Midwestern States In-Place Recycling Conference 2009

Aged Material Properties of Cold In-Place Recycled Asphalt Roads Iowa Highway Research Board TR 502

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Problem Statement

- Recycled roads have inconsistent performance
- Prominent factors:
 - Age of the recycled pavement
 - Traffic volume
 - Support conditions
 - Aged engineering properties of the CIR materials

Objectives

- To answer two questions:
 - How do aged engineering properties of CIR materials, traffic and subgrade conditions affect the pavement performance?
 - What changes should be made with regard to design, material selection and construction in order to improve the performance of future recycled roads?

Selection of CIR Test Sections

- Eighteen 1,500-ft old test sections, which were surveyed in 1996 and 1997, were selected for re-evaluation in 2005.
- Eight 1,500-ft new test sections were surveyed in 2005.
- Test sections were categorized by:
 - Age
 - Traffic level
 - Subgrade support level

Locations of 26 Test Sections

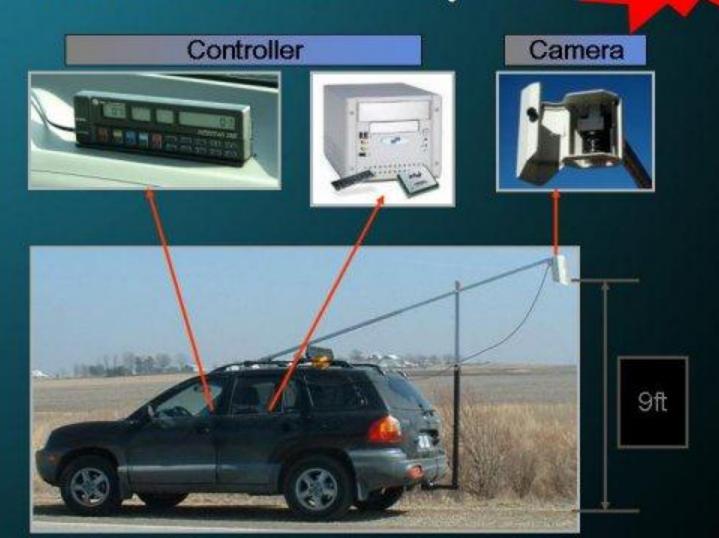


CIR Projects for Sampling Matrix

| | | Good Support (>Subgrade Modulus of 5,000 psi) | | Poor Support (< Subgrade Modulus of 5,000 psi) | |
|-------|---------------------------|--|---|---|-----------------------------------|
| | | Low Traffic (0~800) | High Traffic (>800) | Low Traffic (0~800) | High Traffic (>800) |
| A g e | Young (1999~) | IA-44, Harrison | US-20, Delaware US-61, Jackson IA-48, Montgomery | N-58, Carroll N. of Breda, Carroll S-14, Story | S-27, Story |
| | Medium (1992~ 1998) | - | IA-175, Calhoun IA-4, Guthrie F-70, Muscatine | V-18, Tama E-52, Boone T-16, Butler | G-28, Muscatine D-35, Hardin |
| | Old (1986~ 1991) | R-34, Winnebago B-43, Cerro Gordo R-60, Winnebago | S.S.L., Cerro Gordo Z-30, Clinton E-66, Tama | 198th St., Boone E-50,Clinton | Y-14, Muscatine IA-144, Greene |

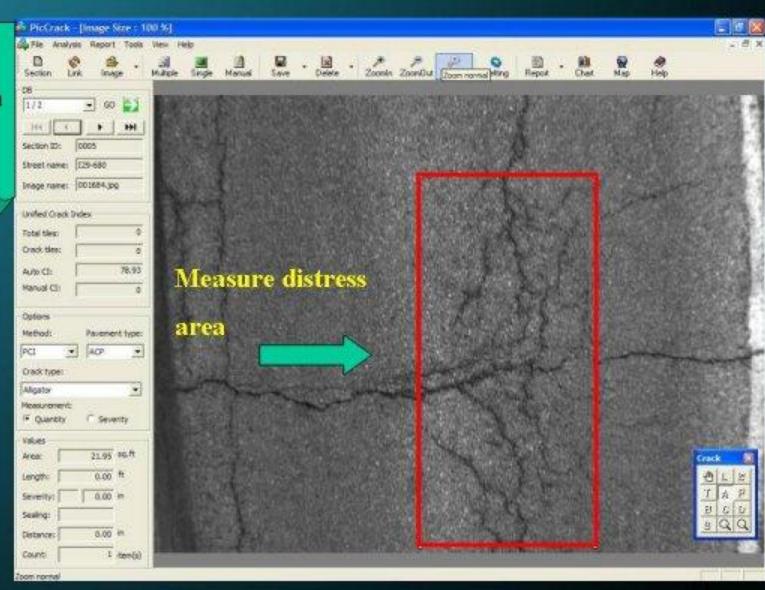
Test Program

Pavement distress survey

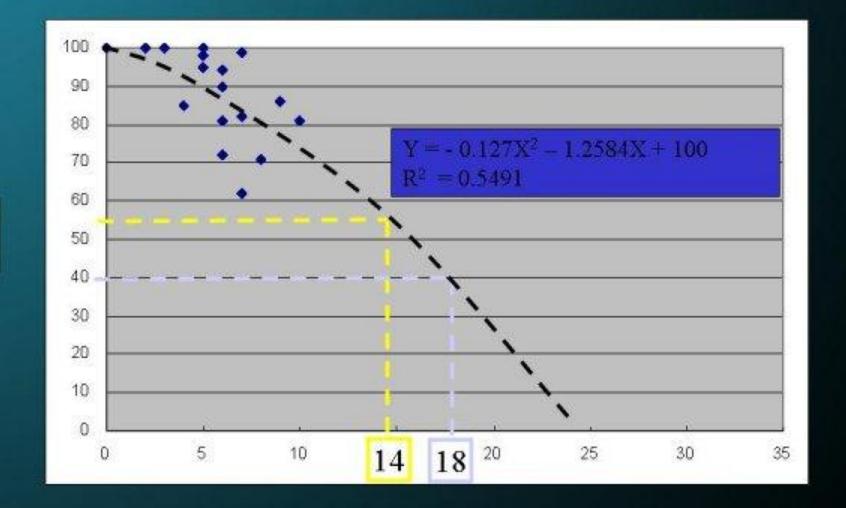


MIAS – Alligator Cracking, Block Cracking and Patching

Measure distress area using a rectangle

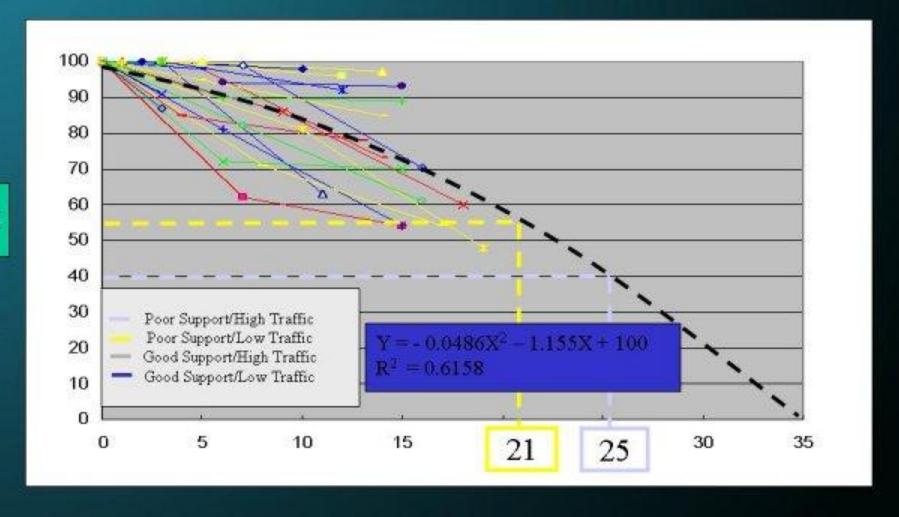


Performance Curve Based on First Survey

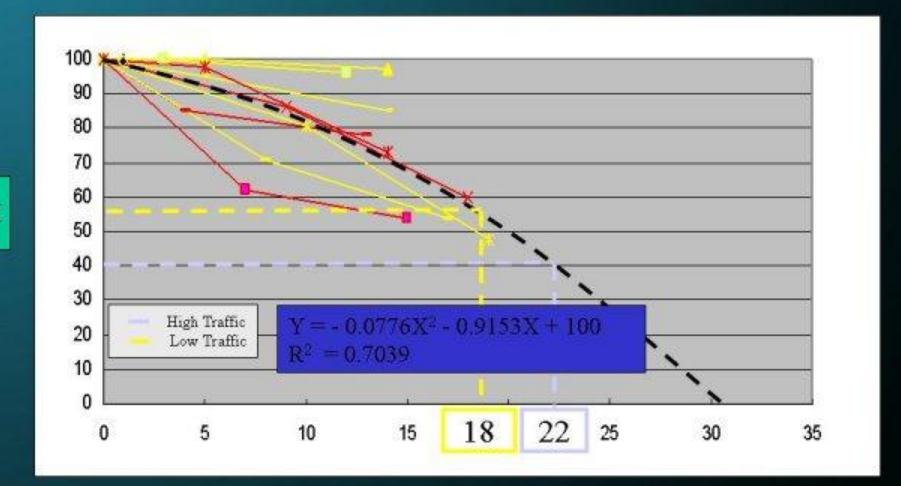


Year

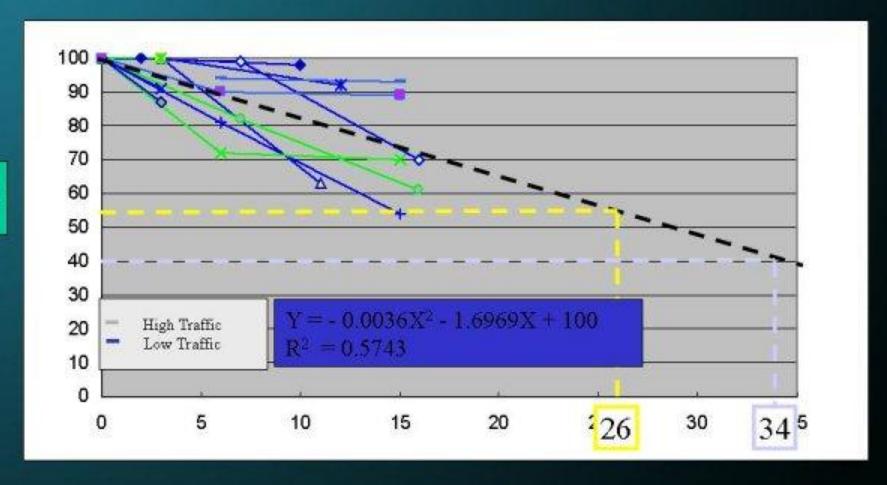
Performance Curve based on both First and Second Surveys



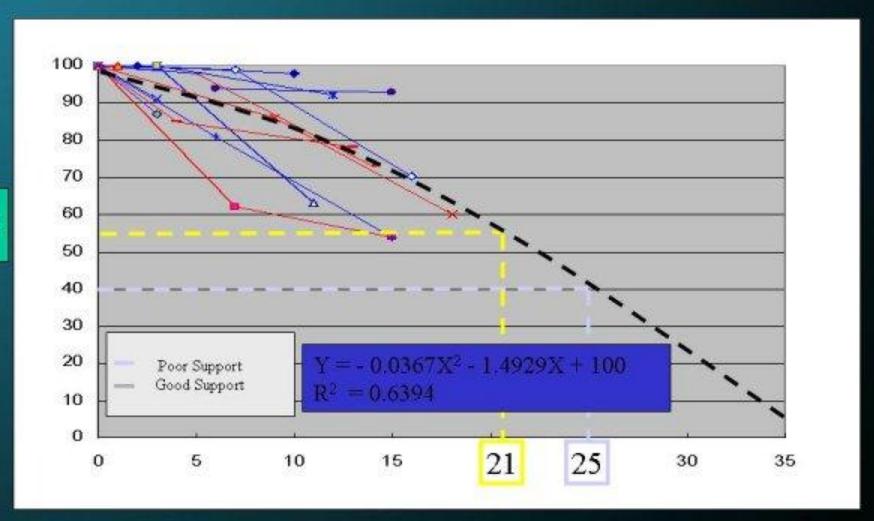
Performance Curve of Test Sections with Poor Subgrade Support



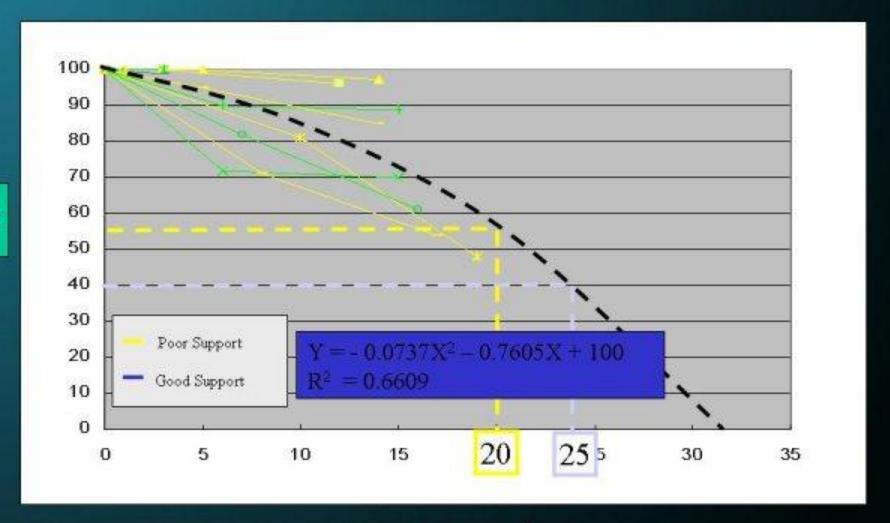
Performance Curve of Test Sections with Good Subgrade Support



Performance Curve of Test Sections with High Traffic Level



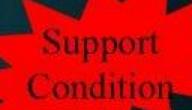
Performance Curve of Test Sections with Low Traffic Level



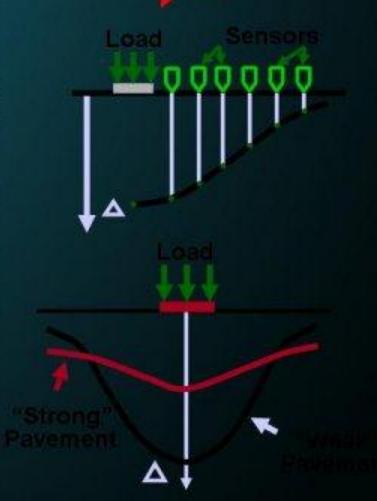


Test Program

FWD executed by Iowa DOT







Test Program

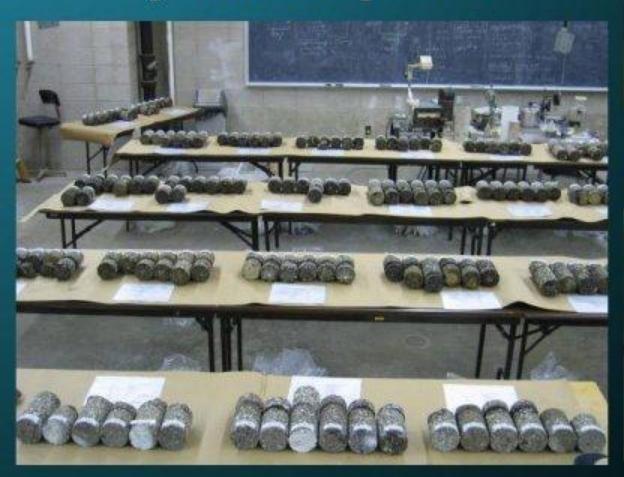
Field coring by Iowa DOT

Engineering Properties



Lab Test Program

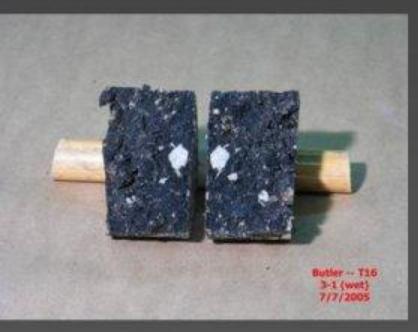
Specimen Preparation





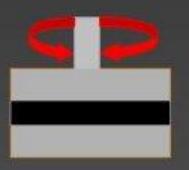








- Indirect tensile testing (IDT)
- Moisture sensitivity
- IDT_{wet} (psi)



- Dynamic shear rheometer (DSR) testing
- Rutting and fatigue
- Complex modulus (G*, KPa)

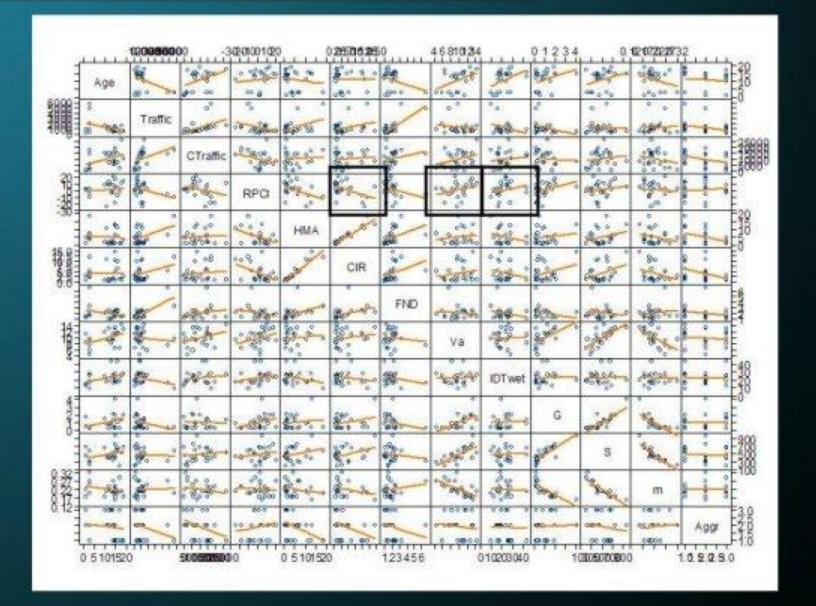


- Bending beam rheometer (BBR) testing
- Thermal Cracking
- Creep stiffness (S(t), MPa), m-value

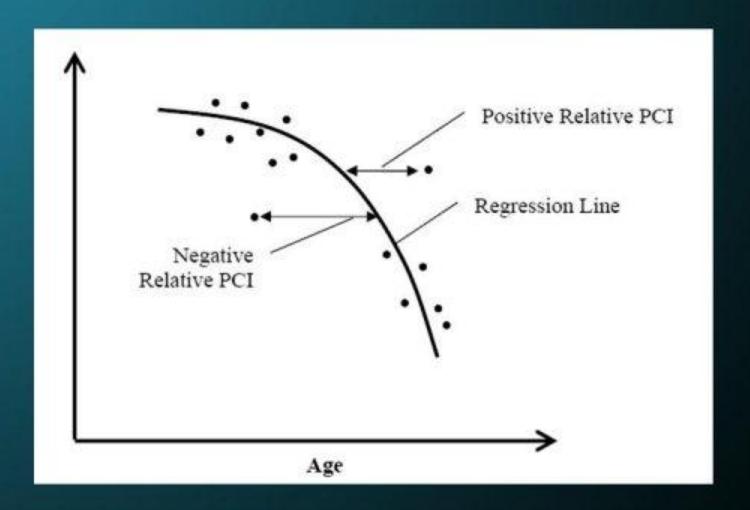
Typical range of HMA/CIR properties

| Type of Property | Property | Typical HMA | CIR in this study |
|------------------------------|------------------------------------|----------------|-------------------|
| Mix | V _a (field measured, %) | 5~9 | 4.5 ~ 14.3 |
| Binder | G*/sin(delta) | > 2.2 | 230 ~ 4,700 |
| Binder | G*sin(delta) | < 5,000 | 170 ~ 3,600 |
| Binder | Penetration (dmm) | 20~30 | 0~30.3 |
| Binder | S(t) (Mpa) | < 300 | 204 ~ 962 |
| Binder | m-value | > 0.3 | $0.16 \sim 0.32$ |
| Pavement Layer Structural | Pavement modulus (ksi)* | 100 ~ 6,000 | 200 ~ 4400 |
| Subgrade Layer Structural | Subgrade modulus (ksi)* | 1 ~15# | 2.7 ~ 15.6@ |

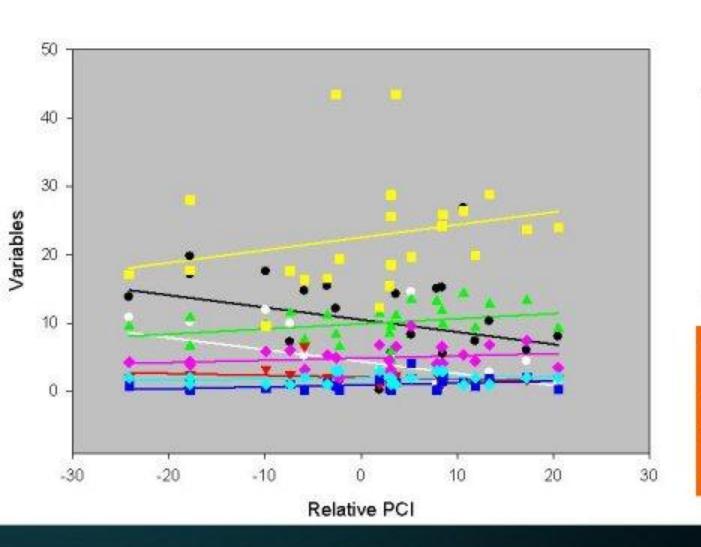
All 24 CIR roads



Relative PCI



All 24 CIR roads



- Cumulative Traffic (1000)
 CIR Modulus (1000 ksi)
- FND Modulus (10 ksi)
- Va (%)
- IDTwet (psi)
- G* (1000 KPa)
- S(t) (100 MPa)
- Aggregate
- IDT_{wet}
- V_a
- Cumulative traffic
- CIR modulus

Conclusions

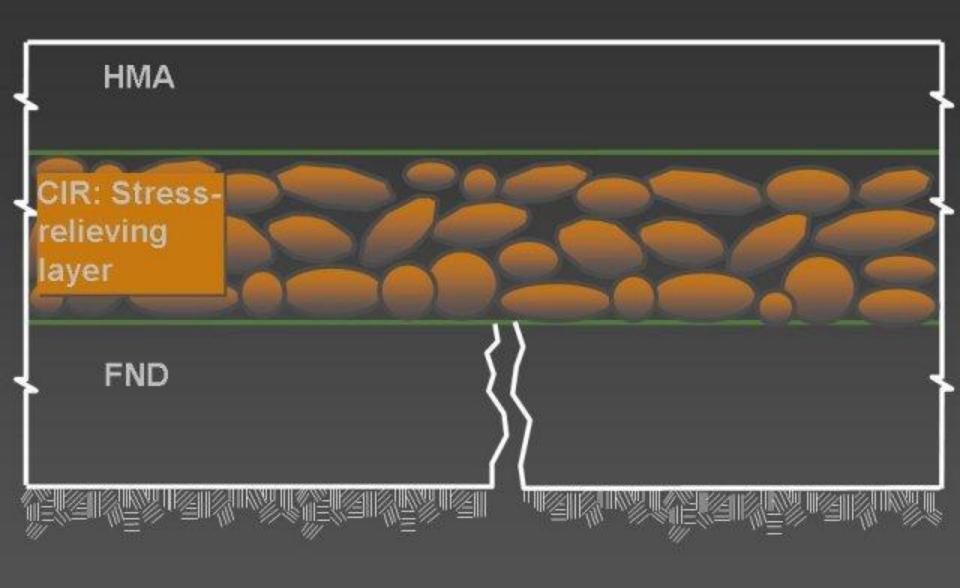
- Predicted service life 21 to 25 years
 - Longer w/ good support (up to 34 yr)
 - Shorter w/ poor support (as little as 18 yr)
- Support more important than traffic
 - within range of analysis (< 2K AADT)
 - Traffic has little effect on roads w/ good support
- Longitudinal and alligator cracking increased... not transverse cracking
 - Rutting, patching and edge cracking associated with poor support

Conclusions

Better performance is associated with:

- V_a (air voids) is higher
 - Range: 6 to 12%
- CIR modulus is lower (more elastic)
 - Range: 700 to 14,500 ksi
 - -- within the range of the analysis

Poor Performance will result from higher V_a and lower CIR Modulus



Conclusions

- Within the range of the data analyzed, higher value of IDT_{wet} significantly and positively affected pavement performance of low traffic roads
- As would be expected, roads with higher cumulative traffic exhibited more distress

ANSWERS TO QUESTIONS POSED BY CONFERENCE ORGANIZERS

Iowa Selection Process

- Selection is made during concept review process
 - Mostly district personnel participate with usually one central office person
 - Includes a site visit
 - Consider funding and road condition
- CIR is usually first choice for < 2000 AADT
- Engineering analysis required for > 2000
- Stimulus funding has resulted in more use

Economic Analysis

- No formal process
- Cost on three recent projects:
 - **\$53,000**; **53,000**; **51,000**
 - Includes milling, and stabilizing agent (foamed Asphalt)
 - Does not include traffic control, mob, overlay and other items
- Cost of stabilizing agent assumed to equal cost of trucking if milling are hauled away

CIR Design /Standard Emulsion

- Start with 0.3 gal/SY/in
- Design procedure not specified and not always used
- Some contractors perform a mix design
- Field adjustment occur regularly
- Milling depth 3 in (2 in with soft subgrade)

Foamed Asphalt Design

- Performed by Iowa DOT
- Determine optimum foaming (water temp and water percent)
 - Typical expansion ratio 10
 - Typical half life 10 sec
- Optimum Moisture Content
 - Usually 4%
- Optimum Foam Content
 - Balance wet and dry IDT

Engineered Emulsion Design

- Performed by emulsion supplier
- Prepare, compact, and cure CIR mixture over a range of emulsion contents
 - Dry density
 - Marshall stability
 - Retained strength
 - Critical low temperature
 - Percent raveling loss
- Select emulsion type and content

Stabilizing agent selection

- Select other than standard emulsion to
 - Improve traffic maintenance after recycling and before overlay
 - Reduce time between recycling and overlay
 - Modify long term performance
 - Foamed asphalt CIR is considered to be a granular material
 - Less water used in engineered emulsion

Challenges

- Maintaining while under traffic
- Occasional rutting after overlay
- Rolled down transverse crack
- Dealing with poor subgrade suppor
- Getting People to try it

Determining Subgrade Support No Distress



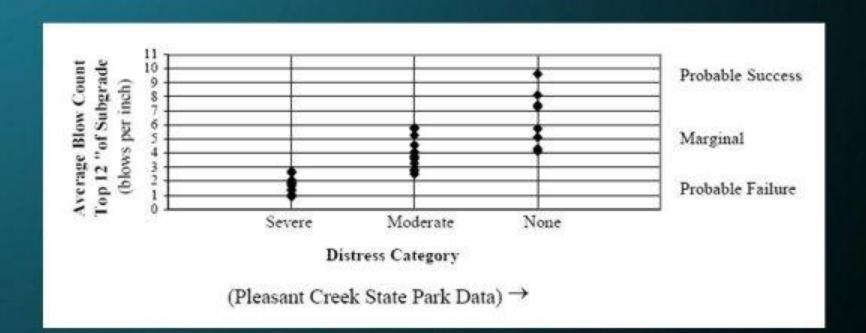
Moderate Distress

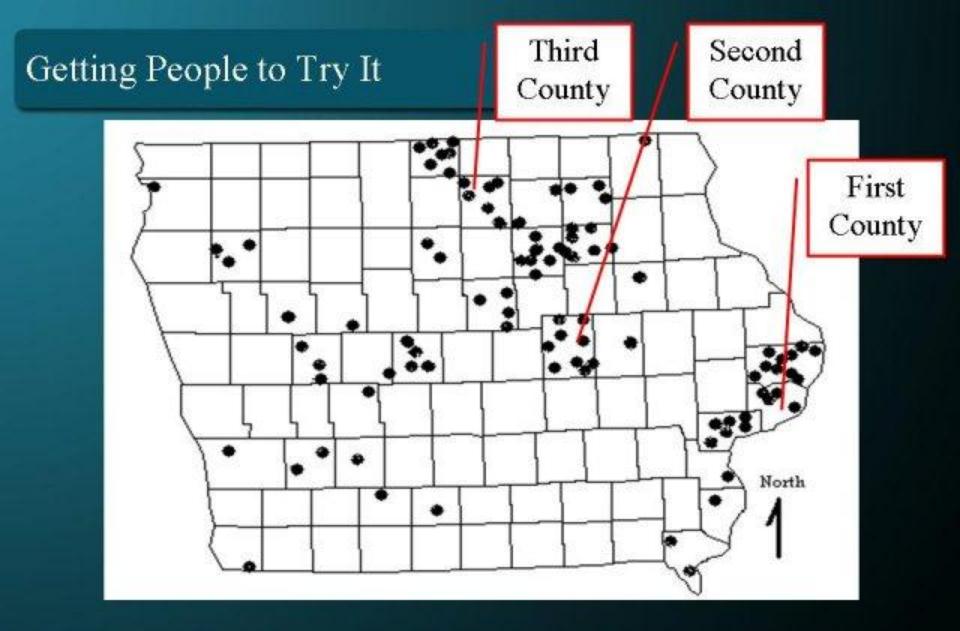


??????? Distress



Pleasant Creek Park Data





CIR Asphalt Projects in 1996

Thank You!!!

