



CENTER FOR RESEARCH & EDUCATION IN ADVANCED TRANSPORTATION ENGINEERING SYSTEMS

Research Goal

> Provide recommendations to improve the current NJDOT design practices and specifications of Cold in-Place Recycling (CIR).

Objectives

- Conduct a thorough literature review to collect information pertaining to CIR design practices and specifications adopted by highway agencies in different states.
- > Prepare and distribute a CIR survey questionnaire to state agencies across the United States;
- > Evaluate the laboratory performance of CIR mixtures prepared with different bituminous additives at constant dosages of cement and water using a Balanced Mix Design (BMD) approach;
- > Provide recommendation to revise and improve the current CIR specifications document.



Improved NJDOT CIR Specification

Recommendations for Improving NJDOT Specifications for Cold In-Place Recycling Ahmed Saidi, Ph.D.¹; Ayman Ali, Ph.D.¹; Yusuf Mehta Ph.D., P.E.¹ ¹ Rowan University CREATES

Efficiency of the BMD approach emulsions and foamed asphalt

Literature Review and Survey Results

✤ Materials



Reclaimed Asphalt Pavement (RAP)





Emulsified **Asphalt**

Foamed Asphalt

CIR Mix Design

Select and procure materials

Characterize materials and finalize factors

Mixing RAP with recycling agents, chemical additives, and water

Compacting CIR mixtures

Allowing CIR specimens to cure

Evaluate CIR Performance & Determine optimum binder content

Summary of Results

RAP size	1 in. (INDOT)				
Bituminous additives	CSS-1H emu				
Recommended contents	Emulsion: 1.5 Emulsion: 2.5				
Chemical additives	Portland cen				
Recommended contents	0.5%- 1.5%				
Typical water content	2% - 3% (mos				
Volumetrics	Vacuum seali				
Compaction	SGC (30 gyra				
Curing Process	3 days at 140 (VDOT); Cons				
Performance Testing	Strength only				





Portland cement

Water

CIR Construction Process

Project Selection				
Mix Design Process				

Milling, Sizing, & Mixing with Additives

Placement of the CIR Mix

Compaction

Curing and Maintenance

); **1.5 in.** (VDOT); **2 in.** (NJDOT)

Ilsion or **foamed asphalt** (most states) 5% - 2.3%; Foamed: 1% and 1.5% (MnDOT); 5% - 3.0%; Foamed: 2% -2.25% (VDOT) **nent** or **hydrated lime** (most states)

st states)

ing or Submerging method

ations) or Marshall

)°F (most states); 3 days at 104°F for foamed mix stant weight at 140°F (Caltrans and PennDOT) Strength only (MnDOT); Strength and crack test (most states)

Laboratory Study Results

- gyratory compactor.



Cracking Test



Rut Depth vs SCB-FE

CIR with Emu **CIR** with Emu **CIR** with Foamed **CIR** with Foamed

Preliminary Conclusions



> The OBC was determined using rutting measures (i.e. APA rut depth) and cracking measures (i.e. SCB FE and ITS) for CIR mixtures at each binder content.

 \succ <u>Cement and Water contents</u>: 1% and 3%, respectively.

> Compaction Method and Effort: 30 gyrations using Superpave

 \succ <u>Curing Process</u>: 140°F for 72 hours.



Cracking Results (ITS Test) • Rutting Results (APA) Rut Depth Threshold Balanced Optimum Binder Content Range Binder Content (%) Binder Content (%)

Rut Depth vs ITS

Mixture	Bind	er Co	ntent	AVG	COV
ulsion at 30 Gyrations	3.20	2.40	2.50	2.70	16.1%
ulsion at 70 Gyrations	2.93	2.93	2.78	2.88	3.0%
d Asphalt at 30 Gyrations	2.70	2.55	2.60	2.62	2.9%
d Asphalt at 70 Gyrations	2	2.8	2.95	2.58	19.8%

 \succ In the most part, the current CIR design and construction specification presented similar steps to those adopted by different highway agencies in different states.

> Vacuum sealing method (e.g., CoreLok device) should be used when determining the density of CIR specimens

> The BMD approach was used successfully to selected optimum contents of emulsion and foamed asphalt for CIR mixtures \rightarrow Rutting parameter should be considered.