APPLIED CONSTRUCTION GEOLOGY TO MAXIMIZE PAVEMENT PERFORMANCE

Adriana R. Schnoebeelen, Geologist
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<td>Develop an in-depth working knowledge of the Geologic formations and their engineering properties.</td>
<td>Work with producers in the quarries, underground mines and gravel pits; and partner Specifications.</td>
<td>Determine Durability Classes for Portland Cement Concrete (PCC) aggregates.</td>
<td>Pavement deterioration evaluations.</td>
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<td>Analyze information obtained from Chemical and Physical testing.</td>
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STRATIGRAPHY

• Iowa has a nearly complete sequence of Paleozoic strata.

• Regional Dip 3° dip NE – SW: Cambrian bedrock outcrops in NE Iowa, progressively younger to SW Iowa where Pennsylvanian bedrock outcrops.

• Glacial deposits overlay the bedrock.
  – Generically termed ‘Gravels’.
  – Thickest in Northwest Iowa
Paleozoic History of Iowa
250 – 500 million years

Mesozoic History of Iowa
65 – 250 million years

Image courtesy of Ray Anderson, Iowa Geological Survey
INDUSTRY

• Nearly 1000 active sources, in and around Iowa. See IM T203
• Provide geologic sections for active sources
  – Assist aggregate producers with ledge control
• Partner specifications with Industry.
VARIABILITY
OF QUARRY LEDGES

Southwest Iowa

Northcentral Iowa

Western Iowa
East Central Iowa

Southeast Iowa
GLACIAL “GRAVEL” DEPOSIT
DETERMINE DURABILITY CLASSES FOR PORTLAND CEMENT CONCRETE (PCC) AGGREGATES USING SALT-SUSCEPTIBILITY QUALITY NUMBER AND PCC PAVEMENT SERVICE HISTORY
BACKGROUND

• Pavement failures in the mid 1980’s led former DOT geologist Wendell Dubberke to:
  – investigate the causes for these failures (high DF)
  – develop an algorithm that combined the pore index with aggregate chemistry to predict durability class.
  – Algorithm was cross referenced to known pavement performance

• In 2000, the DOT began using SSQN as a concrete stone approval specification.

• After 10 years evaluation, current DOT geologist Bob Dawson made revisions to the algorithm.
IOWA DOT DURABILITY CLASSES

3 Classes: 2, 3, 3i

- Class 2—minimal deterioration only after 20 years, non-interstate usage
- Class 3—minimal deterioration only after 25 years, non-interstate usage
- Class 3i—minimal deterioration only after 30 years, interstate usage
**PRINCIPLE REASONS FOR AGGREGATE FAILURE**

- Clay content
- Pore system
  - Capillary pores yield many available sites for chemical reactions from deicing salts to occur
  - Poor freeze thaw performance
- Chemistry of the Aggregates
  - Stability of minerals that form the aggregate.
  - Unstable due to substitutions in the crystal lattice
    - Fe for Mg in CaMg\((\text{CO}_3)_2\)
THESE THREE FACTORS ARE EVALUATED BY:

• Measuring the clay content of the aggregate (XRF, alumina quality number).
• Determining the pore system for pore size and volume (Iowa Pore Index quality number).
• Examining the limestone and dolomite fractions for chemistry and mineralogy (XRF/XRD quality number).
IOWA PORE INDEX NUMBER

- This number quantifies the amount of water an aggregate particle absorbs into its pore system.
- The Pore System comprised of:
  Primary—large pores
  Secondary—small, capillary pores

SEM Image on left (5000X); grain size of a poor performing aggregate.
SEM Image on right (90x); grain size of a good performing aggregate.
Graphical representation and equation showing the proportional fraction that the XRF-XRD quality number has in the salt-susceptibility quality number based on how dolomitic the aggregate is.
STATES WHERE IOWA DOT TESTING METHODS ARE USED OR HAVE BEEN USED.

IOWA PORE INDEX TEST (AASHTO TP120-16)
- Kentucky
- Michigan
- Minnesota
- Missouri
- Montana

XRF (ALUMINA) EVALUATION
- Missouri
- Florida
- Michigan
A recent FHWA nationwide review of state DOT’s, recognized the Iowa DOT for having **the** best system for determining the quality of aggregates used in construction projects.

*We’re the only state in the Nation that addresses salt-susceptibility in construction aggregates.*
FORENSICS FOR PAVEMENT SERVICE HISTORY
Extremely D-cracked pavement from Salt-susceptible Aggregate

US Hwy 30 Carroll County, 30+ years with no aggregate related deterioration
Side views from a recent pavement evaluation showing what D-cracking looks like below the pavement surface.
Salt Reaction Rim on an Aggregate Particle

Staining in the cement paste. ACR?
Why is aggregate important?

It’s the primary component of PCC, HMA, and granular surfacing materials.
PROJECT EXAMPLE

US Hwy 20 from Moville to Galva – Approx. 24 miles
550,000 Total Tons of Aggregate used in 2016

- 25,000 Tons of Floodable Backfill
- 150,000 Tons of Granular Subbase
- 100,000 Tons of Granular Backfill
- 100,000 Tons of Special Backfill
- 70,000 Tons of 1” PCC Rock
- 70,000 Tons of Sand for PCC
- 15,000 Tons of Intermediate PCC
- 20,000 Tons of Reclaimed/Recycled Aggregate

Based on current production to complete the “Final Forty”… these projects will use just over 2 million tons of aggregate.

- Estimates courtesy of Dist. 3 Materials staff.