Iowa Approach to Minimizing D-Cracking

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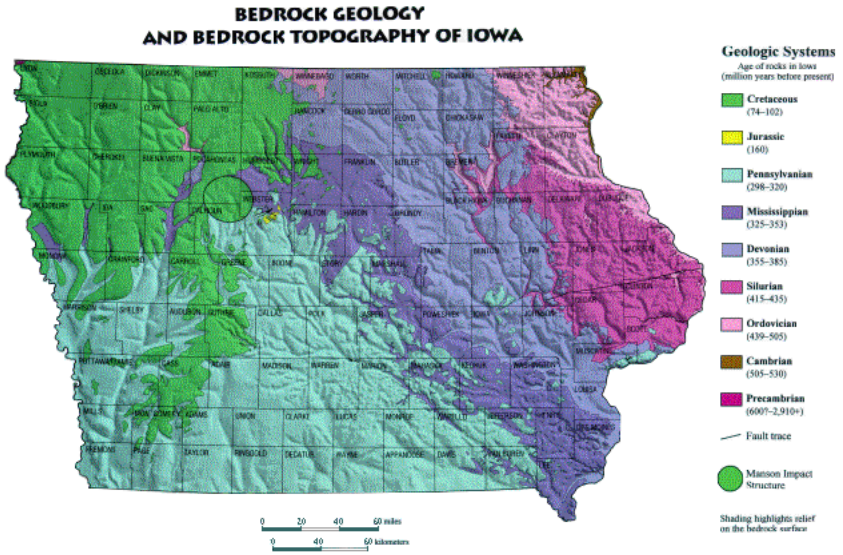
Background

- ASTM 666 is a poor predictor of pavement performance
  - ✓Some aggregates susceptible to deicing salts.
- Late 1970's to the mid 80's
  - ✓Iowa Pore Index test
  - ✓Aggregate chemistry data.

Types of Aggregate Tested and Common to Iowa

- Limestone - CaCO3
- Dolomite - CaMg(CO3)2
- Intermediate Dolomites
- Carbonate fraction of a Gravel

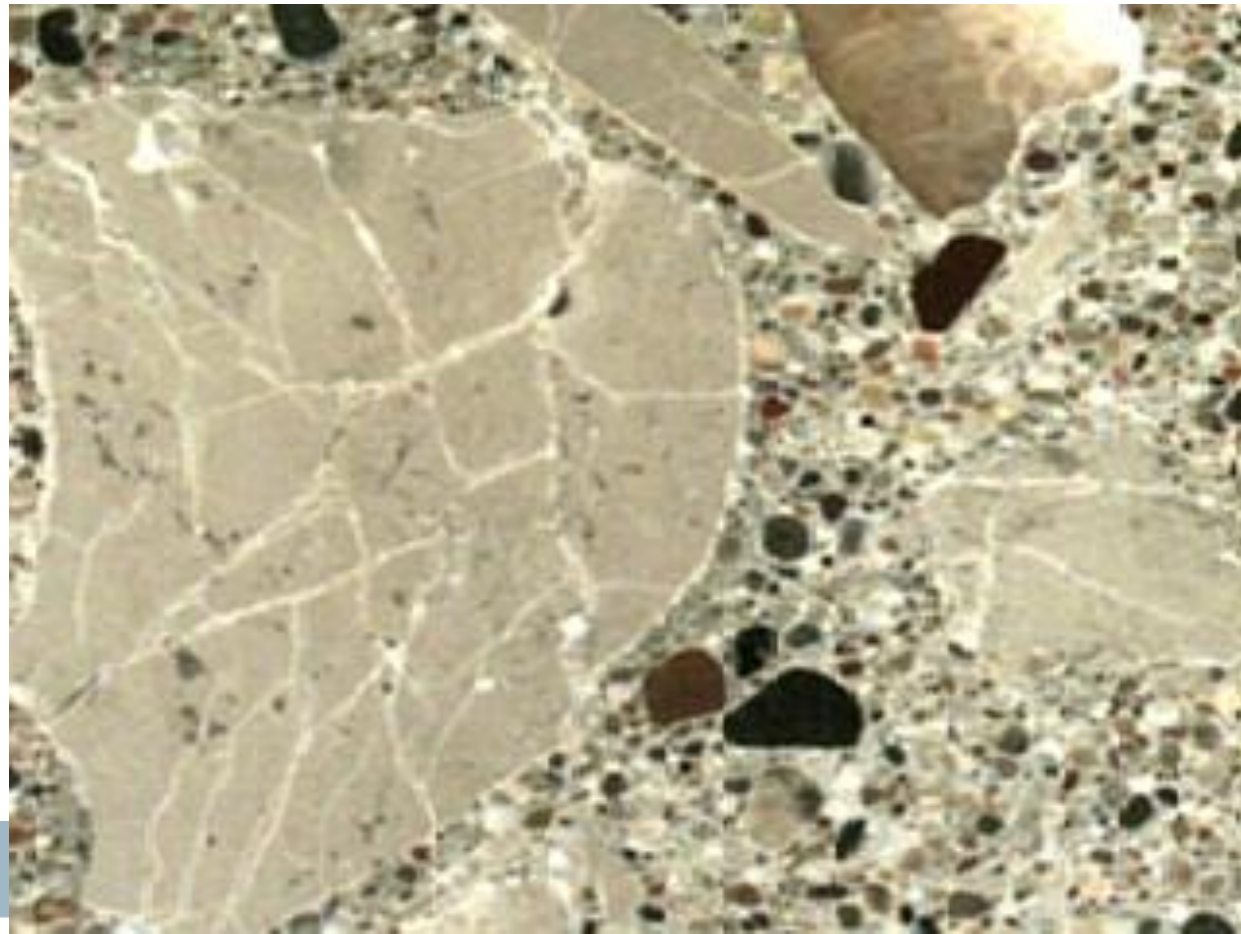


Symptoms

- Initial staining of the joints
- Progressive fractures at the transverse joint
- Decay progresses up from the bottom
- Leads to spalling in 15 to 20 years
- Increases with deicing salting

Symptoms

- Early damage is in the aggregate – not the paste

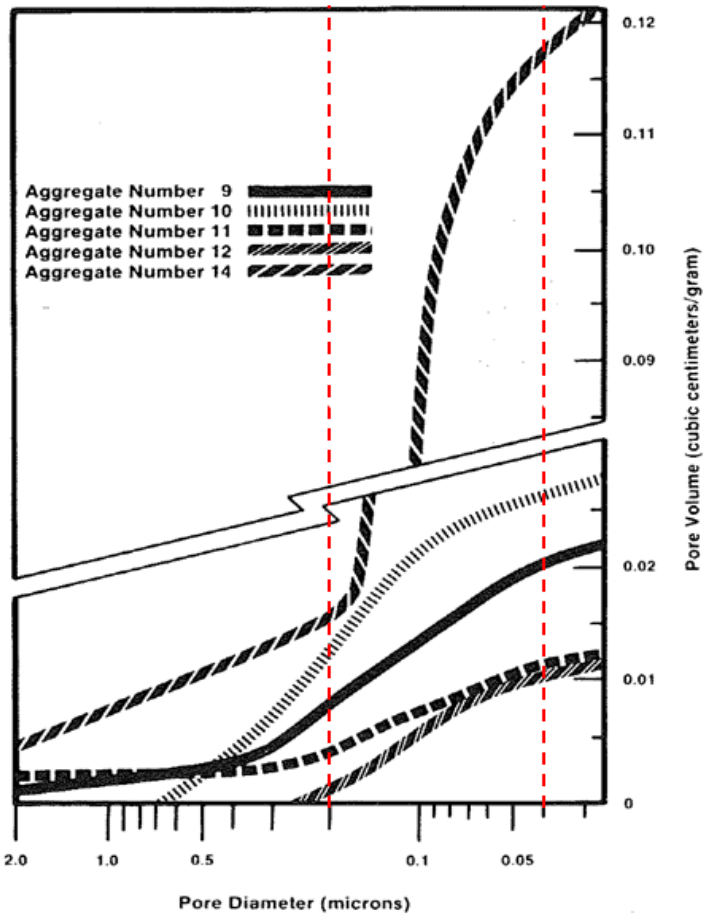


Aggregates in Iowa

- Based on service history, three concrete durability classes identified:
  - ✓Unapproved
  - ✓Class 2 – minimal deterioration 20 yrs
  - ✓Class 3 – minimal deterioration 25 yrs
  - ✓Class 3i – minimal deterioration 30 yrs

Principle Reasons for Aggregate Failure

- Clay content of the aggregate
- Pore system
- Stability of minerals that form the aggregate



Marks and Dubberke 1982

Evaluated by

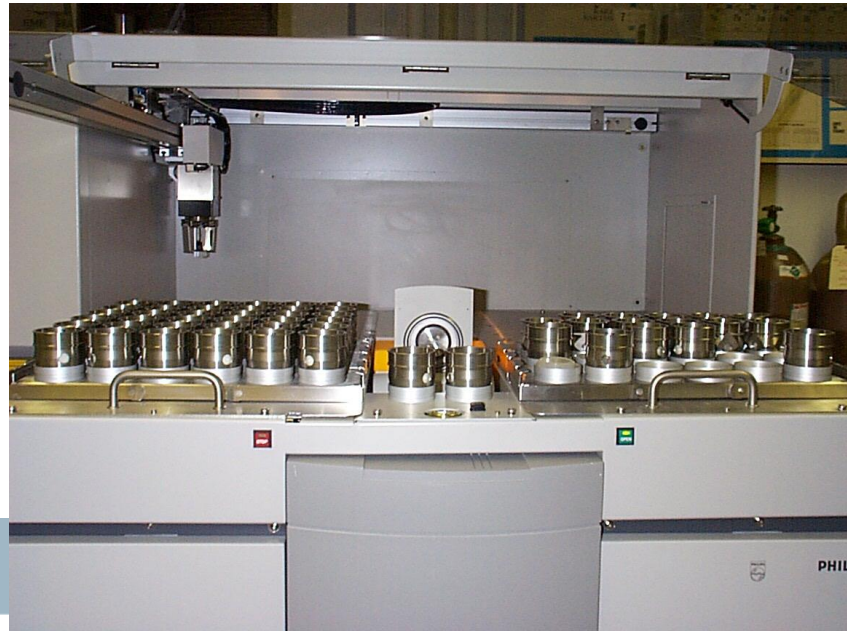
- Measuring the clay content of the aggregate
  - ✓ (XRF, alumina quality number).
- Determining the pore system for pore size and volume
  - ✓(Iowa Pore Index quality number).
- Examining the limestone and dolomite fractions for chemistry and mineralogy
  - ✓(XRF/XRD quality number).

PCC Quality Numbers

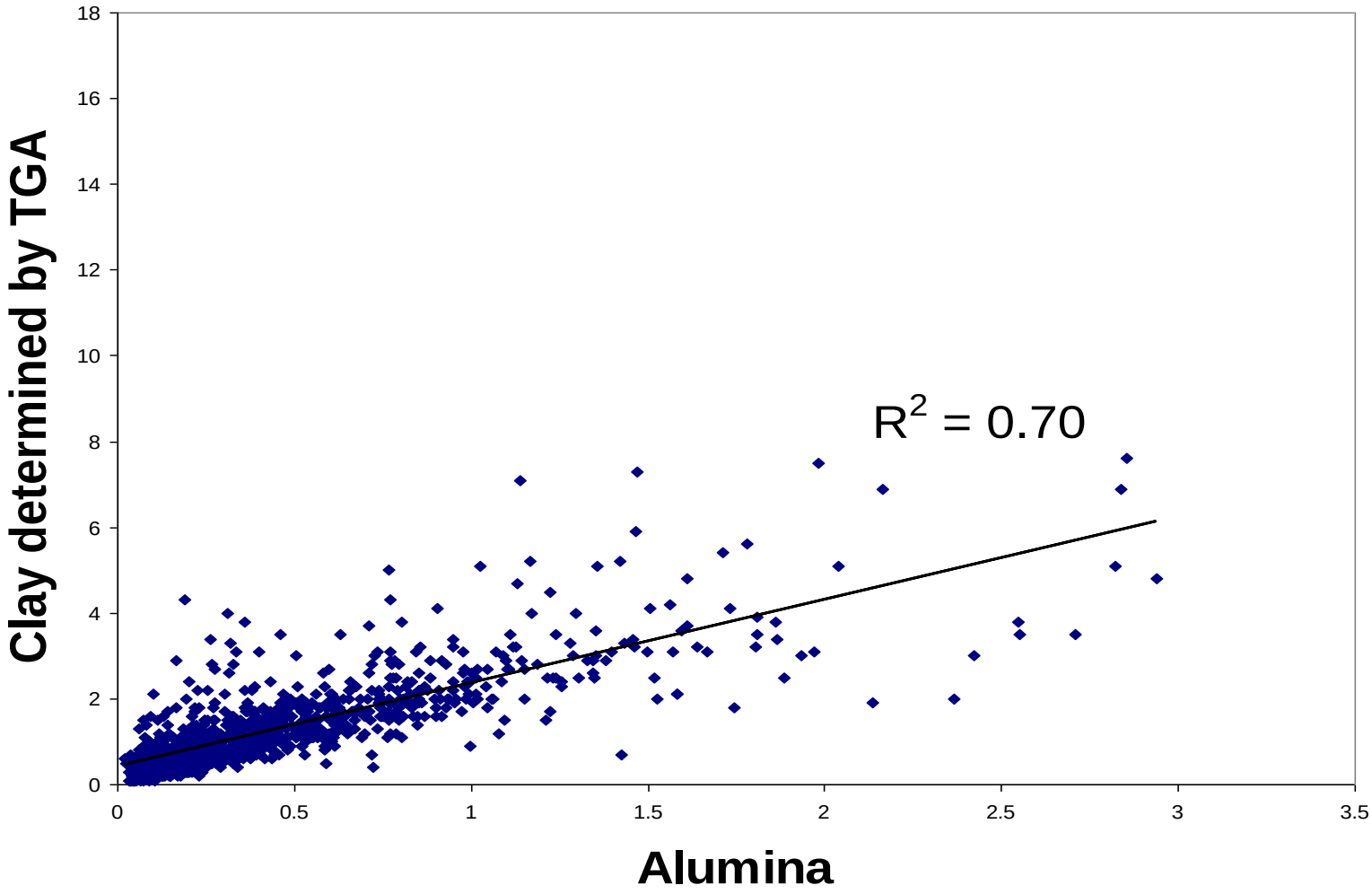
- Quality numbers are correlated with service history
- The three quality numbers are then weighted to generate an overall salt-susceptibility quality number
  - ✓Class 2 quality number <4.5
  - ✓Class 3 quality number <1.5
  - ✓Class 3i quality number < 1.0

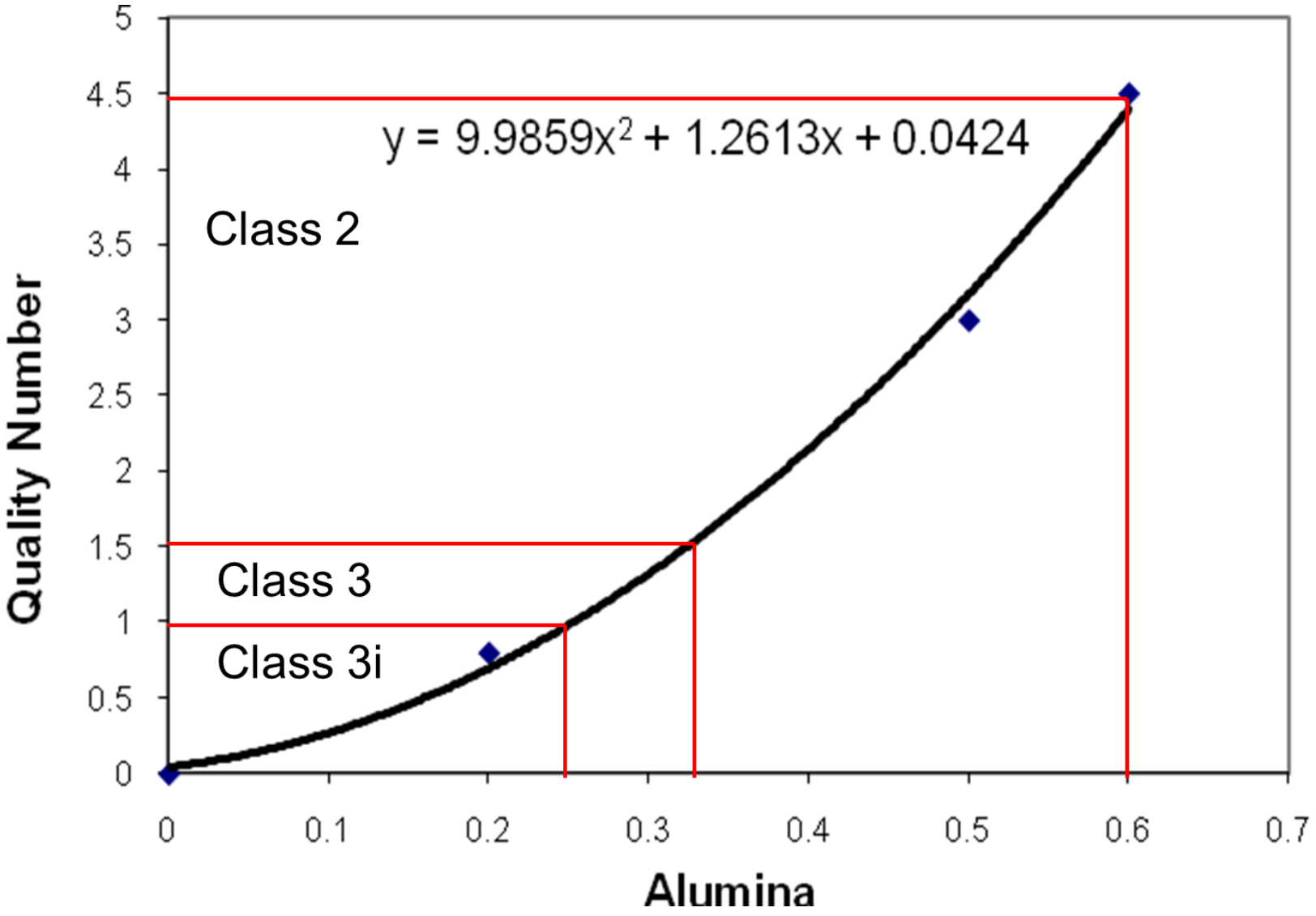
X-Ray Fluorescence (XRF)

- Elemental analysis expressed as oxide percent
- Oxides determined
  - ✓CaO, MgO, SiO2
  - ✓**Al203**, Fe203, Cl
  - ✓TiO2, S, Na2O
  - ✓K2O, P2O5
  - ✓MnO, SrO.



Measurement of Clay by Alumina



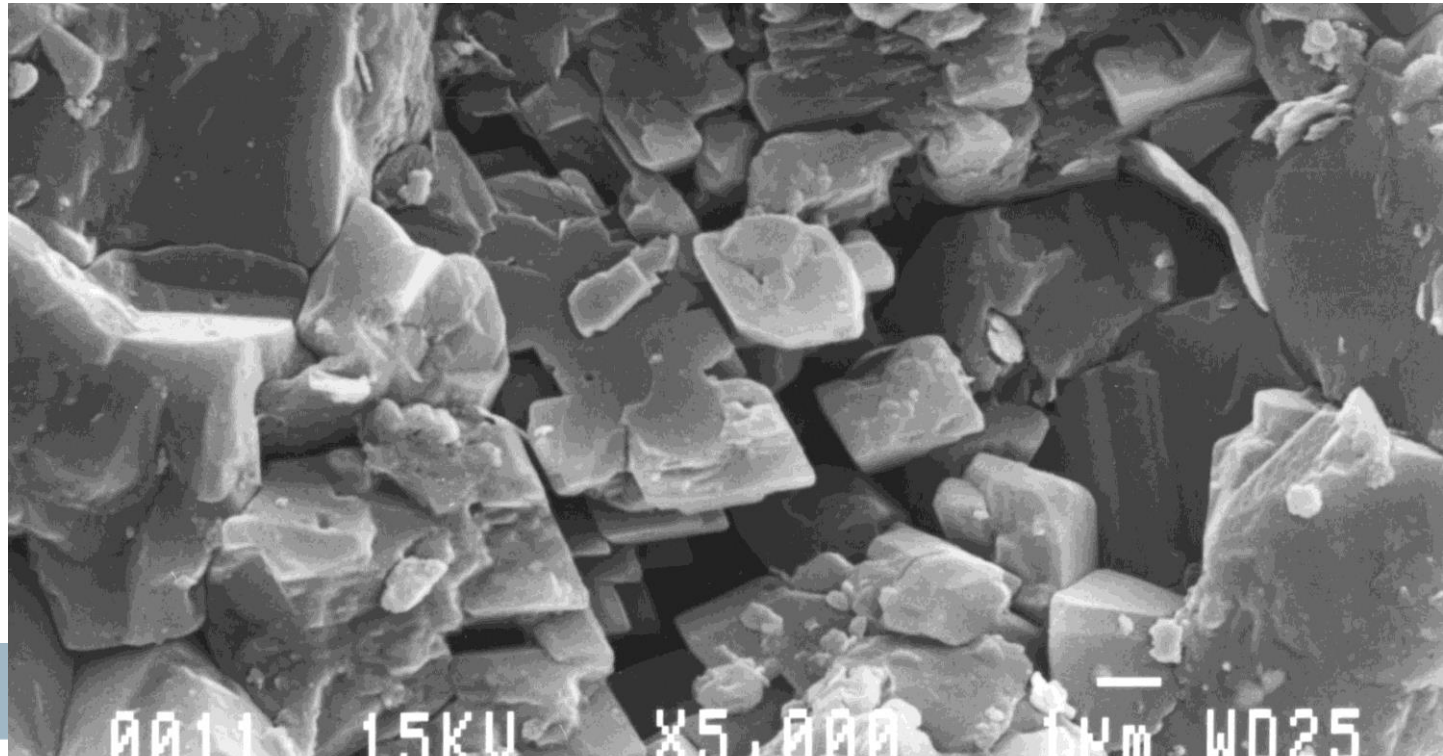

y = 9.9859x² + 1.2613x + 0.0424
Class 2
Class 3
Class 3i
Quality Number
Alumina
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7

Pore Index Equipment

- 4500 grams of ½ x ¾ inch material in a air tight vessel filled with water
- Pressurized to 35 psi
- Volume of water penetrating
  - ✓1 minute (large pore system) (primary)
  - ✓15 minutes (capillary size pores) (secondary)

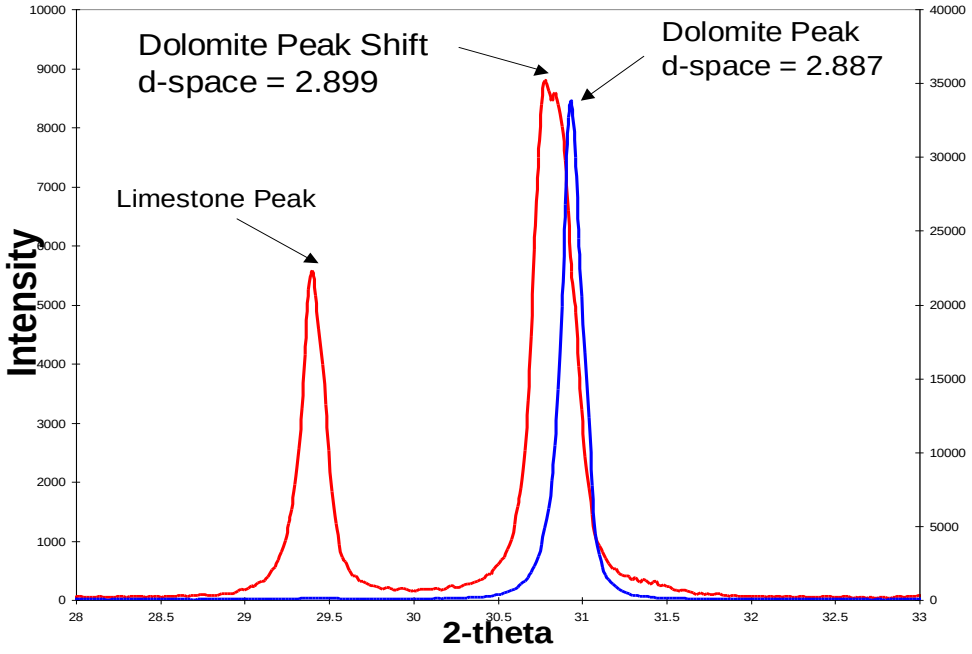
Pore Index Quality Number

- Secondary = 20 → pore quality of 1.0
- Secondary = 25 → pore quality of 1.5
- Secondary = 30 → pore quality of 4.5



X-Ray Diffraction (XRD)

- Determines mineral composition
- Also used to determine the purity of dolomite crystals.



Dolomite Quality

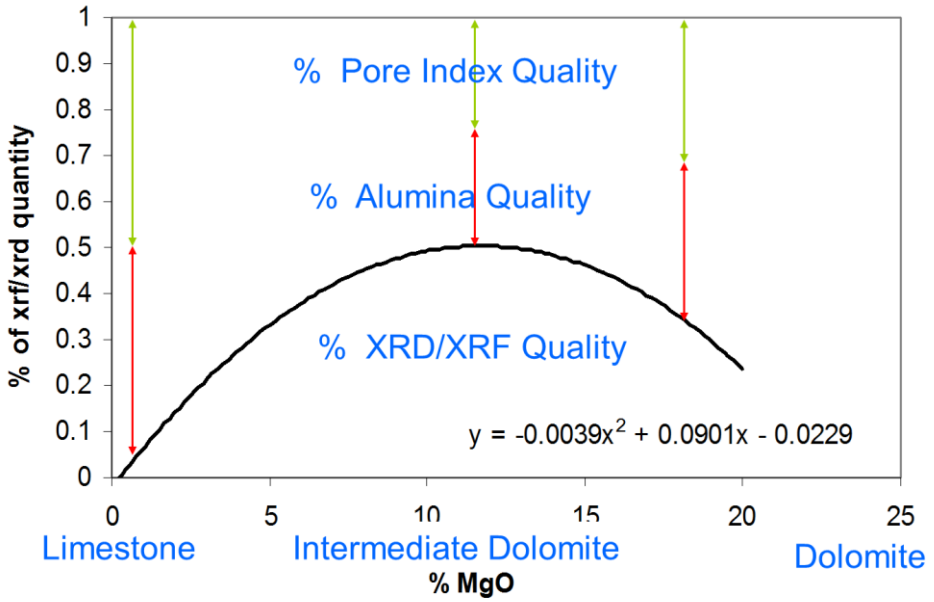
- The greater the peak shift the lower the quality (less stable) the dolomite mineralogy.
- The more sulfur and manganese the lower the quality.

Limestone Quality ($CaCO_3$)

- Elevated levels of Strontium correlate with poor performance.
- In mixed limestone and dolomite aggregates, the quality number is based on the relative weight percent of each.

Overall Quality Number

- The “overall” Salt-susceptibility quality number is a combination of the three individual quality numbers.
- Based on how dolomitic the aggregate is.
- More deterioration occurs in intermediate dolomites.

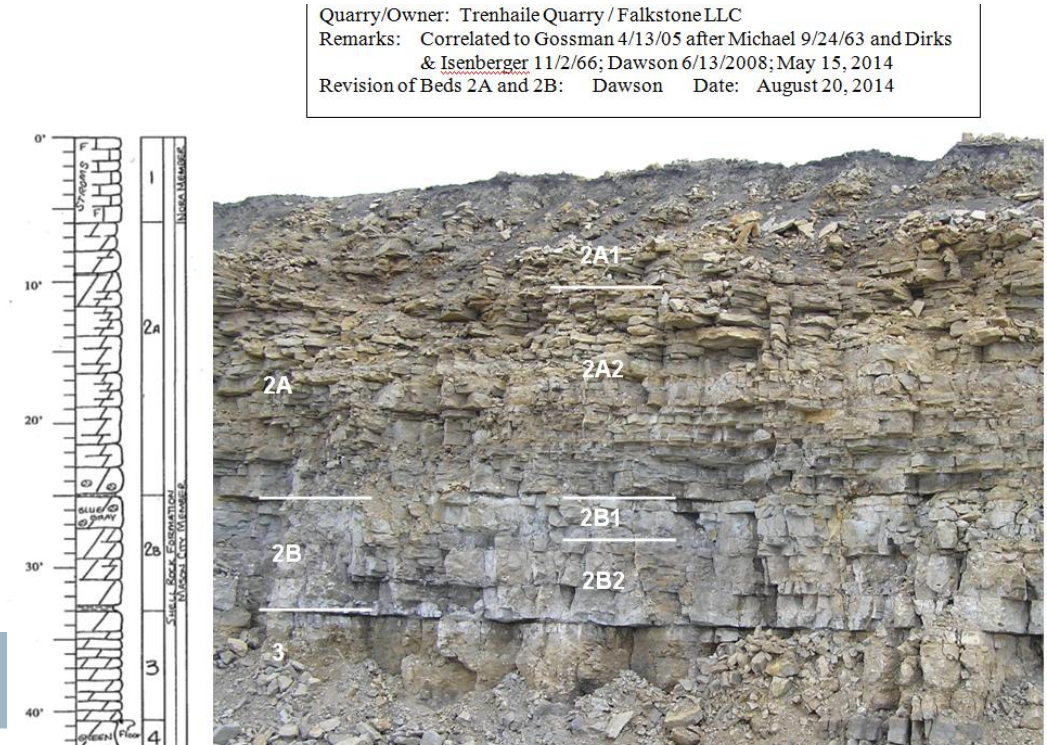


Overall Quality Number

- Pure limestones and dolomites tend to be more stable in the presence of deicing salts.
  - ✓For pure limestones, chemistry is not as important as pore system and clay content.
  - ✓For intermediate dolomites chemistry is very important.
  - ✓For pure dolomites, all three factors are important.

Other reasons for the success of this Method

- Iowa practices ledge control, meaning individual beds within a quarry are evaluated.



Conclusions

- A fast and affective way to predict the performance and service history of aggregates in IA.
- Test results are still actively compared to actual pavement performance.

Where Next?

- Looking at a new approach to assess pore size distribution
- Is there an easier way to find those clays?
- How do we ensure that the aggregate delivered is the same as the approved source?