# Vermont Stone Matrix Asphalt Trial Project


Dr. Ian Anderson

Bituminous Concrete Materials Manager

VERMONT

AGENCY OF TRANSPORTATION

# What was the Problem?

- Observing a decrease in our expected pavement life, and do not have a premium treatment that promised to increase the duration between treatments.
  - Our standard Type IVS (9.5mm) with 70-28 at 80 gyration is not robust enough, is the reduced AC making it brittle?
  - Previously attempted HiMA mix using 76-34, general consensus was positive, thought it was hard to construct.
- We have roads in our highest traffic areas (Burlington area) currently receiving preventative BWC or HMA overlays, that will need a deeper treatment soon, and we don't want that to the be the first time we try something new.

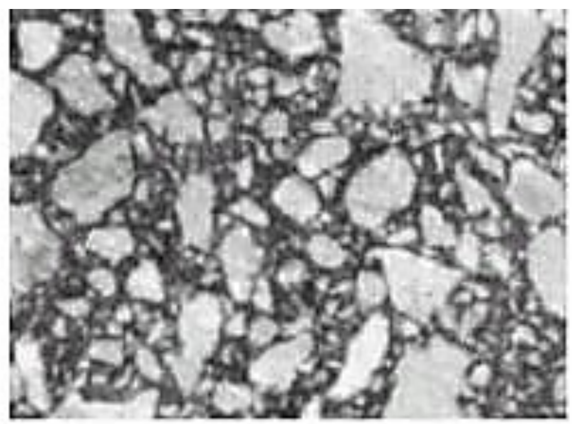
# Project Background

- Sharon-Bethel I-89 NB and SB. Near exit 3
  - 24.7 miles total, the majority of which was BWC.
  - Northern end of each barrel required a deeper treatments, the original plan was for Level and Overlay with Type IVS.
  - Opportunity was taken to trial SMA and compare directly to Type IVS. Ended up with 2 miles of SMA and 2 miles of Type IVS in each direction.
  - 10,000 tons 65 gyration Type IVS, 0.5″ Level, 1.5″ Overlay
  - 9,000 tons 65 gyration Type III SMA (12.5mm), 2″ Overlay

# Stone Matrix Asphalt

SMA deviates from the conventional dense graded mixture, it relies on high quality gap graded coarse aggregates to form an interlocking structure of stone-on-stone contact, bound and filled by a heavy asphalt mastic. Fibers are often used to prevent drain down, which is a concern. SMA is thought to offer both rut resistance through its stone skeleton, and flexibility from the high asphalt content.

Stone Matrix Asphalt



Dense Graded HMA

# Materials Background

- Set out to draft a SMA Project Special provision, reviewing other states specifications, industry publications, research, and consulted with FHWA MATC staff.
- Initial Goals/Concerns
  - Wanted to ensure it was constructable and enforceable
  - Haven't used fibers before, mandated a fiber machine
  - Literature cites early compaction as key to getting density
  - Job could be won by anyone, so needs to be achievable for all our producers/contractors

# Specification Requirements

| Gradation Design Limits | |
|---|---|
| Percentage Passing (Min – Max) | |
| 3/4 inch (19.0 mm) | 100 |
| 1/2 inch (12.5 mm) | 90 - 97 |
| 3/8 inch (9.50 mm) | 58 - 80 |
| No. 4 (4.75 mm) | 25 - 35 |
| No. 8 (2.36 mm) | 15 - 25 |
| No. 30 (0.60 mm) | 0 - 18 |
| No. 200 (0.075 mm) | 8.0 – 11.0 |
| Min AC (%) | 6 |

| Property | Requirement |
|---|---|
| Design Gyrations ($N_{design}$) | 65 |
| VMA(%) | 16.0 min |
| Voids in Coarse Aggregate (VCA) | $VCA_{mix}$ < $VCA_{dry\text{-}rodded}$ |
| Air voids (%) (QA with PWL) | 4.0 |
| Draindown (%) | 0.3 max |
| Tensile Strength Ratio (%) | 80.0 min |
| In place density (QA with AAD) | 95% |

| Test | Property | Requirement |
|---|---|---|
| HWT | Average rut depth, mm (inches) | 10.0 (0.40) max |
| | Stripping Inflection Point, passes | 15,000 min |
| I-FIT | Flexibility Index (FI) | 10.0 min |

| Property | Tolerance |
|---|---|
| Air Voids | ± 1.0% |
| Voids in Mineral Aggregate | ± 1.0% |
| retained on the No. 8 and above | ± 6.0% |
| passing the No. 8 and retained on the No. 30 | ± 4.0% |
| passing the No. 30 and retained on the No. 200 | ± 3.0% |
| passing the No. | ± 1.0% |

# Bid Results

- Two bids, thankfully!
  - Type IVS: $95 and $91.65 / Ton
  - SMA: $116.35 and $147.85 / Ton
  - BWC: $103.64 and $118.90 / Ton

- Considering we had $150/ton it was reassuring we weren't completely off, and that our winning bid came in with what we consider to be a good price for a first-time trial.

# Issues with the Spec

- After their trail blends, it became clear our spec was not reasonably achievable as written. At the courser end with minimum AC at 65 gyration, producer only got 3.1% AV, 15.9% VMA.

- Options on the table:
  - Regress Air Voids
  - Open the gradation
  - Reduce to 50 gyration

# Changes to the Spec

- Removed a requirement related to voids in mineral filler, replaced it with plasticity index limit

- As written, the gradation job aim limits must stay within the broader design limits.  We changed that for all but the ½" and #200, allowing all others to select a JMF anywhere within the design range, and still get the full +/- tolerance.

- During production this was changed to also include the #200, allowing them to target 8% and deviate below that.

- Originally include IRI ride spec for PF. Removed since there was no leveling course on the SMA.

# Beginning of the Project

- Spec required Passing Trail Drops, then passing Test Strip, before moving to normal production.
- Test Strips are not something we currently do, so this was new for us. Minimum 750 tons paving on the shoulder. Paid as a lump sum, and repeated until successful. Unacceptable material must be removed.
  - Mix Design: Two successive QC plant results
  - Compaction: Two successive ¼ mile segments, in which average of 3 density gauge shots are below 3.5 AAD.
  - Forgot about gauge calibration, so we cut some cores to prove the gauge, and used the MATC CoreDry to rapid test. Test strip passed, and they progressed to normal production the first day.



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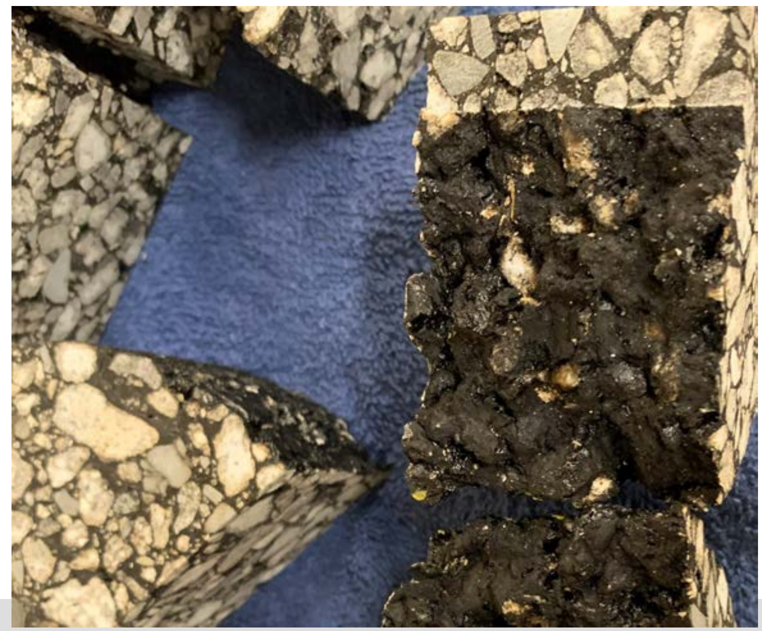
# Material Results

- SMA:
  - QA Air Voids, 3000 ton Lots, 6 sublots.  PWL & PF:
    - 81% (94.4), 100% (103), 84% (98.5)
  - QA Density, 1500-2000 tons, 6 cores. AAD and PF:
    - 0.8 (102), 0.8 (102), 1.4 (101), 1.8 (100)
- HMA
  - QA Air Voids PWL & PF:
    - All 100% (103)
  - QA Density PWL and PF:
    - 73% (96.5), 85% (100), 100% (102), 84% (100), 100% (102)

# Performance Testing

| | HWT | IFIT | IDEAL-CT |
|---|---|---|---|
| VTrans SMA Spec | <10 mm | >10 | |
| Mix Design SMA | 2.9 mm | 10.6 | |
| Mix Design HMA | 2.0 mm | 12.3 | |
| Production SMA | 4.56 mm | 19.8 | 312.9 |
| Production HMA | 2.63 mm | 11.8 | 193.9 |
| 2021 HMA Average | 3.18 mm | 12.4 | 190.2 |



# Early Observations

- Two-hour haul time was a concern for mix temperature, but density results indicate it wasn’t prohibitive.
- Overall, successfully construction of SMA thus far. Very hard to shovel/fix, rolling close to paver is important. Very little movement after initial consolidation.
- Density is likely ensured through mix design, cannot be “improved” in the field.
- There are a few areas showing some permeability, likely areas of connected voids. May consider reducing air voids down to 3.5 to reduce the chance next time, and make mix designing easier to achieve.
- Contractor effort was key to this project's success, it took more than normal QC, as the first attempt at something would.

# Next Steps

- This project will be monitored as a research effort for the years to come.
  - Annual field observations to identify issues
  - Friction testing to compare BWC, HMA, SMA
  - Pavement Distress: IRI, Cracking, Rutting, Surface Texture
  - Cores taken annually to determine density, and potentially for performance testing.
- Work on revisions to the special provision, for another project, or full spec implementation.

# Thanks!

- Thanks to the FHWA MATC, for advice and visiting Vermont in person during construction to assist.
- Thanks to VTrans staff for their efforts to implement this trial, in particular Chris Barker the RE, Andy Willette the paving inspector, and Ryan Darling our Paving Engineer.
- And thanks to our VTrans materials field and lab staff, and Aaron Schwartz for the performance testing

Questions or Comments? Thanks!

Contact info: Ian.Anderson@vermont.gov, 802-272-5568