

Loss of support results in high stresses in the concrete slab upon loading.

- **Ematerial = \( \infty \)**

During environmental loading, the foundation does not conform to the slab and support is lost.

**Case 2:** The foundation is very flexible.

Applied Load

- **Ematerial = 1 psi (0.007 MPa)**

Due to the lack of support, the concrete slab is free to deflect and high flexural stresses develop.

During environmental loading, the foundation conforms to slab, maintaining support.

- **Ematerial = 1 psi (0.007 MPa)**
So what can go wrong?

• Pumping
„Pumpeffekt“

Herausgepresstes Wasser

Betonfahrbahn-Decke

Dichte Trag-Schicht

Angesammelte Teinteile

Erosion
Pumping

• For pumping of a subbase to occur, several conditions must exist:
  – The pavement must have undoweled joints or joints with poor load transfer
  – Water must be present
  – The roadway must have fast moving, heavy loads
  – The subbase must be an erodible material

• Eliminating one or more of these casual factors should mitigate pumping.
Subbase material properties

• Less than 15 percent passing the No. 200 (75 μm) sieve
• An in-place density of 95 percent according to AASHTO T99
• A Plasticity Index (PI) of 6 or less
• A Liquid Limit (LL) of 25 or less
How do regional ABC specs compare?

- Less than 15 percent passing the No. 200 (75 μm) sieve
  - NCDOT: 13% max
  - SCDOT: 12% max (Macadam and Recycled PCC)
  - SCDOT: 20% max (Marine Limestone)
  - GDOT: 11% max (Group 2 – Granite)
  - GDOT: 15% max (Group 1 – Limestone)
How do regional ABC specs compare?

- In-place density of 95 percent according to AASHTO T99
  - NCDOT: 100% T180
  - SCDOT: 100% SC-T-140 ≈ T180
    (Macadam and Recycled PCC)
  - SCDOT: 100% SC-T-140 ≈ T180
    (Marine Limestone)
  - GDOT: 100% T180 (Group 2 – Granite)
  - GDOT: 95% T180 (Group 1 – Limestone)
How do regional ABC specs compare?

- PI ≤ 6 and LL ≤ 25
  - NCDOT: PI ≤ 6 and LL ≤ 30
  - SCDOT: PI ≤ 6 and LL ≤ 25
    (Macadam and Recycled PCC)
  - SCDOT: PI ≤ 6 and LL ≤ 25 (Marine Limestone)
  - GDOT: Not specified (Group 2 – Granite)
  - GDOT: Not specified (Group 1 – Limestone)
Regional experience with ABC subbase

• Georgia
  – Conducted a SPR study of PCC pavement performance with Georgia Tech in 2012
GDOT Study Findings

• Identified 4 categories of PCC pavement
  — Category 1: Non-doweled JPCP on soil or soil cement constructed in the 1960s.
  — Category 2: Non-doweled JPCP constructed on improved base (ABC) constructed in the early 1970s.
GDOT Study Findings

- Identified 4 categories of PCC pavement
  - Category 3: Doweled JPCP constructed on improved base (GAB) constructed late 1970s and 1980s.
  - Category 4: Doweled JPCP with short (15 foot) slabs, widened lane (13 foot), on ABC plus 3 inches HMA constructed 1990s and later.
GDOT Study Findings

An analysis by design category shows pavement service life has been improved through changes in design features. On average, the service life of the original pavements based on major rehabilitation in Category 1 was found to be 17 years; and, Category 2 was 21 years, which is 23% more than that of Category 1.
GDOT Study Findings

Although none of the pavements in Category 3 have reached a major rehabilitation, the average service life is expected to be longer than its average age of 25 years, which is 45% more than that of Category 1.
Regional experience with ABC subbase

• South Carolina
  – I-20 in Lexington County in 1968:
    • 9 inch JPCP, no dowels
    • 8 inch GAB subbase
    • 25 foot joint spacing
    • Asphalt shoulders
  – Moderately faulted.
Regional experience with ABC subbase

- South Carolina
  - Used soil cement, sand-clay, and/or lean concrete subbases, no dowels and long spacing through mid 1970s.
  - First dowels used on I-95, Dorchester County in 1976 with 25 foot spacing over cement treated sand-clay subbase. No faulting to date, was diamond-ground in 2011 to improve ride unrelated to faulting.
Regional experience with ABC subbase

- South Carolina
  - For new interstate/high volume pavement since mid-1990s, has used 2 inches HMA over GAB as subbase, JPCP with dowels, 15 foot joint spacing, widened driving lane or tied shoulder.
  - For lower volume, off-interstate pavement has used 6 inches of GAB as subbase, JPCP with dowels, 15 foot spacing, widened lane or tied curb and gutter.
Regional experience with ABC subbase

• South Carolina
  – Rest Areas:
    • I-26, Newberry County – 2000 (9” JPCP/6” GAB)
    • I-95, Colleton County – 2001 (9” JPCP/6” Recycled PCC)
    • I-20, Kershaw County – 2005 (10” JPCP/6” GAB)
Regional experience with ABC subbase

- South Carolina
  - Hardee Expressway, Cayce, SC
    - Completed 2002
    - 1.5 miles long
    - 12,500 current ADT
    - 9 inch JPCP, 15 foot spacing, doweled joints
    - Tied shoulder/curb and gutter
    - 6 inch GAB subbase
Regional experience with ABC subbase

• South Carolina
  – J. Verne Smith Parkway (SC Route 80), Greer, SC
    • Phase 1 – 2000, Phase 2 – 2002
    • 5.6 miles long
    • 6750 current ADT
    • 10 inch JPCP, 15 foot joint spacing, dowels
    • 14 foot lanes
    • 5 inches ABC subbase
Regional experience with ABC subbase

- South Carolina
  - Carolina Bays Parkway, Phase III
    - Under construction
    - Low truck percentage
    - 9 inches JPCP, dowels, widened lanes
    - 6 inch ABC subbase
Regional experience with ABC subbase

• North Carolina
  – Around 2000, review of test sections on I-95 in Nash County built in mid-1960s indicated a layer of asphalt beneath concrete provided best performance.
  – Have used PADL/dense graded asphalt as subbase over last 20 years or so.
  – Recently began allowing ABC subbase for ADTT less than 2000.
# Regional experience with ABC subbase

## TABLE 3 Distresses Measured in February 2001

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<thead>
<tr>
<th>Base Type</th>
<th>No damage</th>
<th>Mid-slab Break</th>
<th>Shattered Slab</th>
<th>Long. Crack</th>
<th>Asphalt Patch</th>
<th>Spall</th>
<th>Corner Break</th>
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<tr>
<td>6” Cement Subbase</td>
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<tr>
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Performance Curves for Non-Cement Bases

Condition Rating vs. Years since opened to service
Regional experience with ABC subbase

• North Carolina
  – Test sections opened in December 1967 reached design ESALs in 9 years.
  – By 2000, the test sections had carried ten times the design ESALs.
Conclusions

• ABC can be part of a long-lasting concrete pavement structure when properly engineered.

• Short slabs, dowels, and interior loading on new concrete pavements make comparisons with old concrete sections difficult.

• However, new design features should mitigate many of the issues with ABC subbase.