

Cold Recycling Workshop: Research Studies on FDR in California

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Summary

- Introduction
- Research focus areas
- Field testing
- Laboratory testing
- Research implementation

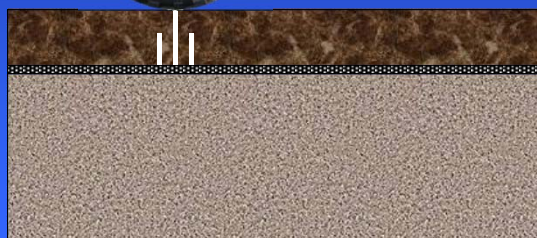


Introduction

- FDR-FA introduced to California in 2000
- Pilot study in 2001
- International research focus
- USA research focus
- California research focus
 - + Thick AC "evolved roads"
 - + Closure limitations
 - + Mix & structural design
 - + Construction factors



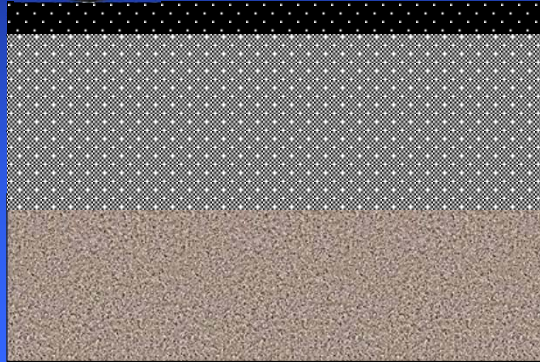
Introduction



- Asphalt concrete (50mm)
- "Oil"
- Subgrade/Base (Old gravel road)



Introduction



Summary

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- **Research focus areas**
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- Laboratory testing
- Research implementation



UCPRC Research Focus

- Recycling/sustainability strategic initiative
- Phase 1: FDR-NS and FDR-FA study
 - + Literature review
 - + Mechanistic sensitivity analysis
 - + Pilot project assessment
 - + Accelerated pavement testing
 - + Laboratory study
 - + Preliminary guidelines
- Phase 2a: FDR-PC and FDR-EE
- Phase 2b: PDR-FA and PDR-EE
 - + As for Phase 1
 - + ME performance models
 - + Comprehensive guidelines for CA



Literature Review (2004)

- Key findings
 - + Very little work on FDR-FA of thick AC pavements
 - + No guidelines suited to CA conditions & practice



Research Focus: USA

- **ARRA**
 - + New Asphalt Recycling Manual
- **South Dakota School of Mines**
 - + FHWA study
 - + New mix design procedure submitted to AASHTO
- **University of North Carolina**
- **Other**



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Field Testing: APT

> Phase 1

- + State route (added lane)
- + Not representative of typical pavement
- + Inconclusive results



Field Testing: APT



Field Testing: APT

➤ Phase 1

- + State route (added lane)
- + Not representative of typical pavement
- + Inconclusive results

➤ Phase 2

- + Test track at UCPRC
- + Recycled rubberized warm-mix asphalt
 - Advantages and disadvantages
- + FDR-NS, FDR-FA-C, FDR-EE, FDR-PC
- + In conjunction with high RAP AC study



Field Testing: APT



Field Testing: APT

FDR-NS	FDR-NS	FDR-NS
FDR-NS	FDR-EE	
FDR-PC (6% + mc)	FDR-FA-C	
FDR-PC (6%)	FDR-PC (5%)	FDR-PC (4%)
50% RAP (R)	50% RAP	15% RAP
25% RAP	25% RAP	50% RAP (WMA)
25% RAP	25% RAP	25% RAP (WMA)
25% RAP	25% RAP	25% RAP



Field Testing: APT



Field Testing: APT



Field Testing: LTPP

> Phase 1

- + Six projects
- + 2001, 2002, 2005, 2006, 2008

> Phase 2

- + Experimental design in progress
- + Continuation of Phase 1
- + 3 FDR-PC, 27 PDR-EE-C



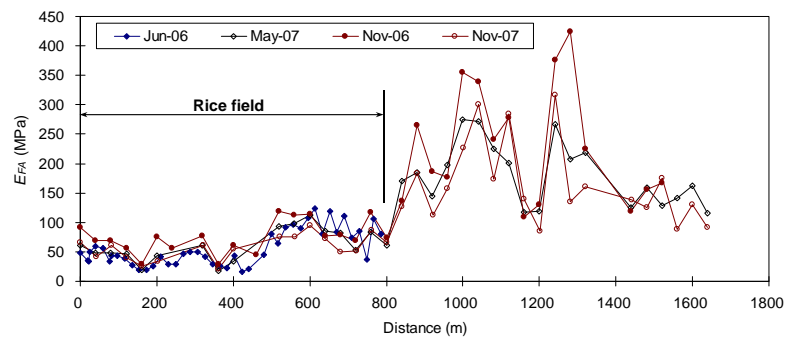
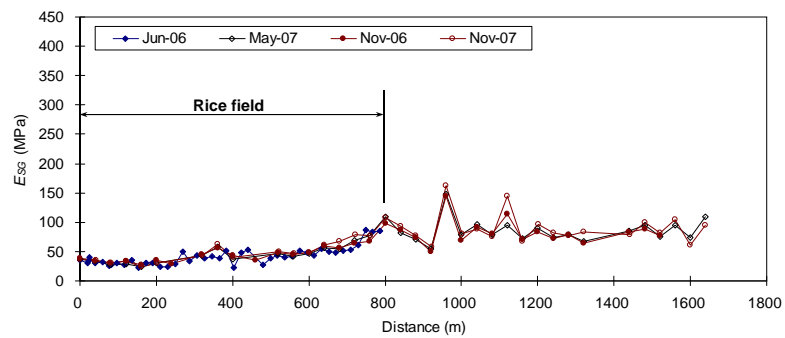
Field Testing: LTPP



Field Testing: LTPP



Field Testing: LTPP



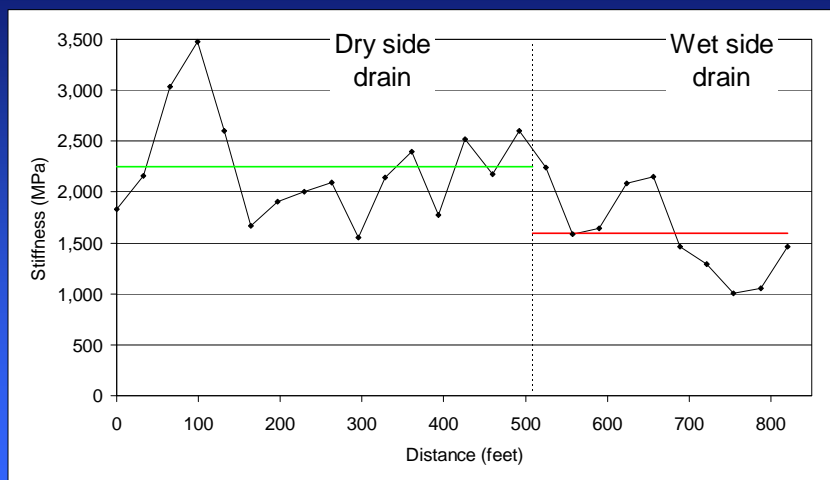
Field Testing: LTPP

Dry

Wet



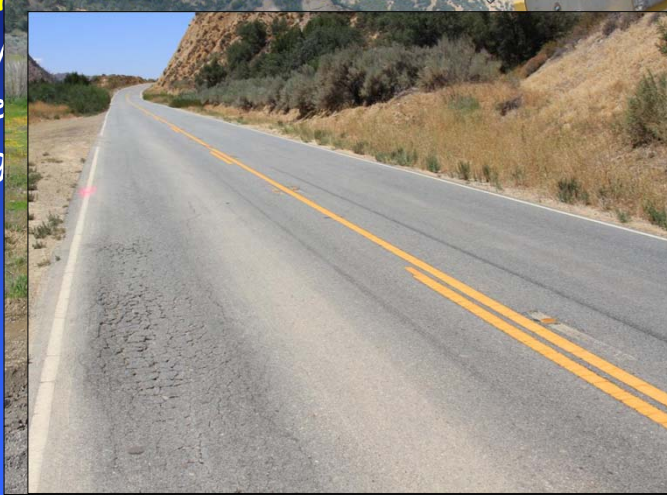
Field Testing: LTPP



Field Testing: LTPP

> Key findings on construction

- + Pre-pulv
- + Equipme
- + Training



Field Testing: LTPP

> Key findings on construction

- + Pre-
- + Equ
- + Tra
- + Tem



Field Testing: LTPP

> Key findings on construction

- + Pre-pulv
- + Equipme
- + Training
- + Temper
- + Compact



Field Testing: LTPP

> Key findings on construction

- + Pre
- + Equ
- + Tro
- + Ter
- + Con
- + Con



Field Testing: LTPP

➤ Key findings on construction

- + Pre-pu
- + Equipm
- + Traini
- + Tempe
- + Compo
- + Compo
- + Qualit



Field Testing: LTPP



Field Testing: LTPP



Summary

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- **Laboratory testing**
- Research implementation



Laboratory Study

➤ Experimental design

- + Full factorial to prepare partial factorial
- + Four phases
 - 1: Specimen preparation, test methods
 - 2: Binder and RAP properties, test components
 - 3: Binder and RAP properties
 - 4: Fillers, curing, and aggregate temperature

➤ Scale

- + >4,000 specimens, 8 tons of RAP, ~100 buckets of asphalt binder



Laboratory Study

➤ Key findings on binders

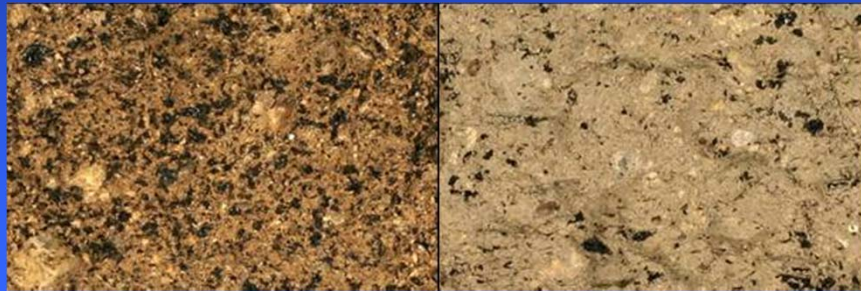
- + Highly variable in California
- + Anti-foamants
- + Softer binders have best foam characteristics
- + Foamability requirements linked to pavement temperature



Laboratory Study

➤ Key findings on aggregate

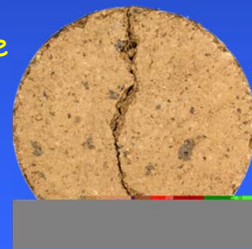
- + Lab aggregate temperature: $>20^{\circ}\text{C}$
- + Fines content (P0.075mm): 5-12%



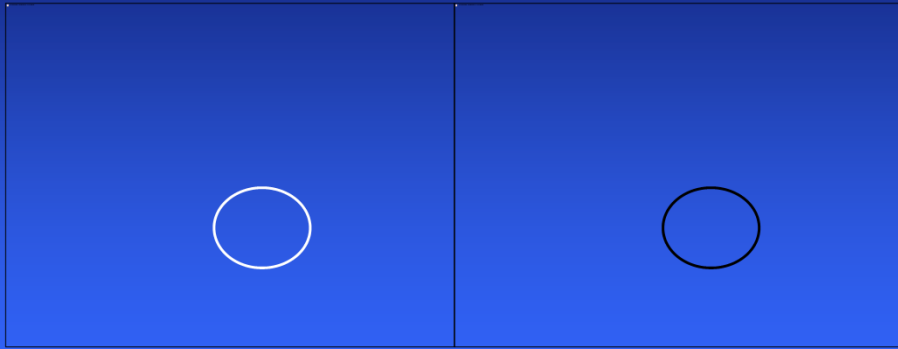
Laboratory Study

➤ Key findings on lab test methods

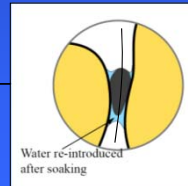
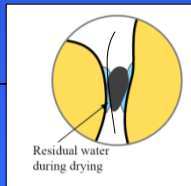
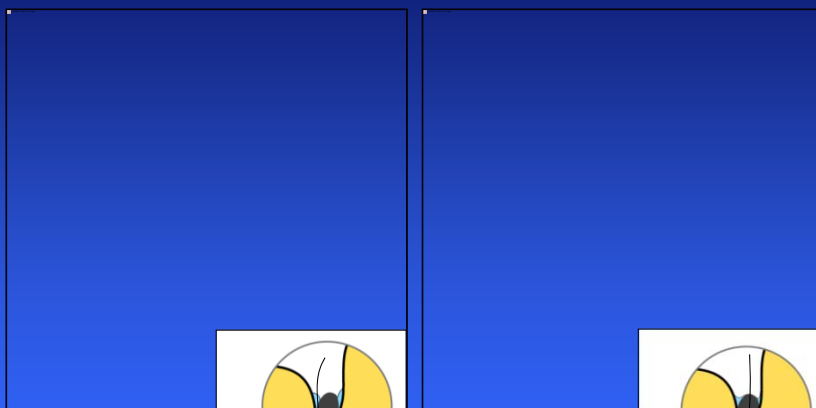
- + Focused on addressing field observations
- + Focused on same-day opening to traffic
- + Restricted by testing ability in districts
 - Monitor & record temperatures throughout
 - FA and then FA plus active filler
 - Compare fracture energy/shrinkage
 - Soaked and unsoaked tests
 - Soaked test for mix design
 - ITS test ok with reps
 - Fracture face analysis



Fracture Face Analysis (1)



Fracture Face Analysis (2)



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Research Implementation

- **Research reports documenting each phase**
- **Guideline for California**
 - + Project investigation
 - + Strategy selection
 - + Mix design
 - + Structural design
 - + Construction
- **FDR and PDR chapters in Highway Design Manual and Standard Specifications**
- **Tech transfer on projects**
 - + Implementation decision at District and county level



Guidelines

> Strategy selection

- + Each project should be designed
- + FWD, Cores, DCP, possibly GPR
- + Material sampling

> Mix design

- + Two phase
- + Active filler mandatory on FDR-FA
- + Fines content
 - 5-12% recommended (excl. active filler)
 - >15%: monitor soaked strengths closely
- + ITS test, monitor fracture face



Guidelines

> Construction

- + Just-in-time training
- + "Walk behind" technician
- + No pre-pulverization on FDR-FA and FDR-EE
- + Temperatures
 - Air: > 10° C
 - Surface, filler (and mid depth): >15° C
- + Mixing moisture content
 - In recycler, not after
 - No added water until after pad-foot



Guidelines

➤ Construction

- + Min compactor weight
- + 1 pad-foot roller per train
- + Distance control behind train
- + Surfacing assessment



Project Status

- FDR-NS and FDR-FA considered standard practice in California
 - + Implementation dependent on Districts
 - + >60km FDR-FA in 2012
 - + No data on FDR-NS
- FDR-EE, FDR-PC and PDR still special provision
 - + PDR: issues with project selection



Thank you!



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