Performance Testing of Tack Coats and General Bond Strength

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Pavement design is conducted assuming layers are “fully bonded”

Poor bonding in HMA layer is associated with:

- Reduced fatigue life;
- Increased rutting;
- Slippage cracking and instability
Importance of Bond Strength

½” Deflection, 60# Load

¼” Deflection, 160# Load

Unbonded

Fully Bonded

(Harder, 2018)
Importance of Bond Strength

- For plywood example:
  - 5 unbonded layers deflected 4 times more than 5 bonded layers with same loading
  - 5 bonded layers had same deflection as 5 unbonded layers at 2.5 times the load
Pavement design is conducted assuming layers are “fully bonded”
Importance of Bond Strength

Missouri Department of Transportation

(Gerhart and Johnson, 2018)
Importance of Bond Strength

New Jersey Department of Transportation (NJDOT)
Bond Strength of Field Cores in New Jersey
In 2018, NJDOT began piloting the use of bond strength testing when failing tack coat samples occurred.

- 5 field cores taken and tested using NCAT procedure
- Results averaged for reporting
  - Unbonded layer = 0.0 psi for averaging

Same time, additional testing being conducted to evaluate “typical” bond strength

- Selected NCAT shear procedure for ease of use and ability to use Marshall Stability and Flow device
Tran et al. (2012)

- Indicated bond strength $\approx 100$ psi should be reasonable for field cores
- Slippage failure evaluations indicated
  - Bond strength $> 87$ psi for No Slippage Area
Wang et al. (2015) evaluate shear stress at interface
- 0.5, 1, 1.5, 2 inches from surface
- Different temp, axle loads & braking conditions
- At “bonded” condition, shear stress at interface ranged from 30 to 70 psi
  - Increased ≈ 2 psi/kip axle load
  - Less sensitive to temp & load with depth
Bond Strength of Field Cores

- Completed projects (< 1 year old) were cored for test specimens
  - Milled and new surface
  - Some tack materials “failed” QC testing (penetration)
- NCAT Bond Strength (ALDOT-430)
  - Cohesion + interface texture
- ASTM C1583 – Pull-off Testing
  - Cohesion
22 pavement sections
- Minimum of 3 cores
- Ave Milled = 178.3 psi
- Ave New Surface = 187.9 psi
  - Average COV% = 28.2%
- Only 1 section < 100 psi
13 pavement sections
- Minimum of 3 cores
- Ave Milled = 88.5 psi (only 2 sections)
- Ave New Surface = 89.0 psi
A positive trend does exist between the Shear and Pull-off results.

Results would indicate the frictional component of the bond strength has considerable influence:
- Residual, tack type
Initial bond strength testing showed “good” bond strength
- Does bond strength decrease with time?

Project Level analysis coring shows high level of debonding
- Moisture damage over time weakening bond?
- Tack coat residual too thin?
- Hoping to repeat testing on same sections to evaluate bond strength vs time
Spray Paver to Improve Bond Strength
Spray Paver to Improve Bond Strength

- Bond strength clearly important
- So why are contractors sometimes reluctant to tack?
Advertised benefits of using spray pavers for paving:

- Different types of emulsions can be used;
- Dilution of emulsion not required;
- Application rates not limited by construction
  - Strong evidence suggesting greater application rate improves cracking performance
MoDOT Route T – 2008 Construction
Longitudinal Crack Length at 6 years
1 3/4" BP-1 over HMA/PCC Composite

89.5% reduction
MoDOT Spray Paver Study

MoDOT Route T – 2008 Construction
Transverse Crack Length at 6 years
1 3/4" BP-1 over HMA/PCC Composite

31.9% reduction

Transverse Cracking per 1,000 feet

Yr 1  Yr 2  Yr 3  Yr 4  Yr 5  Yr 6

Conv Paving
.05/gal/yd²

Spray Paver
.21/gal/yd²
MoDOT Spray Paver Study

½” Mill, 1 ½ “ SR-12.5A, PG 58-28
**Longitudinal Crack** Length at **6 years** (w/no tack)

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**Graph:**
- **Conv Paving** .05/gal/yd²
- **Spray Paver** .20/gal/yd²
- **No Tack**
1/2” Mill, 1 1/2 “ SR-12.5A, PG 58-28
Transverse Crack Length at 6 years

88% reduction
NJDOT Study – Spray Paver vs Conventional

- High Performance Thin Overlay (HPTO) placed over 12.5 mm, 64-22
  - Micro-milled for profile prior to the overlay
  - “Conventional” paving vs Spray Paver sections in ramp and shoulder area of I295.
- Focused on bond strength comparison between procedures
  - Cores taken after 3 months of service
On average, Spray Paver obtained a 20% increase in Bond Shear Strength (NCAT procedure)

- Greatly improved variability (Std Dev)
  - Spray Paver = 10.7 psi
  - Conventional = 28.9 psi
On average, Spray Paver obtained a 13% increase in Bond Pull-off Strength (ASTM C1583)

- Improved variability (Std Dev)
  - Spray Paver = 10.3 psi
  - Conventional = 16.3 psi
Testing for Tackiness of “Trackless” Tacks
To help compensate for tack coat pick-up, Trackless Tacks are becoming popular
  - Promise to provide bond strength while allowing for construction vehicles to quickly access tacked surface with little to no tracking
  - Question: How to verify?
Current Tracking Test Procedure

- 10 lb stainless steel wheel
- Draw down apparatus used to provide different film thickness for evaluation
- Rolled onto felt paper at different curing temps and time
DSR Tackiness Test

- Tackiness test designed to quantify how sticky, or non-sticky, a material is at expected field temperatures.
- If tacky at pavement temps, may not be suitable for trackless tack coats and bond coats.
Tack Comparisons at 15°C

- RS-1
- RS-1H
Tack Comparisons at 35°C

- **RS-1**
- **RS-1H**
Tack Comparisons at 55°C

- RS-1
- RS-1H
Trackless Tacks – Initial Testing

- Four tack coats evaluated from same manufacturer
  - 1, 2, 3% latex
  - Trackless Tack
- Replicate testing at 5 test temperatures
  - Trackless – lower tackiness at temps < 35°C (95°F)
    - Can tackiness envelop be used to recommend optimal usage temp?
Analytical and field studies show importance of bond strength

For NJ, test results within 3 months of placement show “good” bond strength
  - Many cores from Project Level analysis show debonding
  - Bond strength reduction over time? Aging? Moisture Damage?

Spray Paver shows promise with HMA paving
  - Increased tack coat thickness
  - Lesser tracking potential

New DSR procedure can help with identification of Trackless Tacks
  - Optimal field temperature range
  - Test may also be helpful to identify influence of additives on “tackiness”
  - Still more testing needed
Thank you for your time! Questions?

BE CAREFUL WHEN YOU ONLY READ CONCLUSIONS...

Reference: The Anscombe's quartet, 1973

Designed by @YLMSportScience

These four datasets have identical means, variances & correlation coefficients

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