INTERNALLY CURED CONCRETE PAVEMENT FOR INTERMODAL FACILITY

HEAVY-DUTY CONCRETE PAVEMENTS, PART 1/2

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RAO RESEARCH
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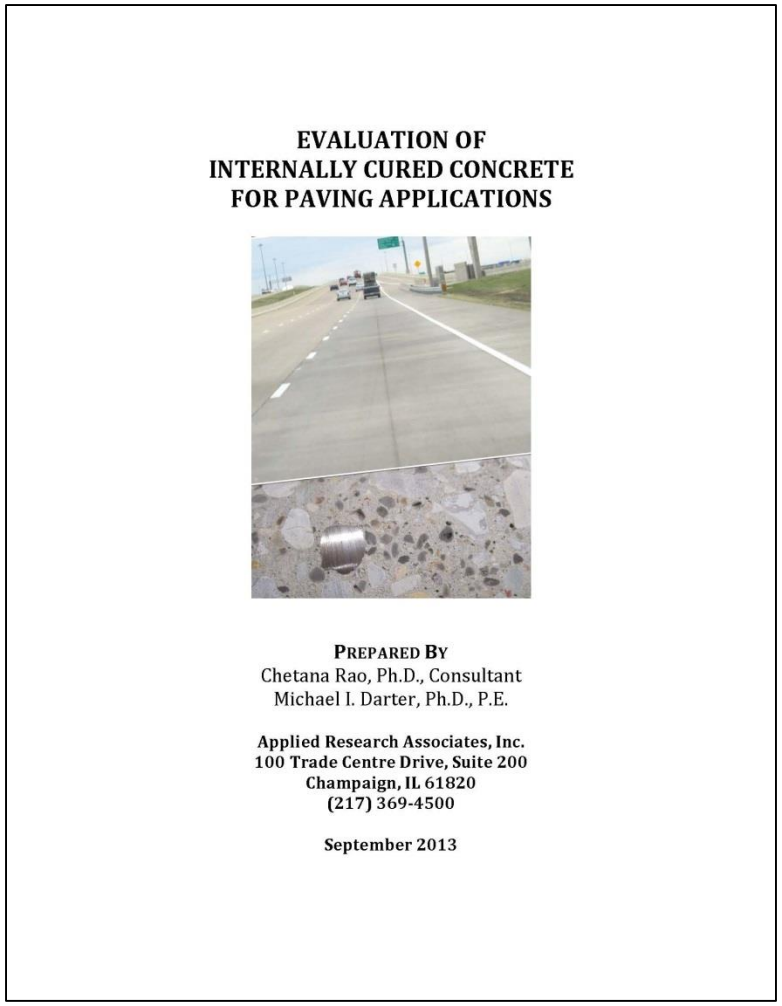
Research References and Acknowledgements



EVALUATION OF INTERNALLY CURED CONCRETE FOR PAVING APPLICATIONS

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- John Ries, FACI
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- Victor H. Villarreal, FACI
  - *TXI/US Concrete*

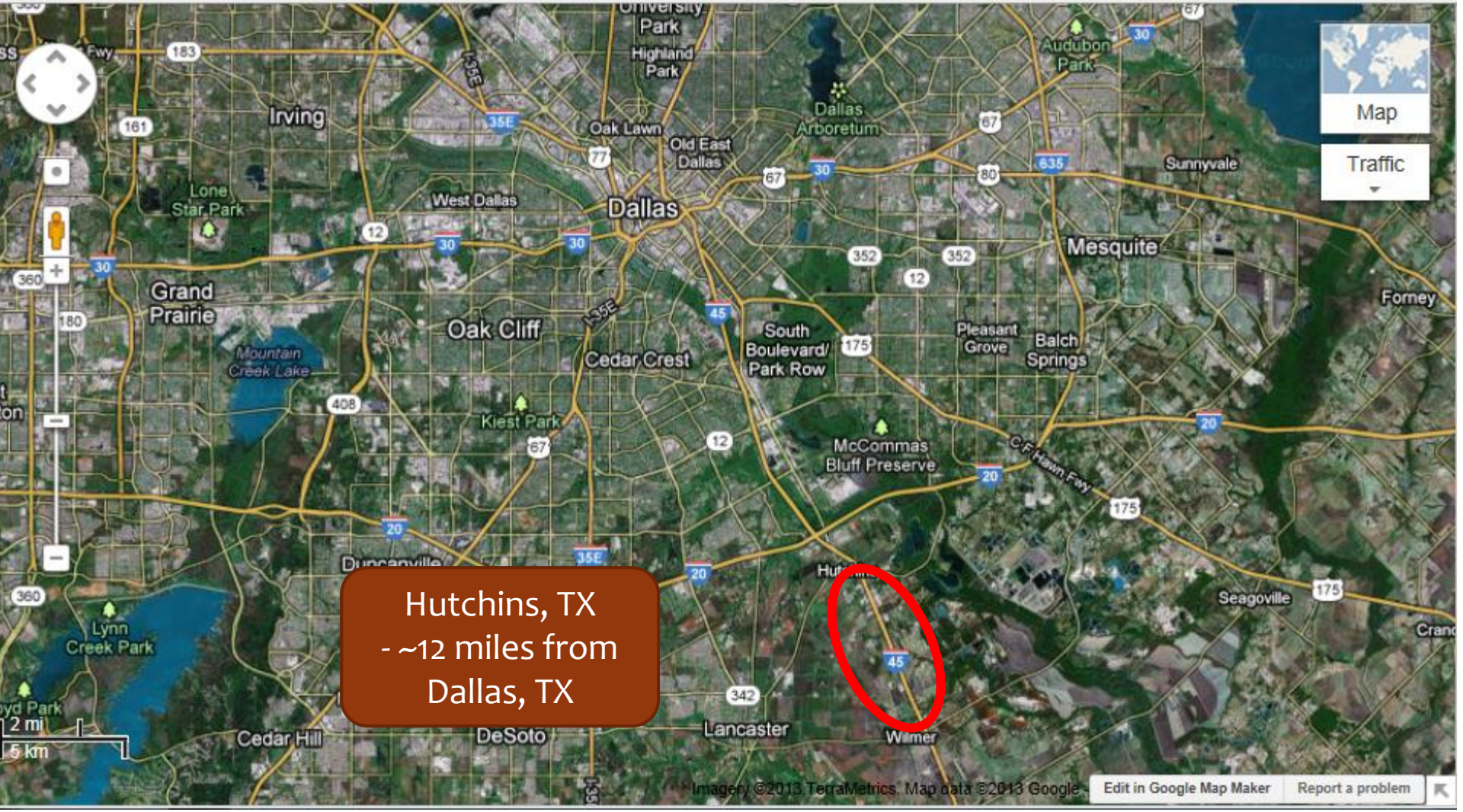
Villarreal, V., and Crocker, D.A.
"*Better Pavements through Internal Hydration - Taking lightweight aggregate to the streets*"
Concrete International, Feb 2007

Outline for Presentation

- Details of Intermodal facility with ICC pavement construction
  - Field observations
- Internally cured concrete (ICC) and potential mixture advantages for concrete pavements
  - Mechanical properties
  - Durability
- AASHTO Pavement Design Guide Performance prediction for intermodal facility pavement slabs

Union Pacific Intermodal Facility

Union Pacific Intermodal Facility



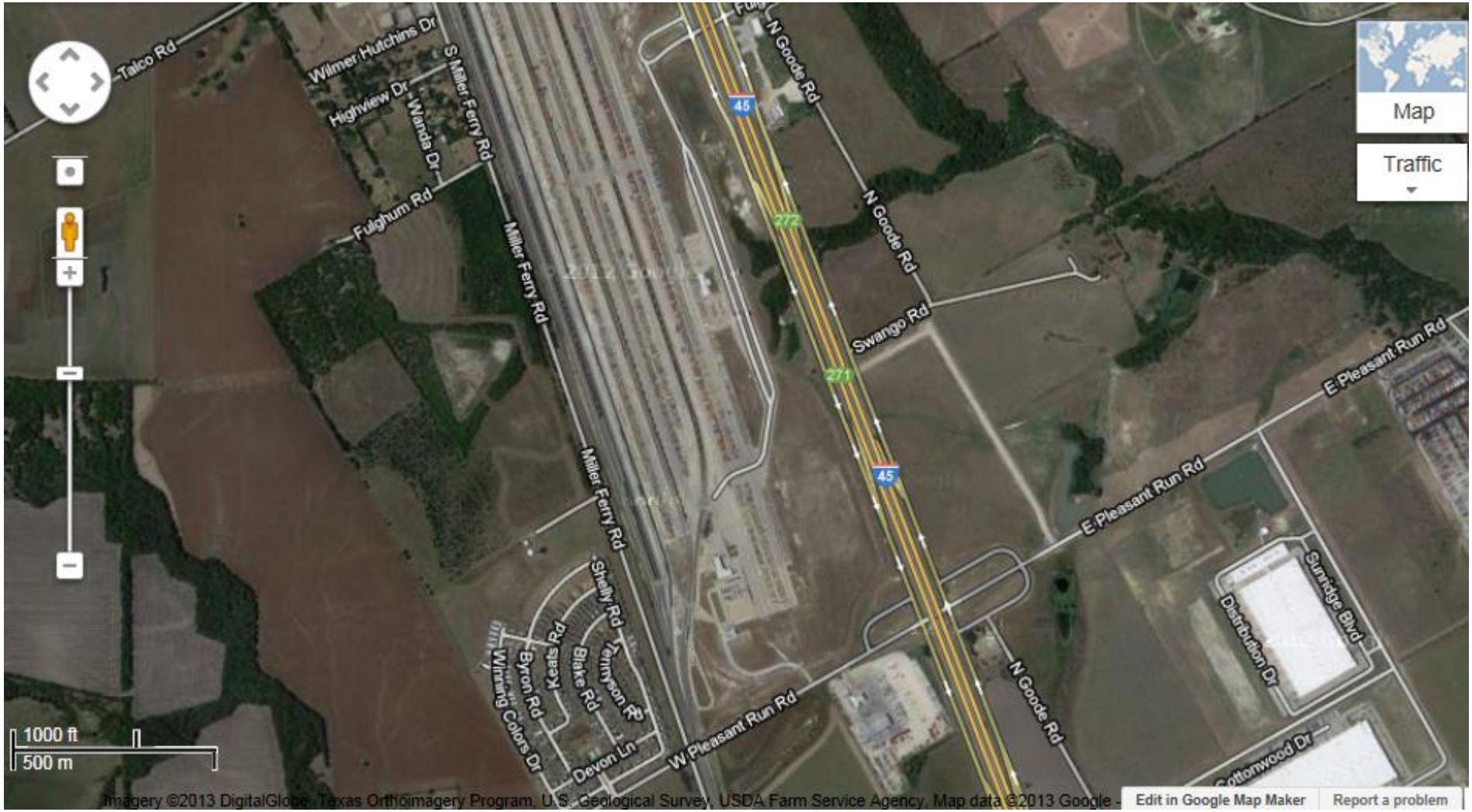
Multimodal Facility

Facility Features

- 365,000 lift capacity and 4,000 parking stalls
- 10-lane automated gate system entrance
- 24-hour, seven-day-a-week operations
- Four loading tracks
- Future expansion
- Paving in 2005, and construction throughout the year

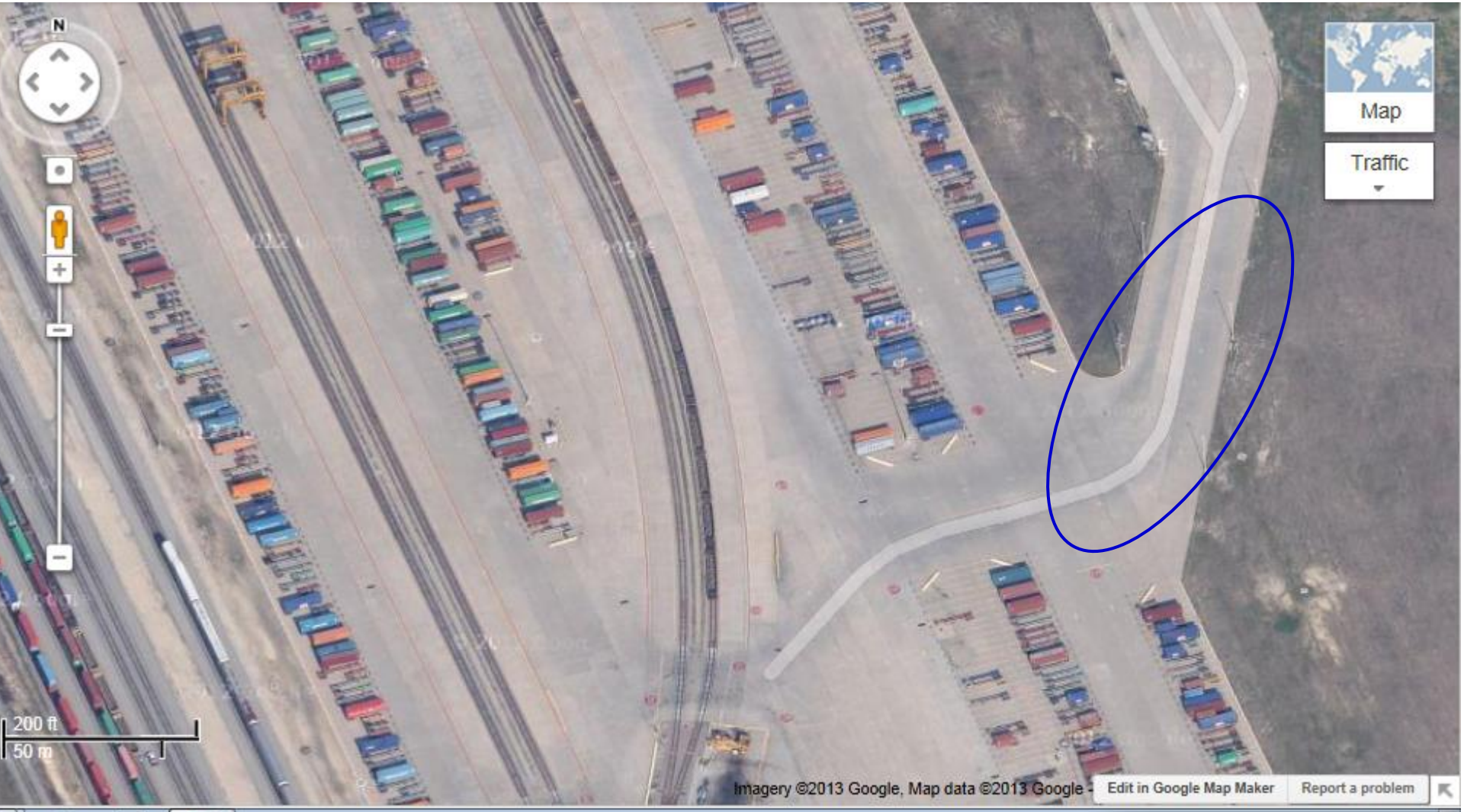
Source: Union Pacific Railroad www.uprr.com

Multimodal Facility



View of Security/Gate Entry

Facility's Maximum Traffic Zone



Excellent Performance after 8 years

Two locations with spalls and one slab with cracking – That's all!

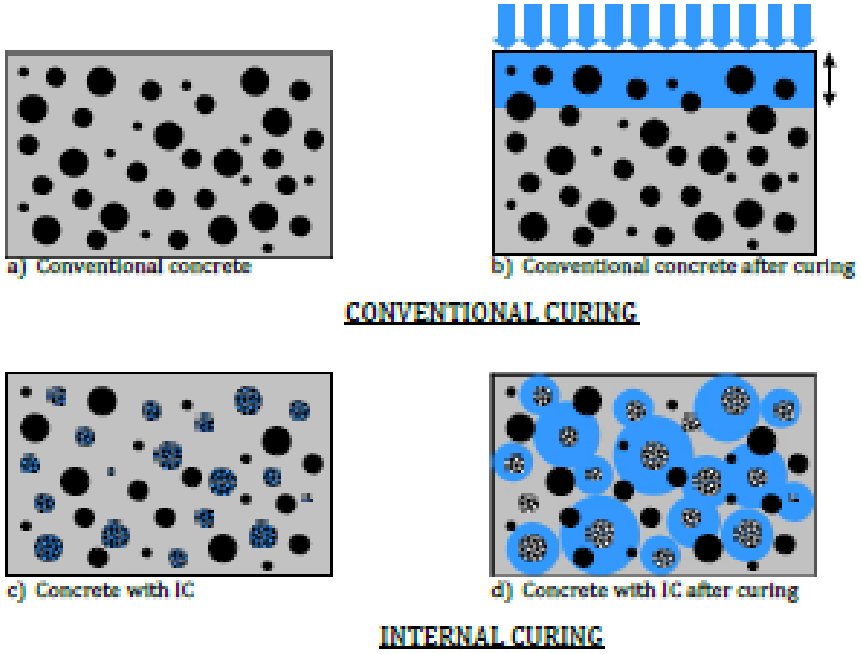
Internally Cured Concrete Pavement

Internal Curing

Internally Cured Concrete

- Use of pre-wet lightweight aggregates (LWA) as partial replacement to coarse/ fine/ coarse and fine fractions
  - For example 30 percent of sand
  - Replace 500 lb of coarse and fine with 300 lb of intermediate size LWA

Physical and mechanical properties favorable for performance



(Castro et al., 2010).

ICC Mixture and Control Mix Design

Material	Control	ICC
Cement (lb/yd^3)	451	451
Fly ash (lb/yd^3)	113	113
Coarse aggregate (lb/yd^3)	1840	1540 {-300lb}
Intermediate LWA (lb/yd^3)	0	300
Fine aggregate (lb/yd^3)	1301	1099 {~ -200 lb}
Water (lb/yd^3)	242	242
Water reducer (fl oz/100 lb)	As needed	
AEA	3.0 to 6.0%	
Air content (3-6%)	2 ± 1 in.	
Compressive strength (psi)	4,500	

Villarreal, V., et al., 2007

Impact of IC on Concrete Properties – The Basics

Steady and prolonged moisture supply from LWA

Reduced mass from aggregate

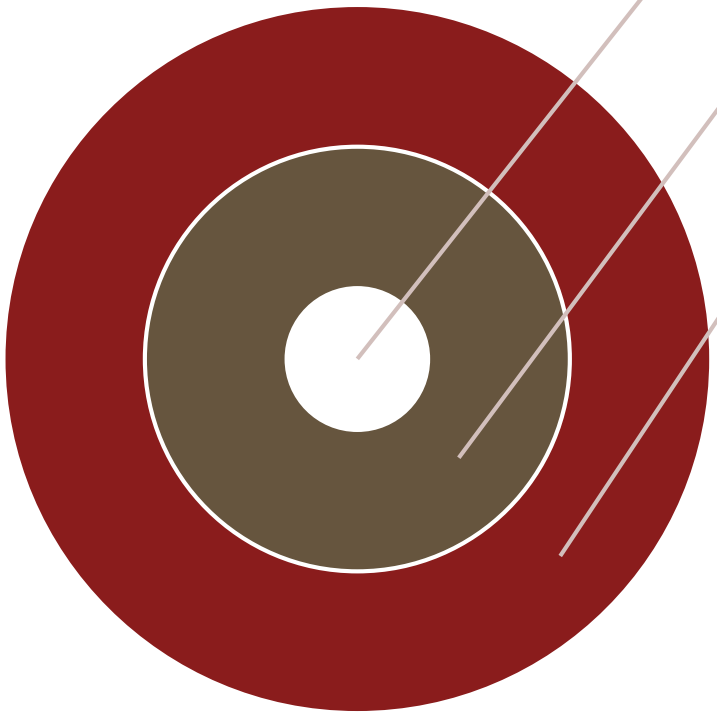
Improved hydration products

- Durability benefits
- Lower early age shrinkage
- Reduced stresses from restraint

Enhanced mechanical properties

- Lower unit weight (6pcf)
- Lower elastic modulus (5%)
- Lower CTE (5%)
- Higher strength (5-20%)

Potential Effect of Reduced Shrinkage on Pavement Performance



Reduced early autogenous shrinkage

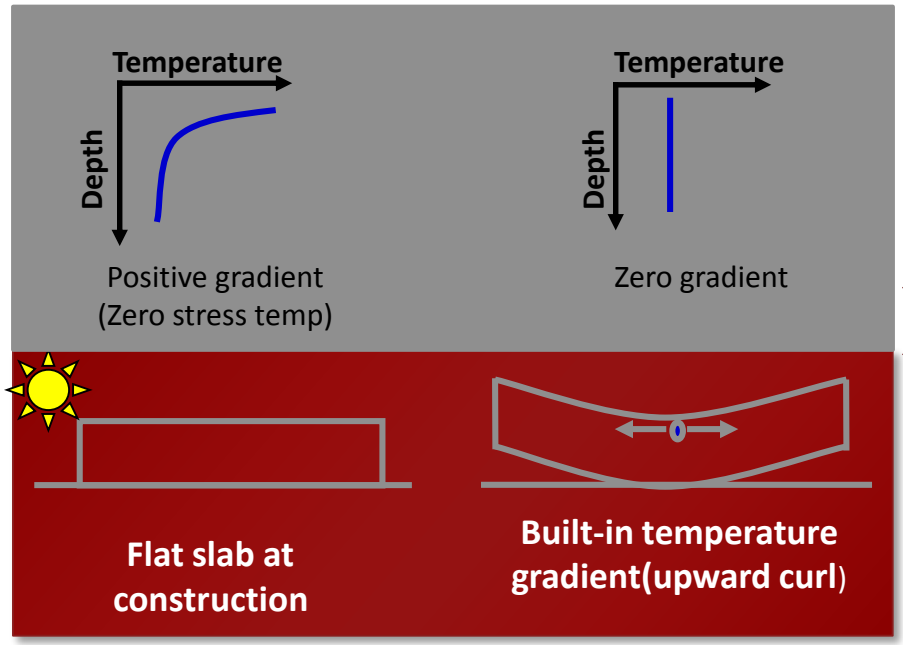
Permanent Influence

- **Effects slab upward curling**
- **Lowers zero stress temperature**

Performance Benefits

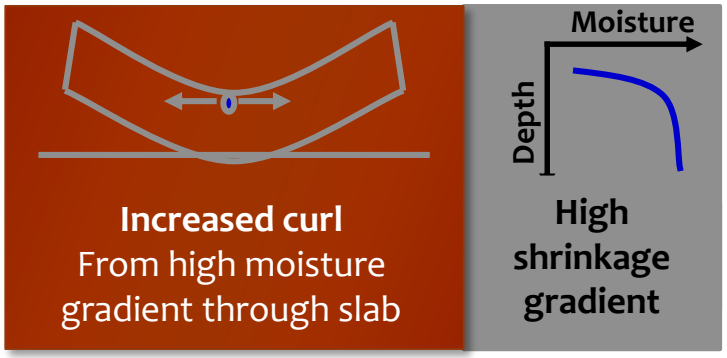
- Reduces premature shrinkage cracking
- Affects crack spacing and width in CRCP and rate of crack development
- Affects transverse crack development in JPCP

Potential Impact of Temperature & Moisture On Curling of Slabs

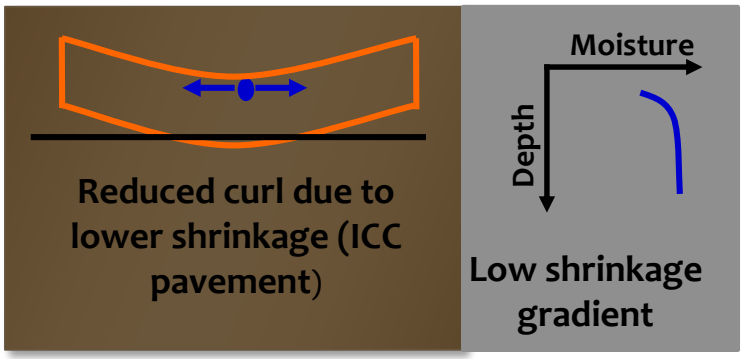


CONCRETE PLACEMENT AND FINISHING STAGES

CONVENTIONAL CONCRETE



CONCRETE WITH INTERNAL CURING



CONCRETE CURING AND EARLY AGE SHRINKAGE

Upward Slab Curl Causes Cracking

Transverse Fatigue Cracking (Top-Down)
I-80 PA

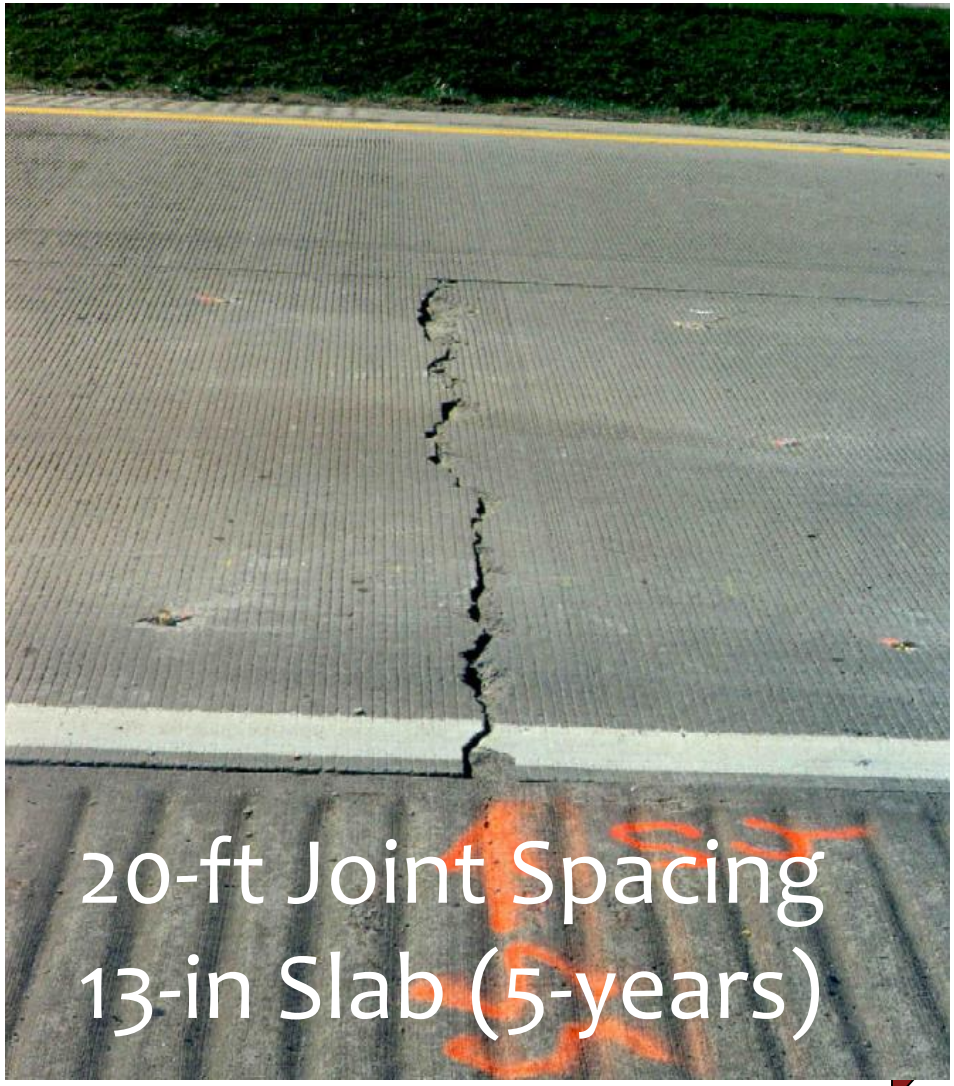
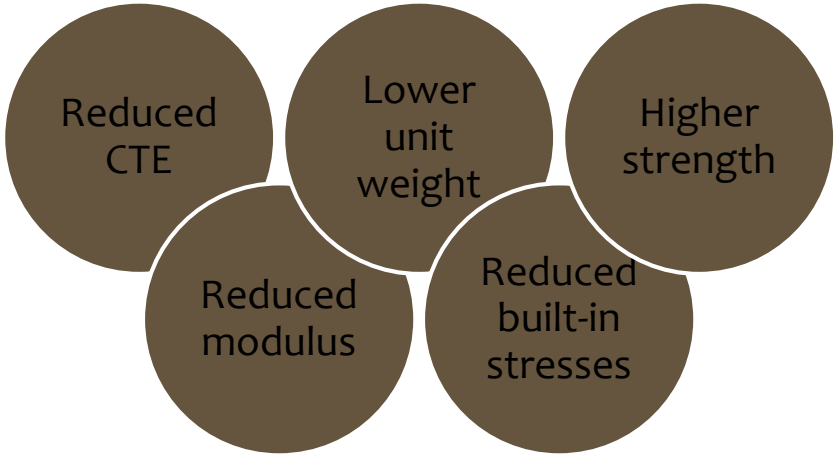


Photo of Transverse & Longitudinal Top Down Cracking

Plastic Shrinkage Cracks

Interaction Effects – Cannot Isolate Single Cause for Performance Benefits



Depends on

- Range of temperature changes in local climate
- Traffic level and traffic characteristics
- Slab thickness
- Aggregate type

Suitable for use when fly ash is incorporated in mix design

AASHTOWare Pavement M-E Analysis – Dallas Intermodal ICC Pavement

Project Analysis Details

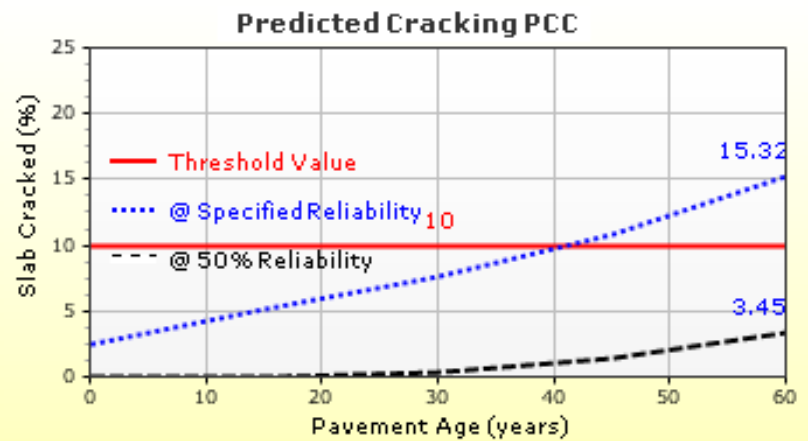
- Assume about 240 trucks per day per lane
  - Class 9 trucks single trailer trucks
- Pavement Structure
  - 8.5 inch JPCP
  - 12 inch aggregate base on subgrade
- Construction through several months (all seasons)
  - **Measured zero curling in the slab with string line**
- 60-yr analysis period

Concrete Inputs (Measured & Estimated)

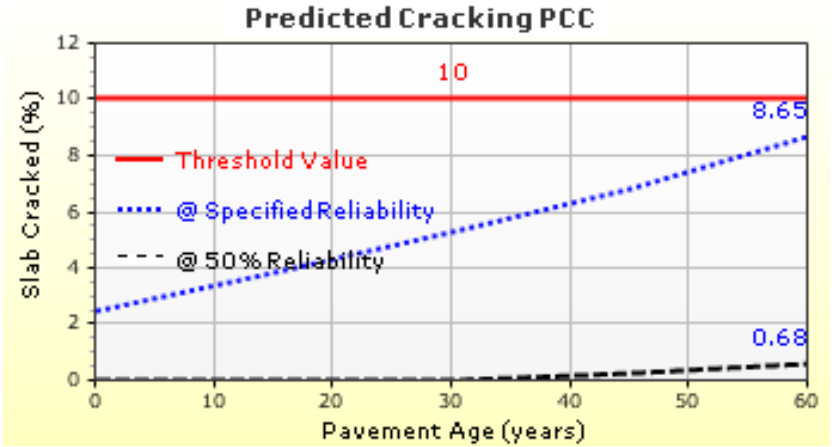
Inputs (or Calculated Values)	Control	ICC
Unit weight, pcf	145	137
CTE, x 10^{-6} in/in/°F	4.8	4.3
Compressive strength, psi	5130	6070
Elastic modulus, psi	4,127,000	4,123,000
Permanent deltaT	-10F	-10F
Ultimate shrinkage, x 10^{-6} in./in. Calculated by program	611	592
w/cm ratio	0.43	0.43
Base layer	12" crushed stone aggregate	
Subgrade	AASHTO A-7-6	

Predicted Performance, Transverse Cracking

- 8.5-inch JPCP - CONTROL



- 8.5-inch JPCP - ICC

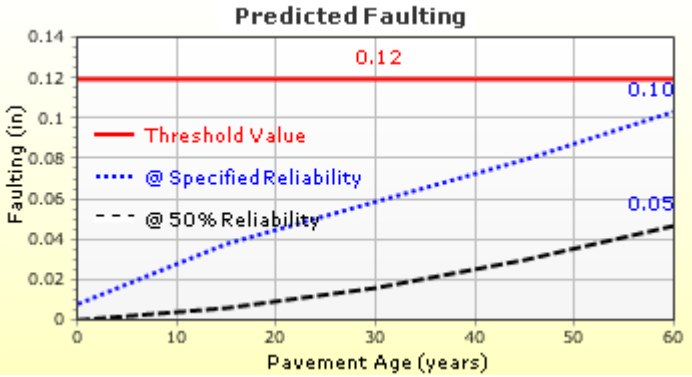


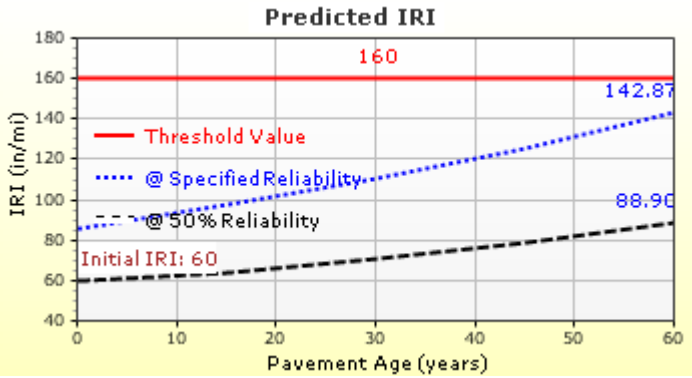
ICC JPCP predicts one-half or less cracking over 60-years

(Note: No concrete durability problems were noted during the field survey at 7 years age. No upward curling was measured on several slabs).

Predicted Performance, Faulting and Roughness

- 8.5-inch JPCP - CONTROL





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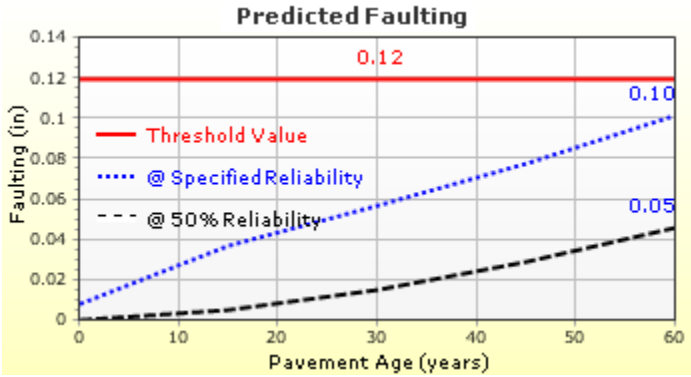
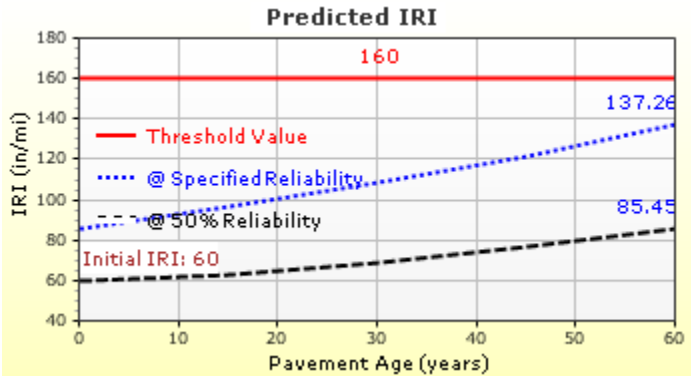
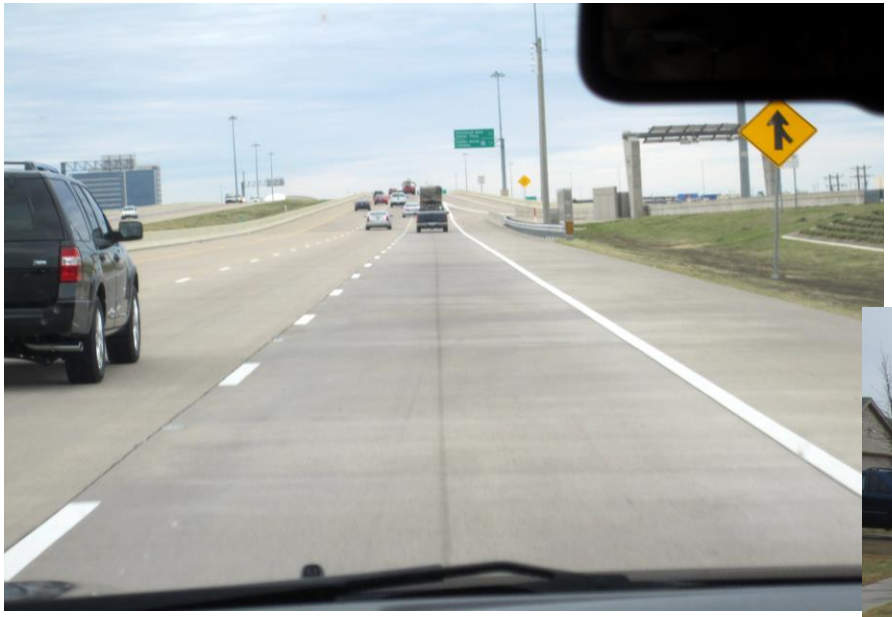




Other Field Project

ICC Pavements in DFW area



SH121 CRCP

Residential street

Conclusions

- Changes in mixture properties with small replacement of normal weight aggregates with prewetted aggregates, i.e. ICC
  - Changes in properties are favorable for pavement performance
- M-E analysis validates excellent performance observed on field
  - ICC properties are within the range of values applicable for M-E analysis
  - Long-term projections seem reasonable
  - Will reduce initial construction costs if proper inputs for ICC are used in design
- ICC used in a heavy-duty pavement application has shown excellent field performance and is validated with M-E analysis

THANK YOU.

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