Application of Petrography to Highway Materials

Hosted by
Andrew Dawson
University of Nottingham, UK

chair, TRB Committee AFP70 "Aggregates"

Your presenters

- Steven J. Stokowski, P.G.
  - Principal Petrographer, TEC Services

- D. Stephen Lane
  - Research Scientist, Virginia D.O.T.

Today's Content

- Concrete, Asphalt, Masonry
  - Steven J. Stokowski
- Training, Literature, Soils, Major Contributors
  - D. Stephen Lane.

Petrography

- Petrographic examination is a visual examination and analysis in terms of both lithology and properties of the individual particles. The procedure requires use of a hand lens and petrographic and stereoscopic microscopes. Less commonly, X-Ray diffraction or differential thermal analysis supplement the microscopic examinations.

  R.C. Mielenz, 1966

Professional Requirements

Knowledge of:

- Physical, chemical, and optical properties and characteristics of rocks, minerals, and materials
- Composition and design of construction materials
- Behavior of materials in varied environmental settings

Capabilities:

- Describe and interpret the facts in writing
- Predict what could and did occur

Petrographic Manual

U.S. Department of Transportation
Federal Highway Administration

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Pavements

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Petrographic Methods of Examining Hardened Concrete: A Petrographic Manual

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July 2006

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VTRC Virginia Transportation Research Council

FOREWORD

Petrographic Methods of Examining Hardened Concrete: A Petrographic Manual was originally published in 1992 by the Virginia Transportation Research Council (VTRC) as Report VTRC-92-R14. Authored by Hollis N. Walker, it was the culmination of a quarter century of work by her in concrete petrography at the VTRC.

This edition, revised by D. Stephen Lane, senior research scientist at the VTRC, builds on the original work. It has been revised and updated to reflect recent advances in techniques and work in concrete petrography. Major additions to the manual include a new chapter (chapter 14, written by Paul E. Stutzman, physical scientist, National Institute of Standards and Technology) on the use of the scanning electron microscope to examine concrete and concretemaking materials, and additional information on the identification and classification of rocks and minerals in aggregates (appendix D). Chapter 10, Alkali-Aggregate Reactions, was reorganized to outline the process one would follow to investigate a case of concrete deterioration and illustrate the features that provide evidence of alkali-silica or alkali-carbonate reactions. It is hoped that the manual will be of great use both to those entering the field of concrete petrography and to the experienced petrographer.

More Information

- Pavement Publications

Contact

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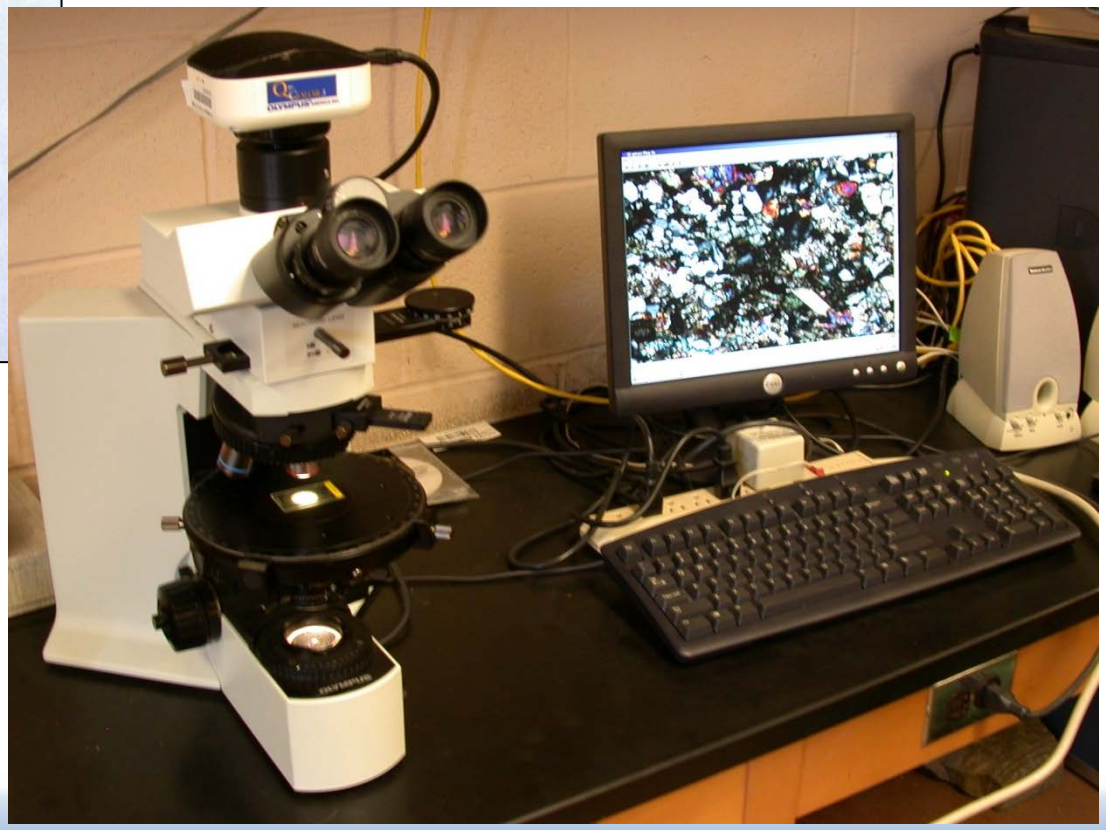
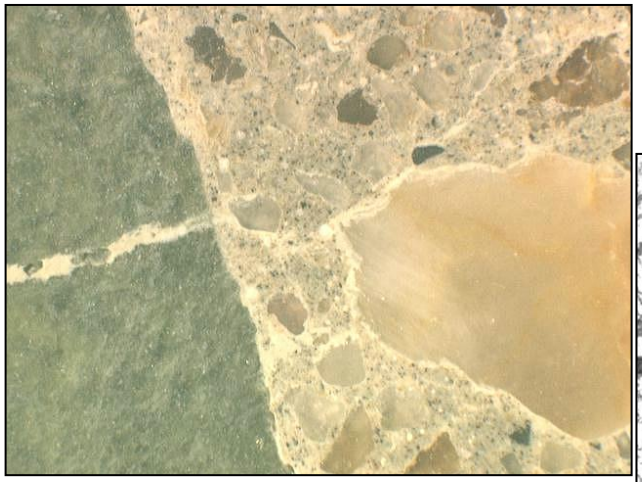
Turner Fairbank
202-493-3091
E-mail Richard

http://www.fhwa.dot.gov/publications/research/infrastructure/pavements/pccp/04150/

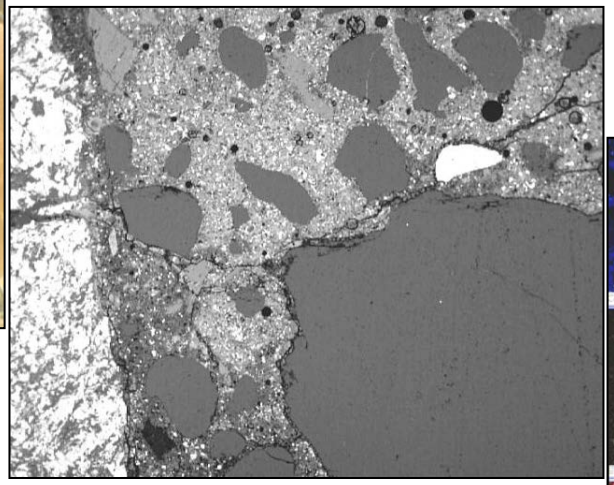
Hand Lenses, Petrographic Microscope



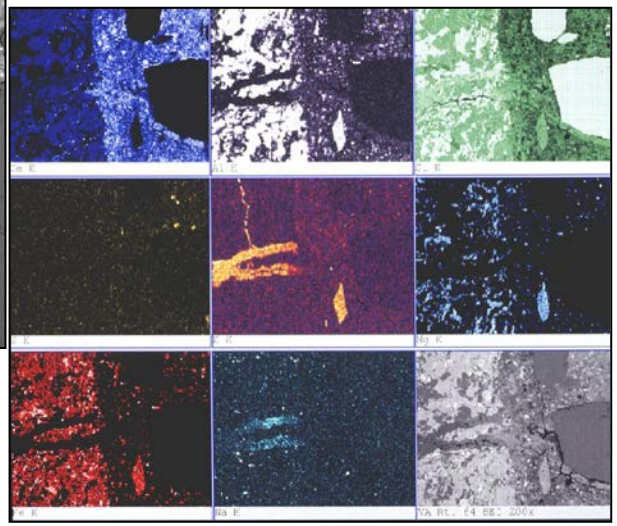
Petrography, ASTM C856 Standard Practice Polarized Light, SEM, EDX



Optical

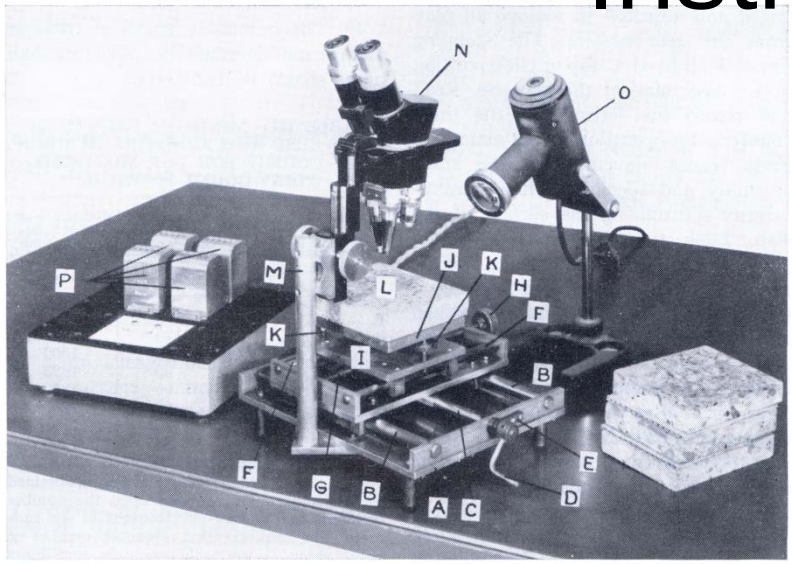


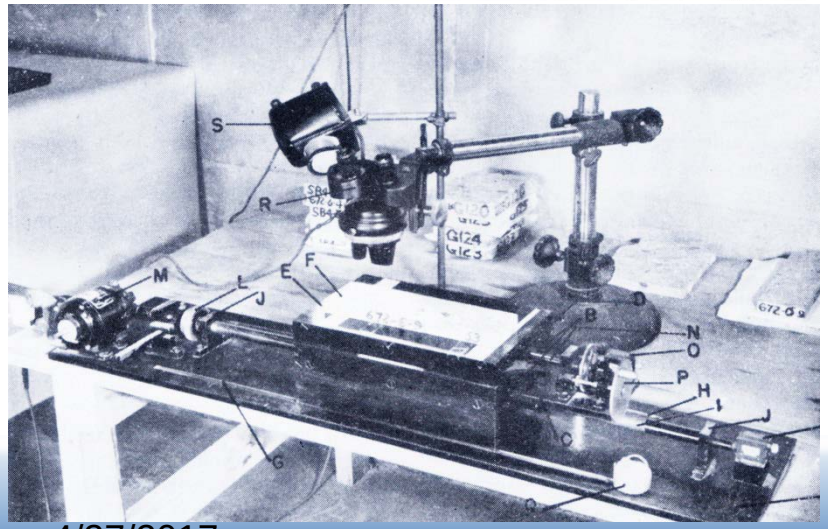
SEM/BSE



SEM / EDX

C457 Standard Method Instruments





Application to Highway Materials

- Raw Material Characterization
  - Aggregate, Dimension Stone, Bedrock, Soil
  - Cementitious Materials
  - Recycled Materials
- Performance Investigations
  - Highways
  - Bridges
  - Tunnels
  - Incidental Construction

Application to Highway Materials

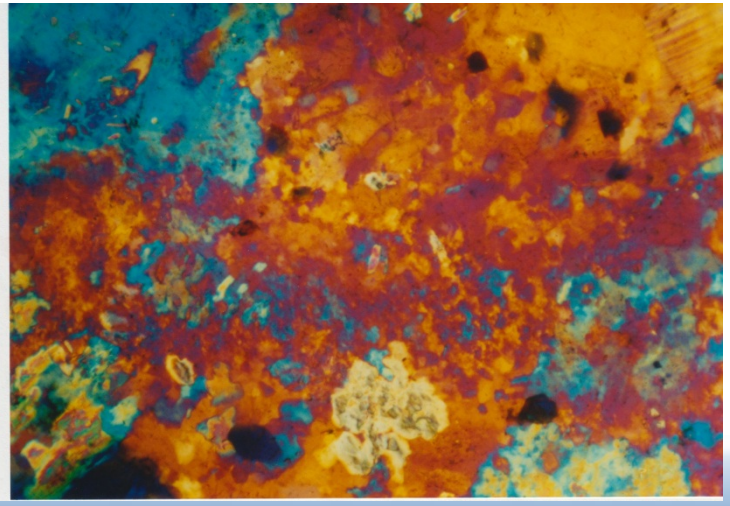
- Raw Material Characterization
  - Aggregate, Dimension Stone, Bedrock, Soil
  - Cementitious Materials
  - Recycled Materials

Sand – ASR Potential

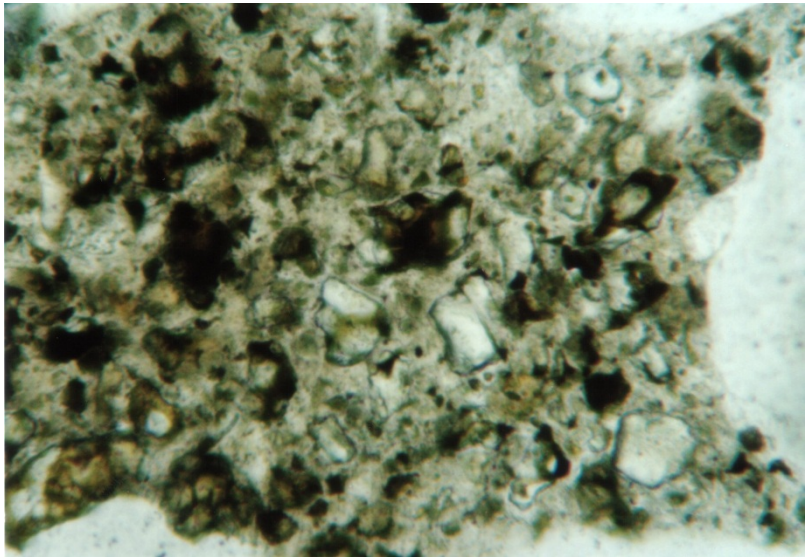
SUMMARY

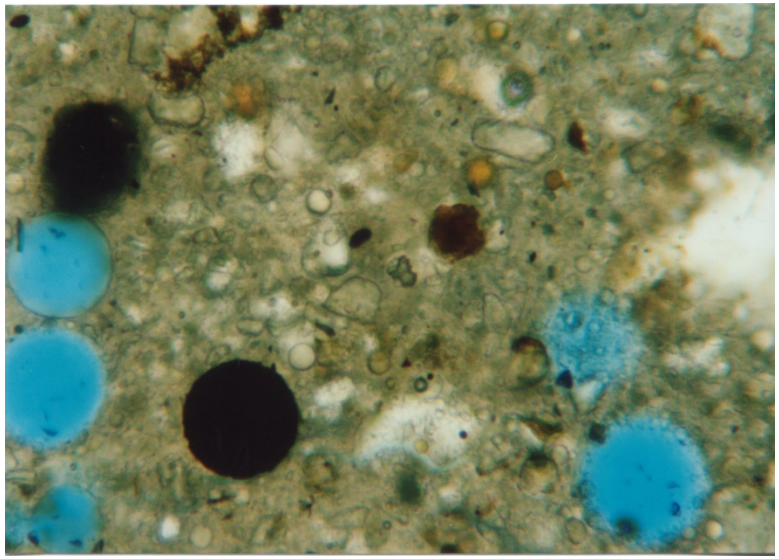
The sand product is suitable for use in Portland cement concrete with a lengthy design life. There is no significant potential for an alkali-aggregate reaction if used in a continuously moist concrete compounded with high-alkali cement, other high-alkali cementitious materials. No further testing for potential reactivity is required for this aggregate.

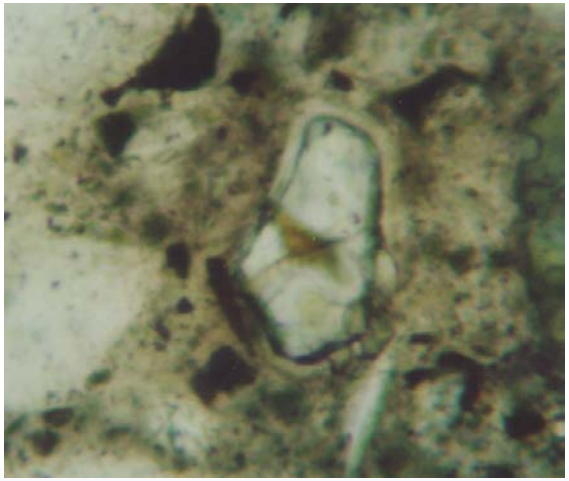
This product is a natural sand composed primarily of single grains of quartz that are not considered to be potentially alkali-reactive. The sand also contains feldspar, mica, garnets, heavy minerals and fragments of granitic rocks and schists. Optically strained quartz within the fragments of granitic rocks and schists (approximately 2.6% of the volume of the total aggregate) is within the limits (5.0%) established by the Massachusetts Highway Department in Section M4 of the Standard Special Provisions for Cement and Cement Concrete Materials.



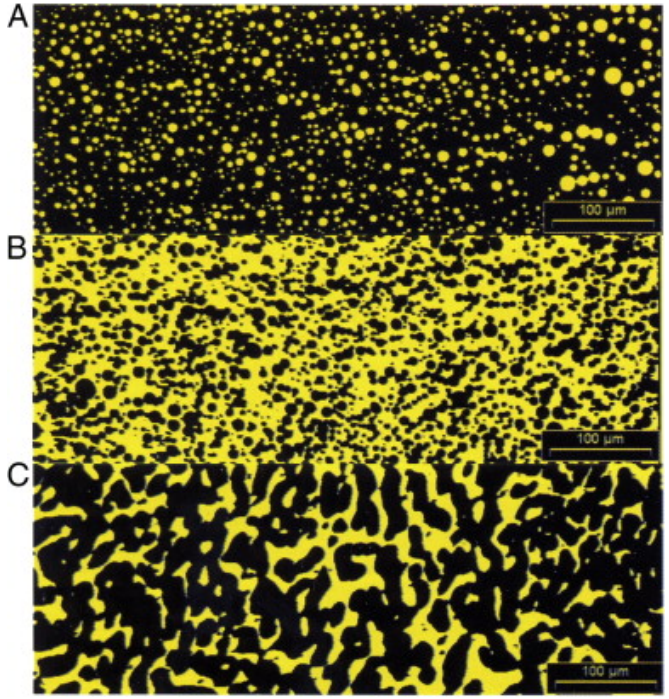
Cementitious Materials







Polymer Asphalt



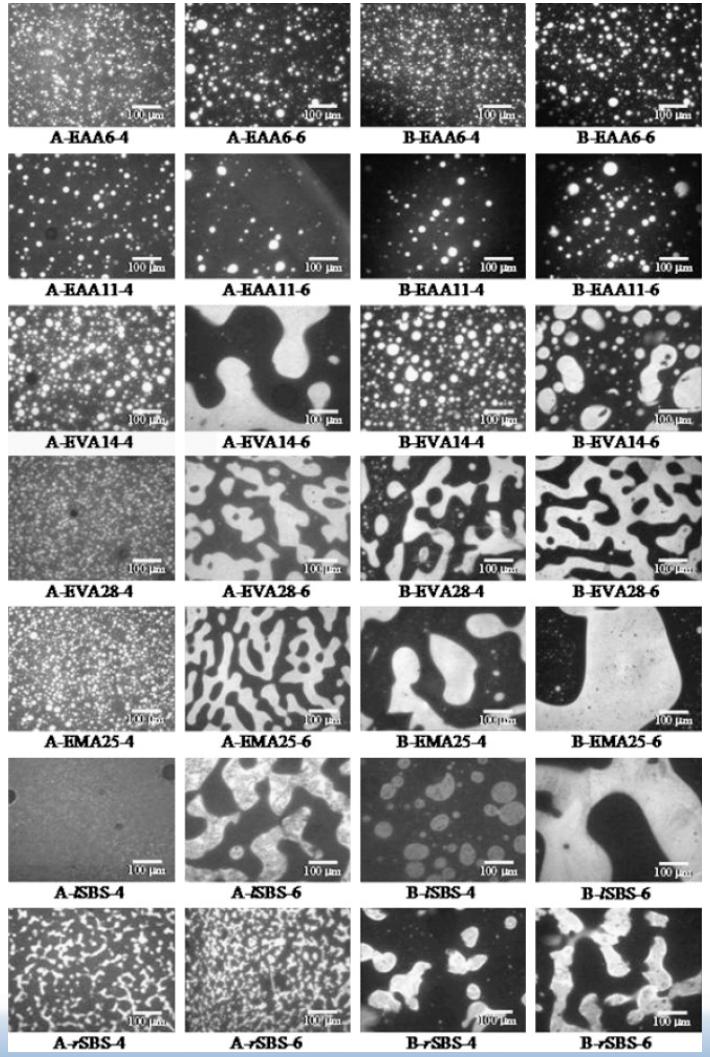
3%

5%

7%

EVA –modified bitumen

Lesueur, D., 2009, The colloidal structure of bitumen: Consequences on the rheology and on the mechanisms of bitumen modification



Guiliani, F. et al, 1998, Effects of polymer modification on the fuel resistance of asphalt binders

Application to Highway Materials

- Performance Investigations
  - Highways
  - Bridges
  - Tunnels
  - Incidental Construction

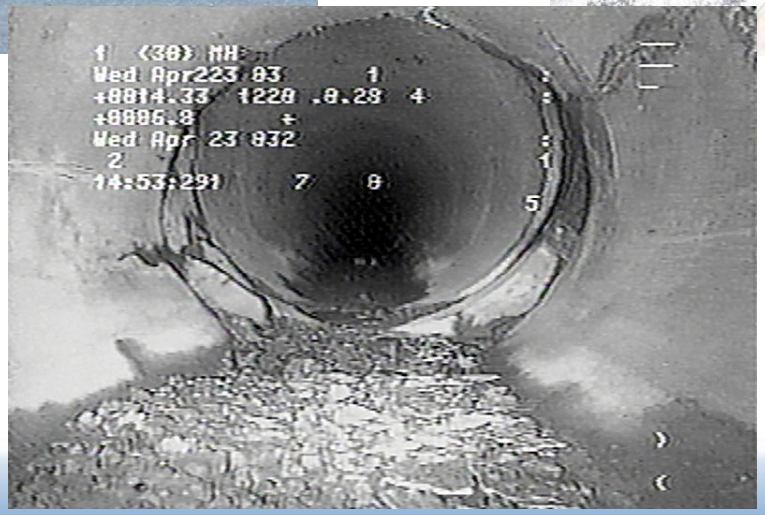
Application to Highway Materials

- Performance Investigations
  - Highways
    - Earthwork & Fill
    - Cut slopes
    - Granular Base
    - Pavement
      - Hydraulic Cement Concrete
      - Asphaltic Concrete

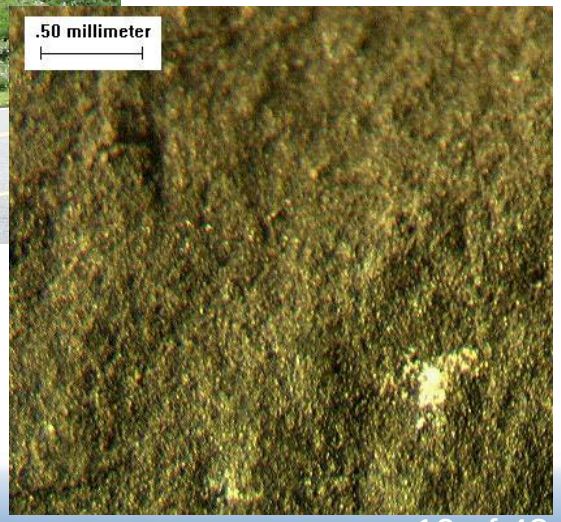
Highways

- Earthwork and Fill Material
  - Heaving, Acid Drainage
- Swelling clays
- Gypsum/anhydrite
- MgO-rich slag
- CaO-rich fly ash, slag
- Sulfide Minerals (iron pyrites)

Fill-Related Pavement Heave Bristol, VA



Fill Related Pavement Heave Bristol, VA



Improper Use of Borrow

Cut Slopes - Disruption of Soils with Sulfide Minerals, Fredericksburg, VA

Orndorff & Daniels, 2003, VTRC 03-CR2,

Associated/Continuing Problems:

- Acid drainage damaging plants, concrete, metals
- Sulfate attack of concrete
- Heave of lime-stabilized soils

Highways

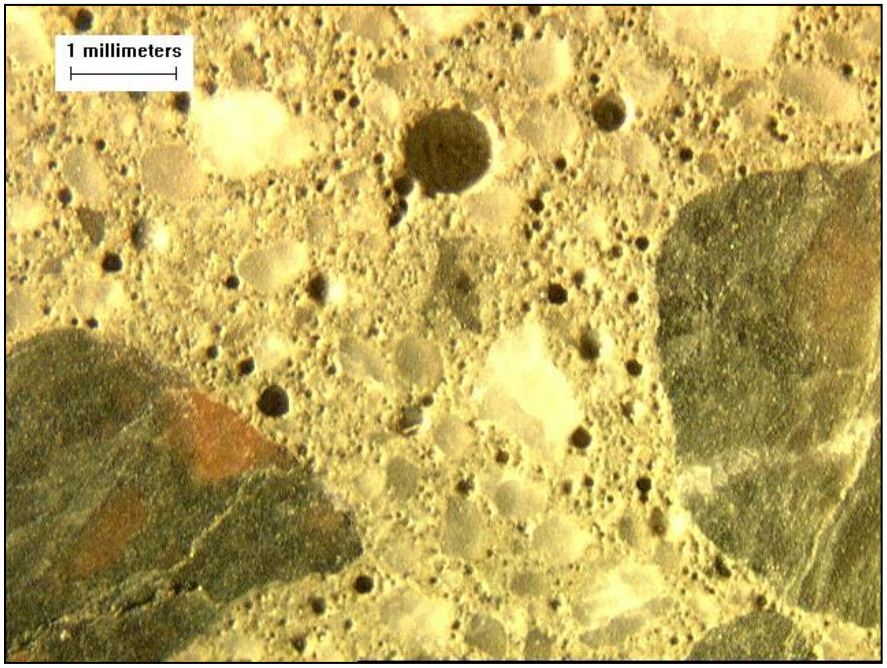
- Granular Base
  - Heaving, Degradation, Compacted Stability

- Gravel vs. Crushed Gravel
- Crushed Stone
  - Clay in weathered rock, altered basalt or shale
- Crushed Concrete
  - Calcite in drains
- Crushed Slag (free MgO, CaO)
  - Heaving

Highways

- Pavement
  - Hydraulic cement concrete
    - Composition
    - Consolidation
    - Air-entrainment, freeze-thaw damage
    - ASR/ACR
    - D-cracking
    - Joint deterioration (rot)
    - Chloride attack of slag cement concrete

Air-Entrainment Data Collection
Linear-Traverse / Point-Count

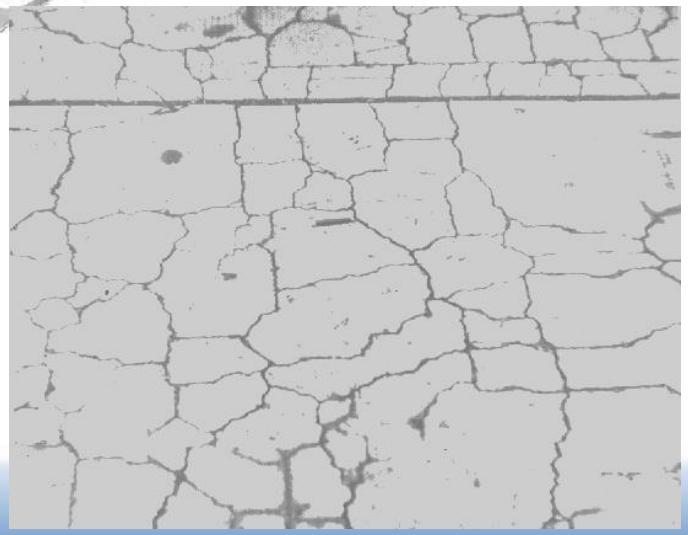


CA%	FA%	P%	Air%	SF(mm)
34.5	22.0	32.8	10.6	0.07

ASR/ACR Manifestations

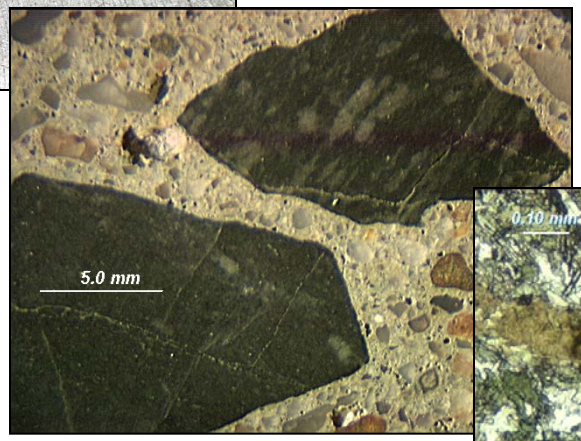
Expansion & Closing of Joints In Bridge Decks, Jersey Barriers, etc.

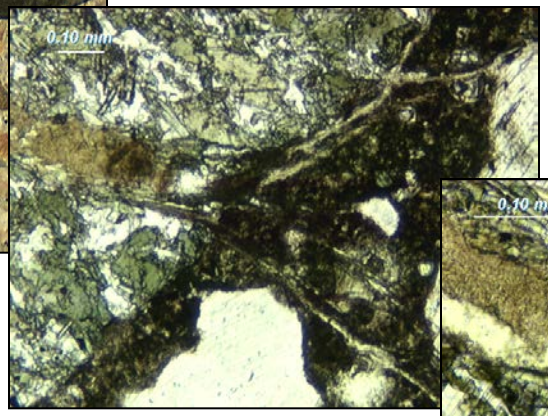
Map Cracking of Pavement, Retaining Walls, etc.

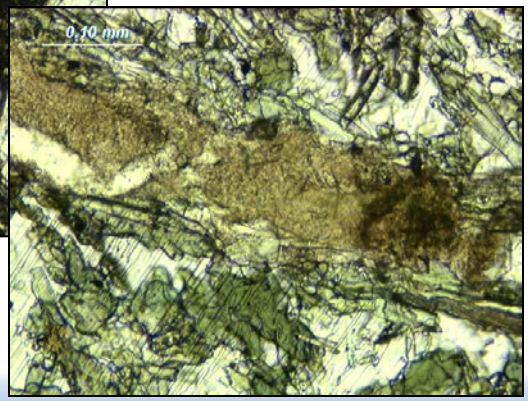


ASR Distress

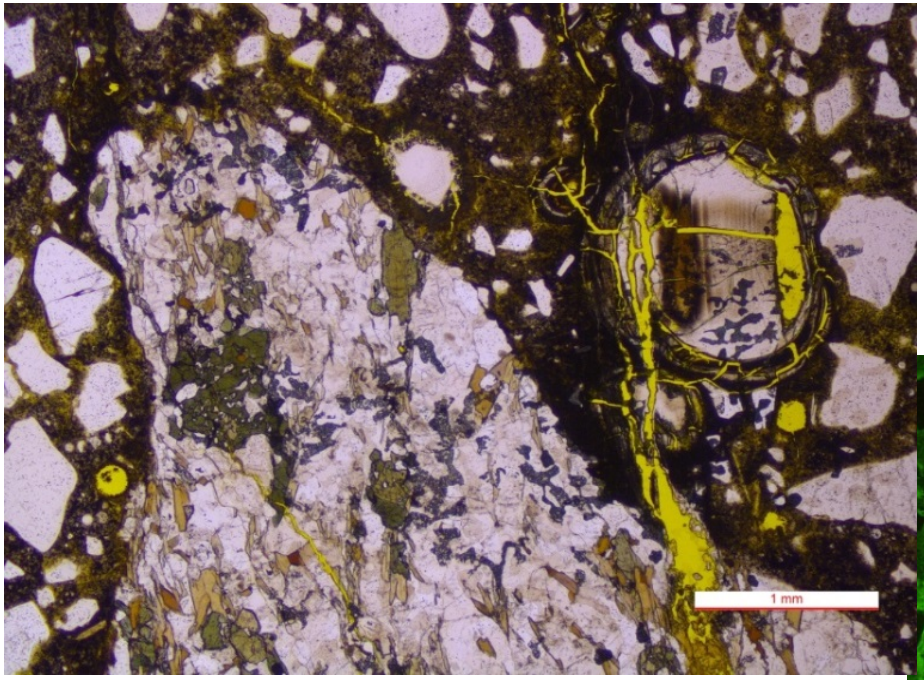
Macro to Micro Scale

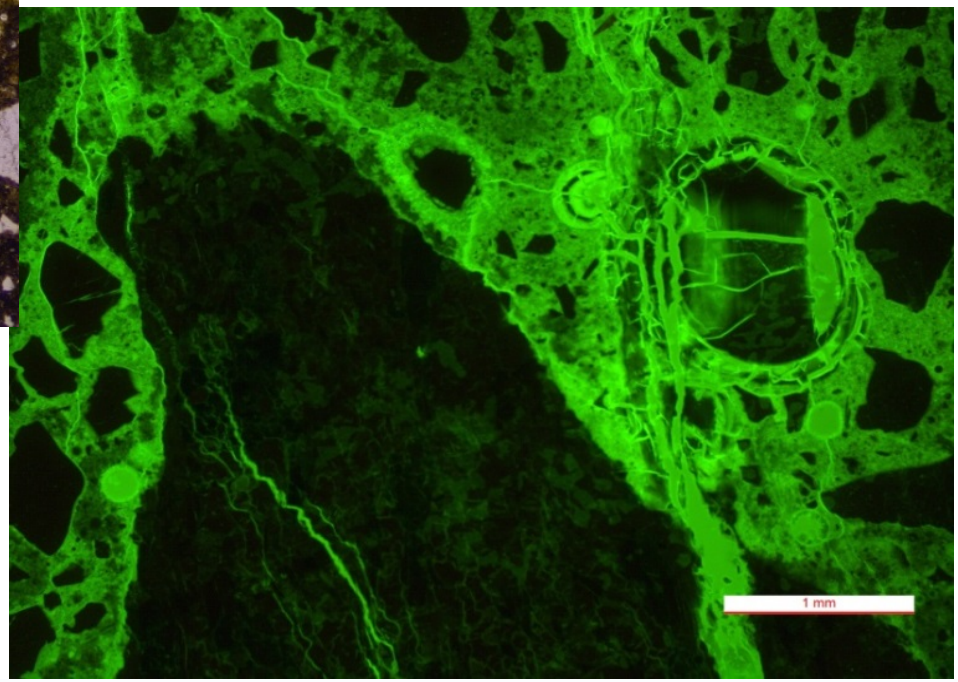






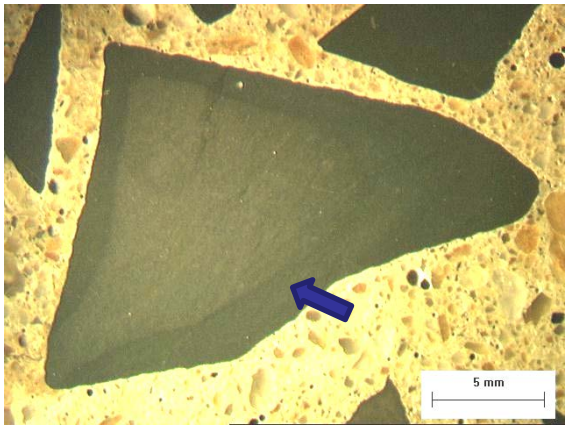
ASR Diagnostics

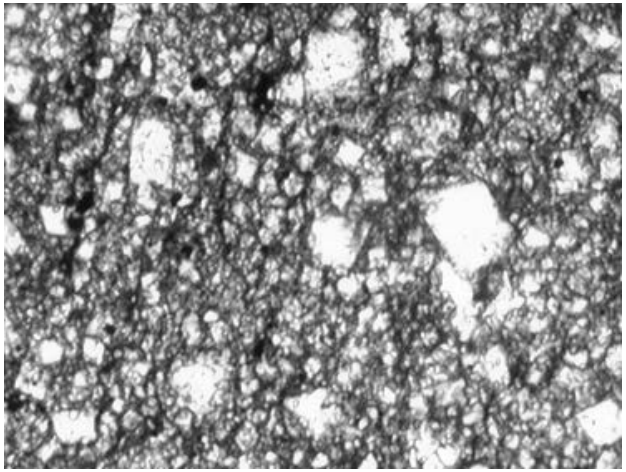




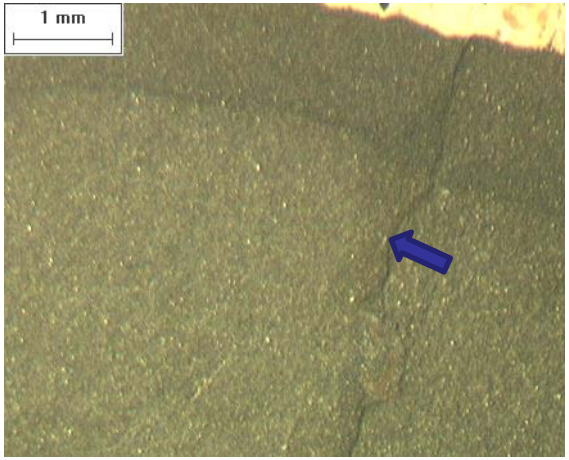
ACR Diagnostics

Peripheral Rims

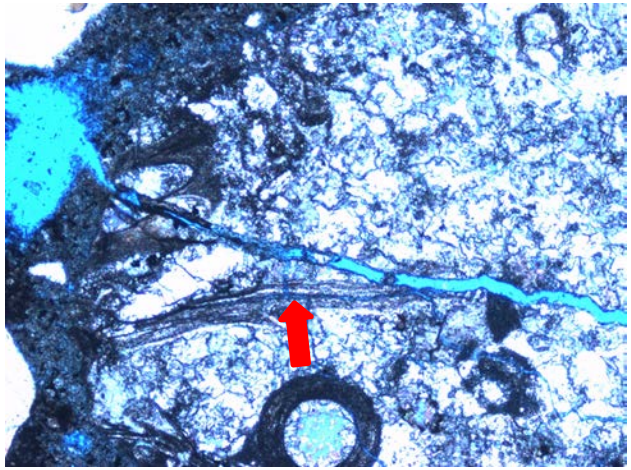




Characteristic texture



Internal Cracks



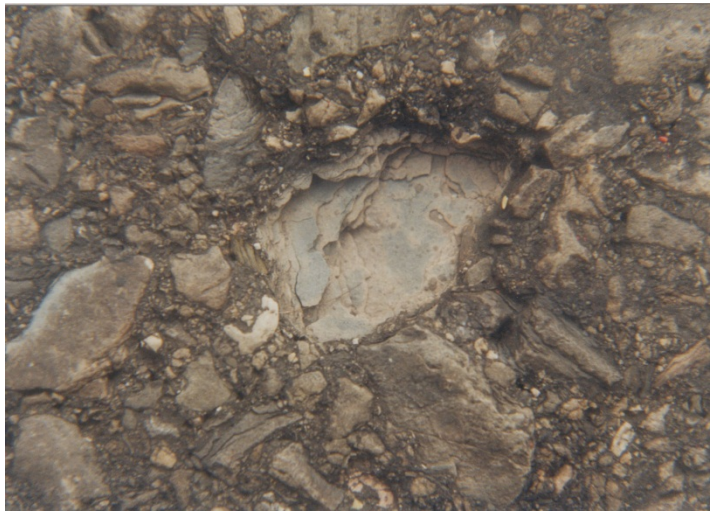
Dedolimitization to form Brucite & Calcite

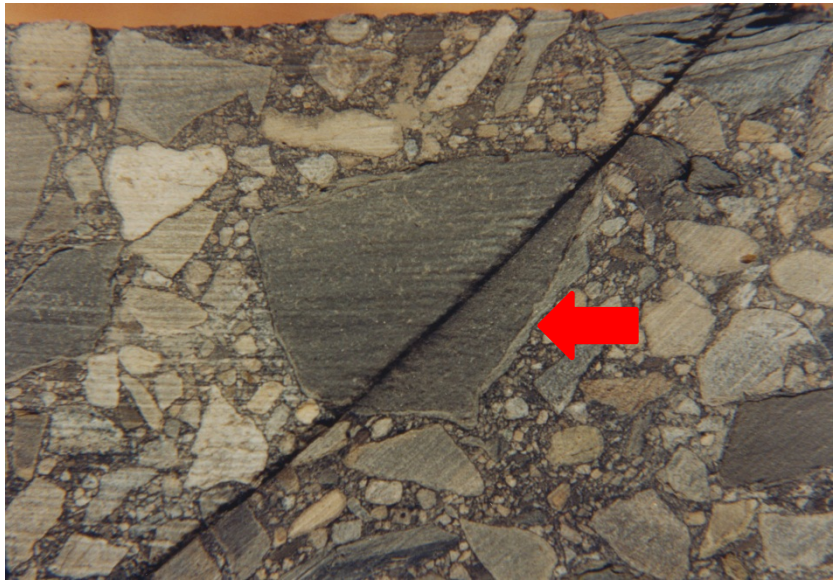
Highways

- Asphalt Concrete
  - Polymer modification of asphalt (UV fluorescence)
  - Mica content of manufactured sand (GA DOT)
  - Absorption of asphalt by aggregate
  - Aggregate quality and performance
  - Compactability during construction
  - RAP/virgin AC homogenization

HMA Pavements - Aggregates

Shale

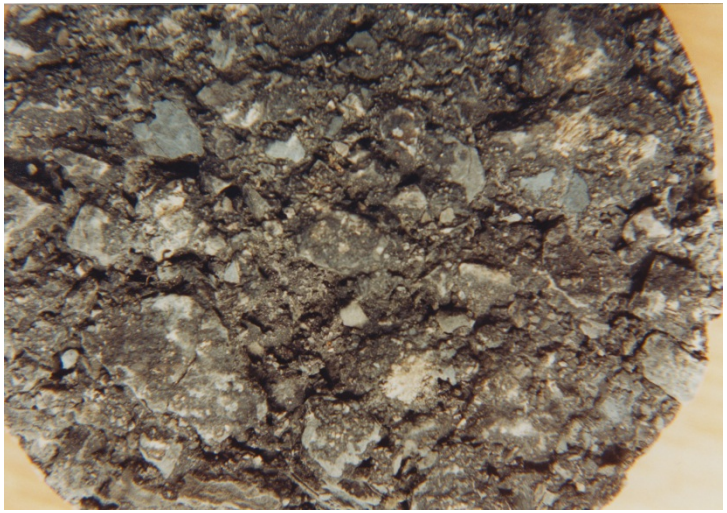




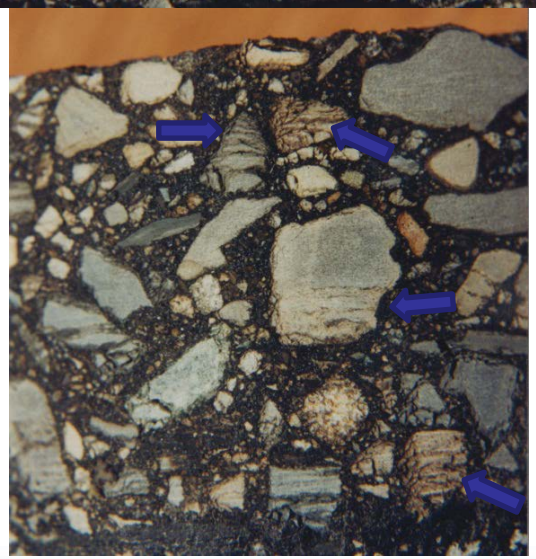
Dusty

Dolomite

HMA Compaction

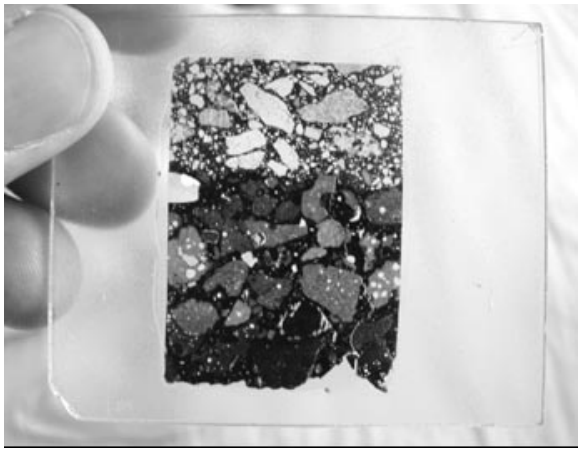


Cold Surfaces



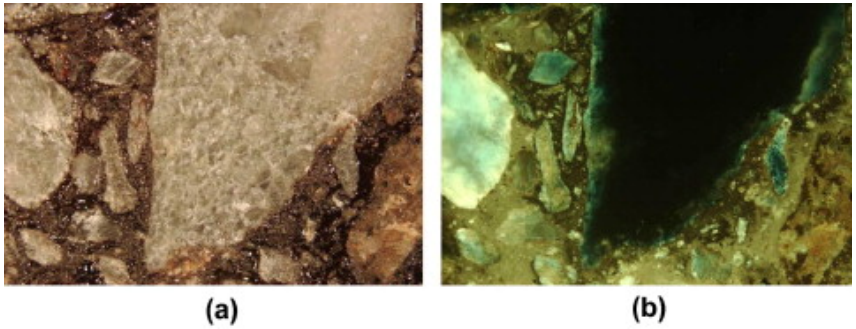
Broken Aggregate

HMA Investigations

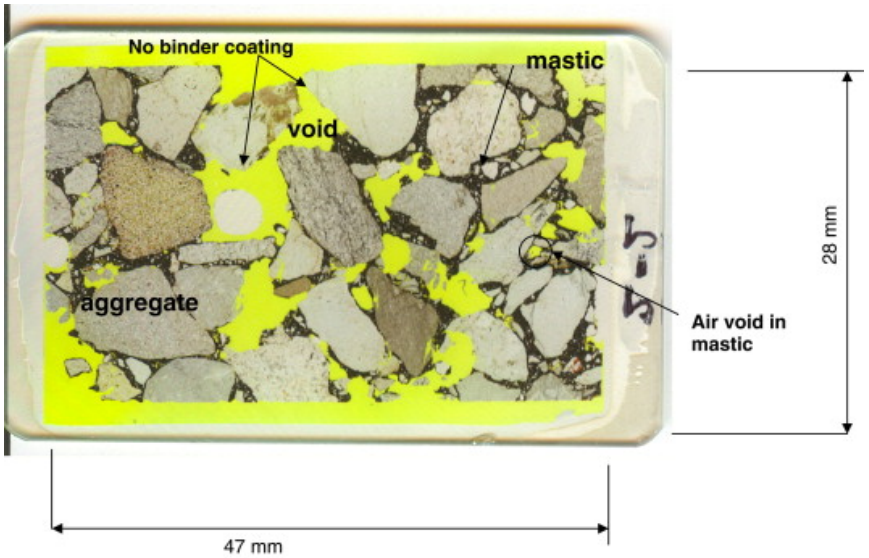


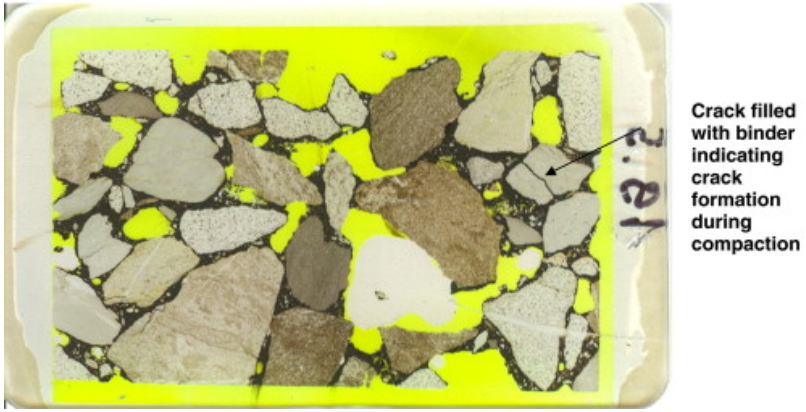
HMA Microscopy, Denmark

FHWA, 2004, Superior Materials, Advanced Test Methods, and Specifications in Europe



Navaro, J. et al, 2012, Observation and evaluation of the degree of blending of reclaimed asphalt concretes using microscopy image analysis



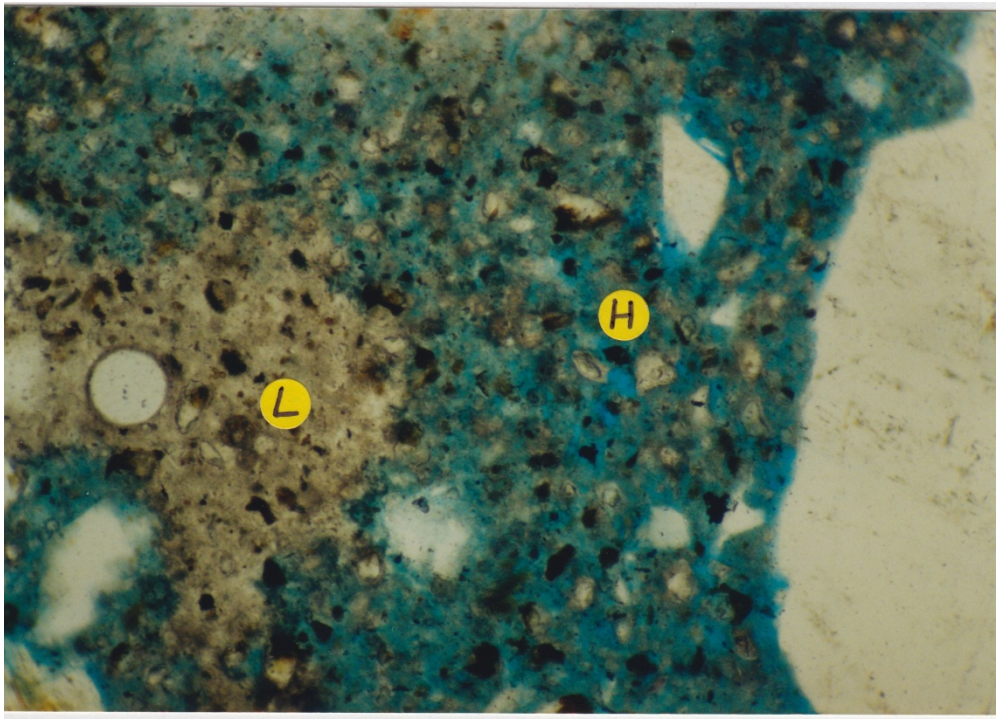


Poulikakos, L., & Parti, M, 2009, Evaluation of moisture susceptibility of porous asphalt concrete using water submersion fatigue tests

Bridges

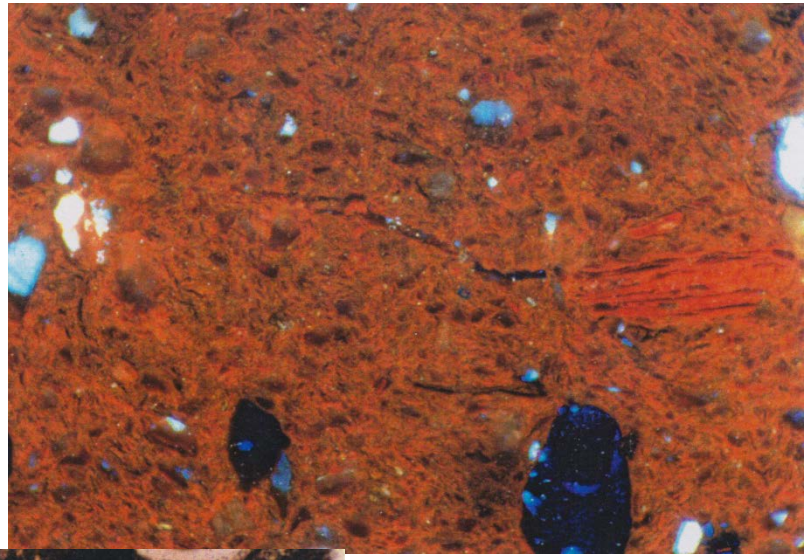
- Substructure, Columns
  - Mass Concrete
  - Masonry
  - Shotcrete and other Repairs
  - Use of dimension stone and sculpture
- Decks
  - Lightweight concretes
  - Overlays (LMC, SFC), Repair Materials
- Beams
  - Precast – DEF

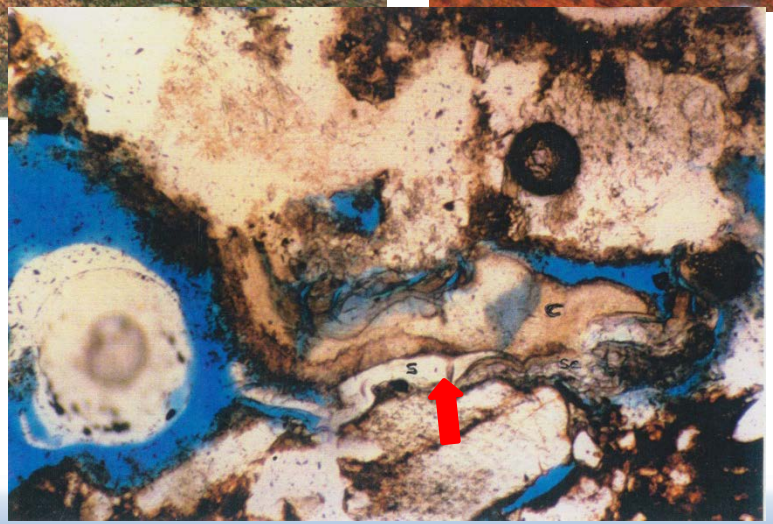
Drilled Shaft for a Bridge



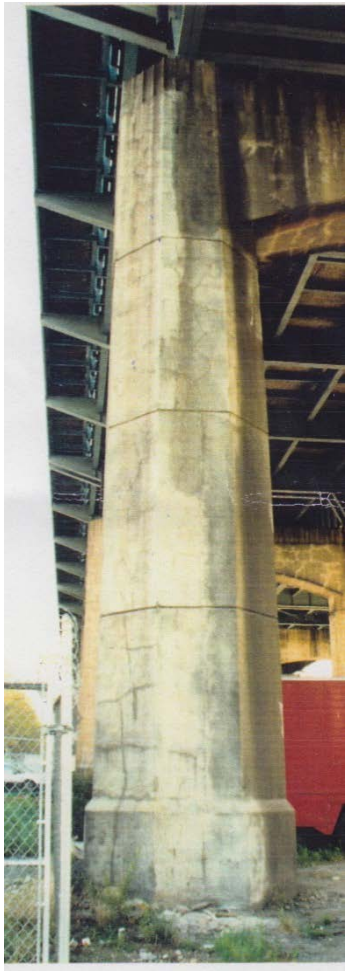
Tremie Concrete,
lost tremie & mixed with water

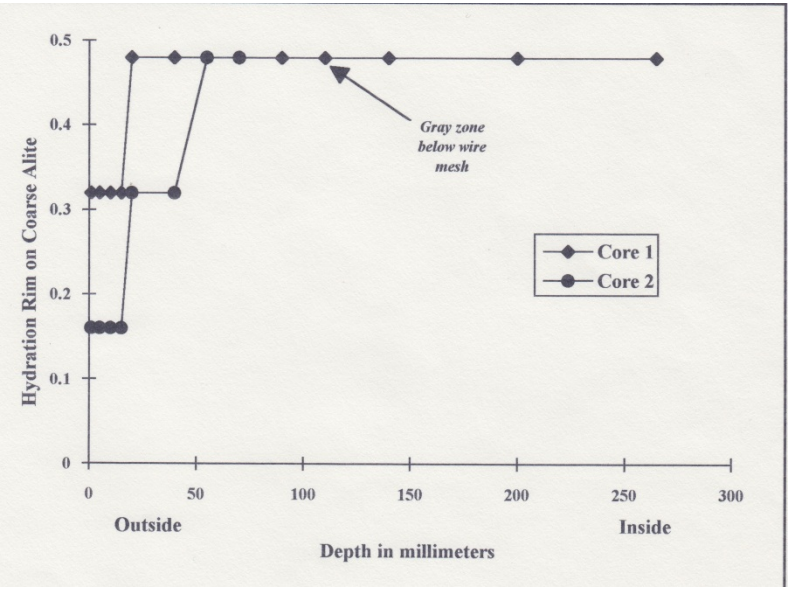
Masonry Bridges

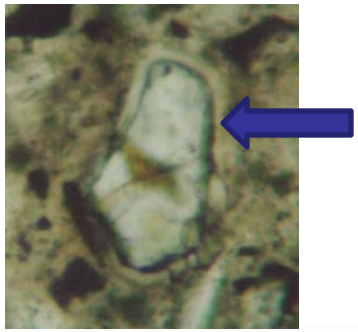




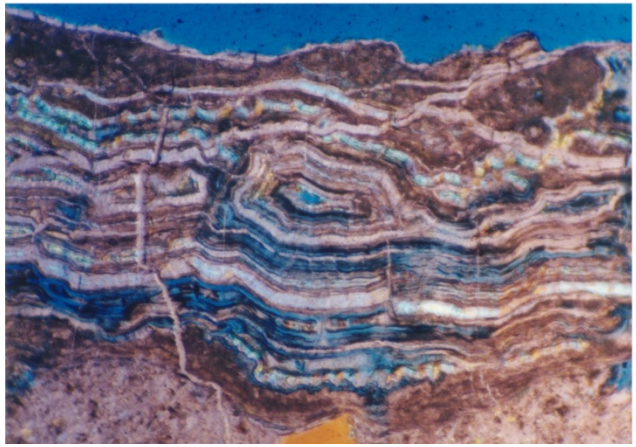
Shotcrete Repair, Triboro Bridge, NY



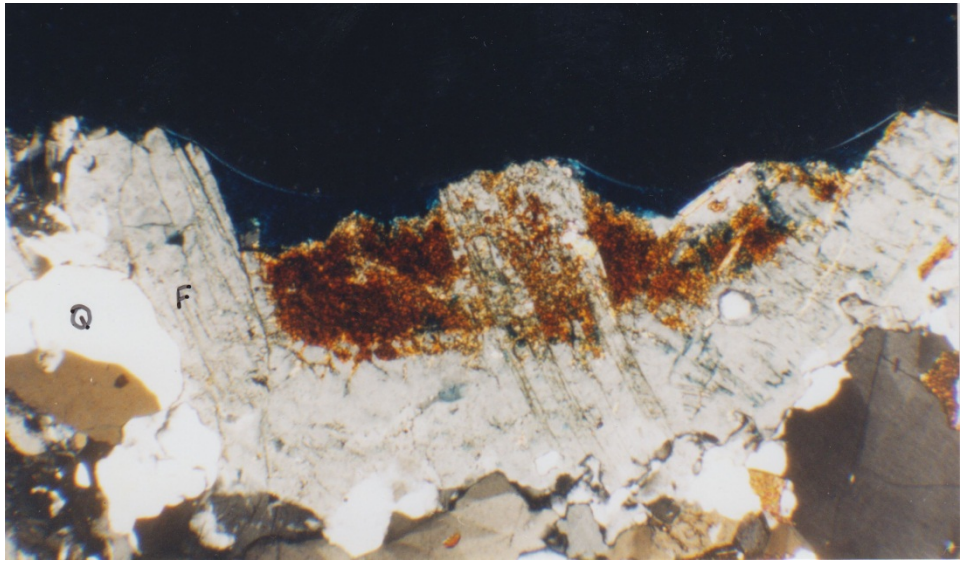




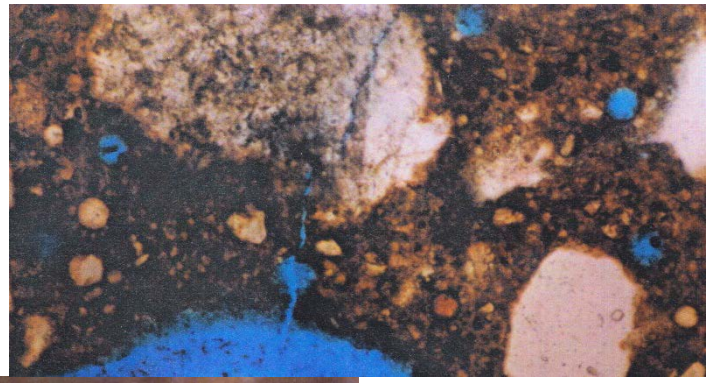
ASR
Fore River Bridge, MA

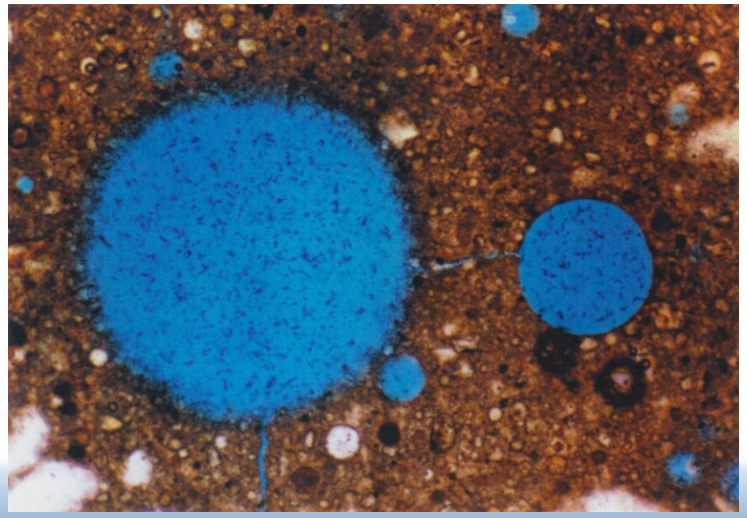


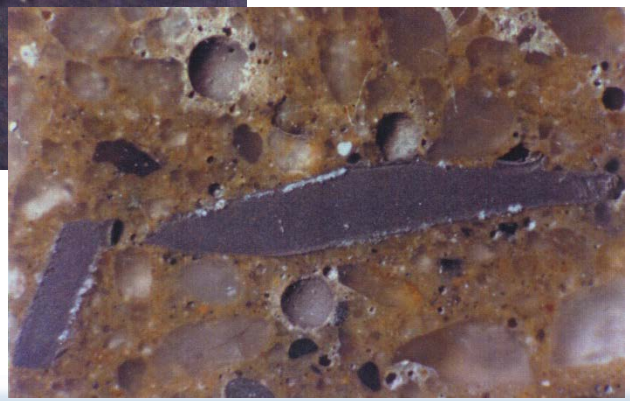
Manhattan Bridge Sculpture, NY



Bridge Deck Repairs, Pyrament, Tappan Zee Bridge, NY





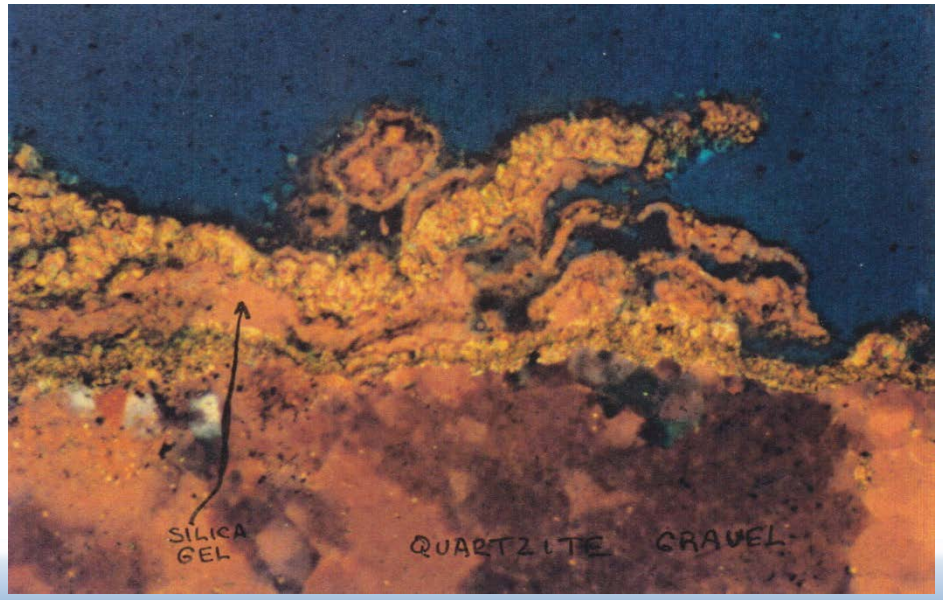


Collision, Fire Damage, Richmond, VA

Tunnels

- TBM Performance in rock
  - Penetration rates and abrasion
- Linings
- Mass Concrete
- Pavement
- Fire resistant panels and attachments

Lincoln Tunnel, NY



Incidentals

- Incidental Construction
  - Road markings
  - Crash barriers
  - Sound Barriers
  - Pavers
  - Curb and Gutter
  - Light poles
  - Drainage structures
  - Flowable Fill

Major Contributors to Petrography for Highway Applications

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