

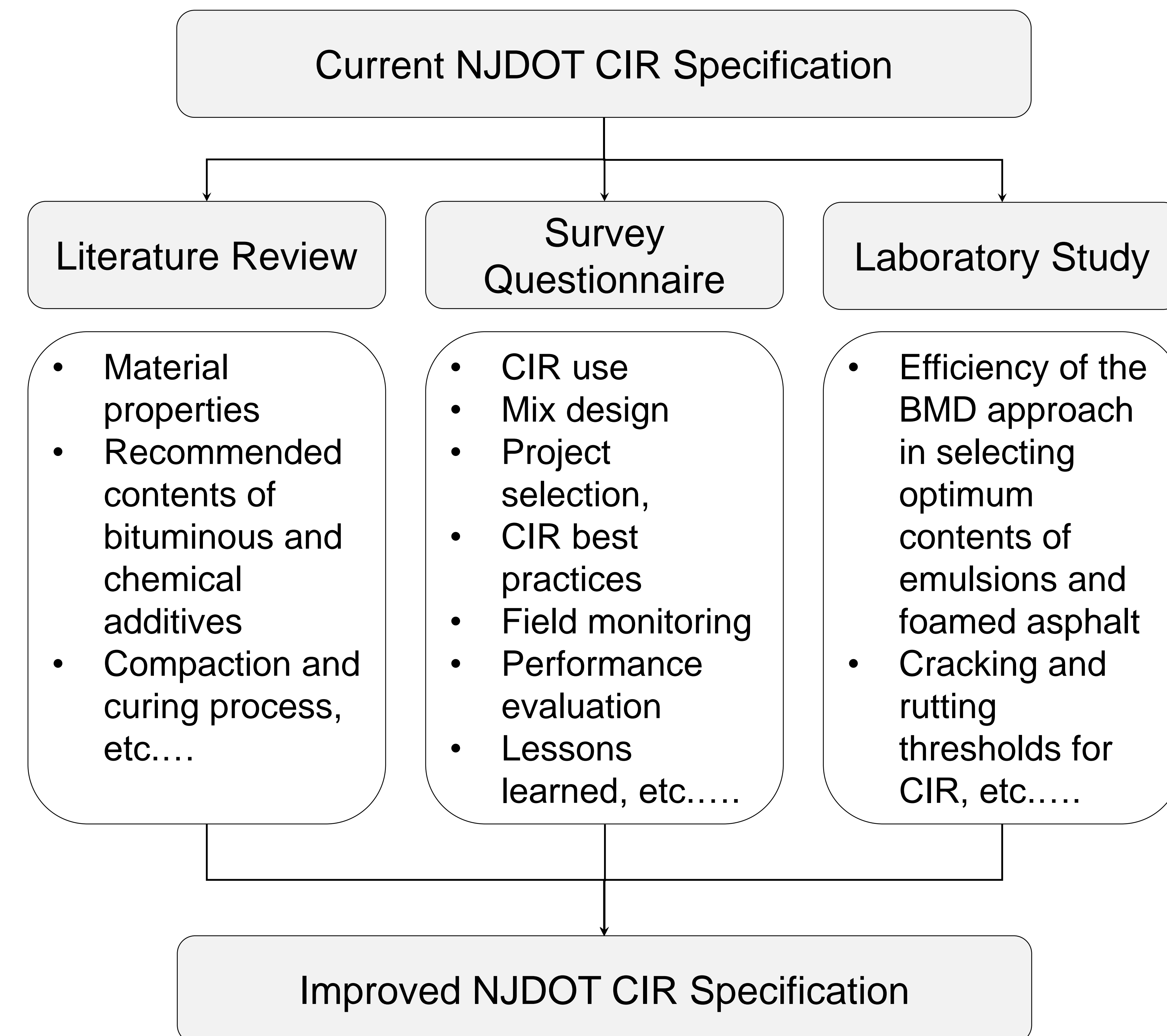
## Research Goal

- 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.

## Research Methodology



## Literature Review and Survey Results

### ❖ Materials



**Reclaimed Asphalt Pavement (RAP)**

**Portland cement**

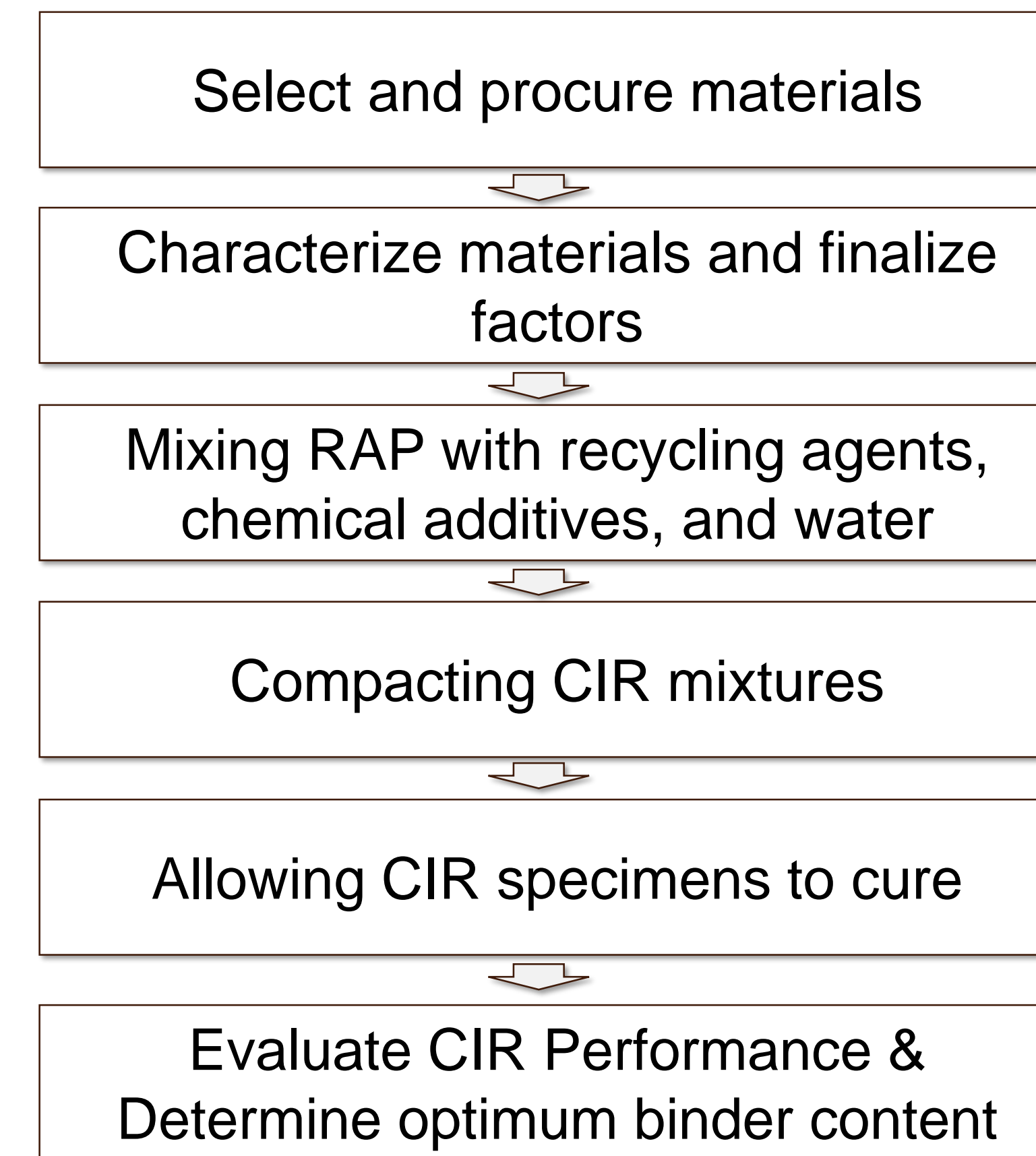


**Emulsified Asphalt**

**Foamed Asphalt**

**Water**

### ❖ CIR Mix Design



### ❖ CIR Construction Process



### ❖ Summary of Results

<b>RAP size</b>	1 in. (INDOT); 1.5 in. (VDOT); 2 in. (NJDOT)
<b>Bituminous additives</b>	CSS-1H emulsion or foamed asphalt (most states)
<b>Recommended contents</b>	Emulsion: 1.5% - 2.3%; Foamed: 1% and 1.5% (MnDOT); Emulsion: 2.5% - 3.0%; Foamed: 2% - 2.25% (VDOT)
<b>Chemical additives</b>	Portland cement or hydrated lime (most states)
<b>Recommended contents</b>	0.5% - 1.5%
<b>Typical water content</b>	2% - 3% (most states)
<b>Volumetrics</b>	Vacuum sealing or Submerging method
<b>Compaction</b>	SGC (30 gyrations) or Marshall
<b>Curing Process</b>	3 days at 140°F (most states); 3 days at 104°F for foamed mix (VDOT); Constant weight at 140°F (Caltrans and PennDOT)
<b>Performance Testing</b>	Strength only (MnDOT); Strength and crack test (most states)

## Laboratory Study Results

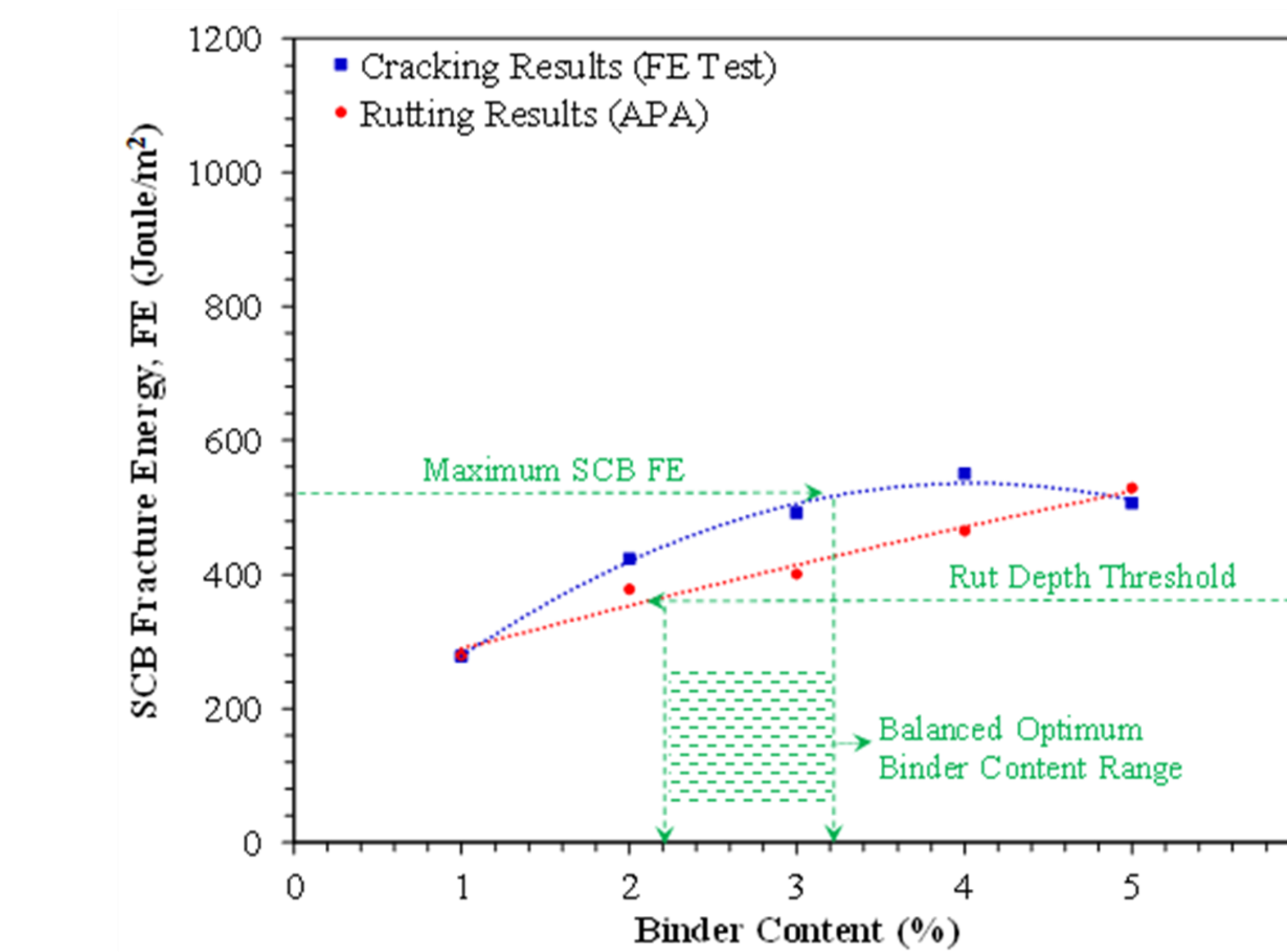
- The OBC was determined using rutting measures (i.e. APA rut depth) and cracking measures (i.e. SCB FE and ITS) for CIR mixtures at each binder content.
- **Cement and Water contents:** 1% and 3%, respectively.
- **Compaction Method and Effort:** 30 gyrations using Superpave gyratory compactor.
- **Curing Process:** 140°F for 72 hours.



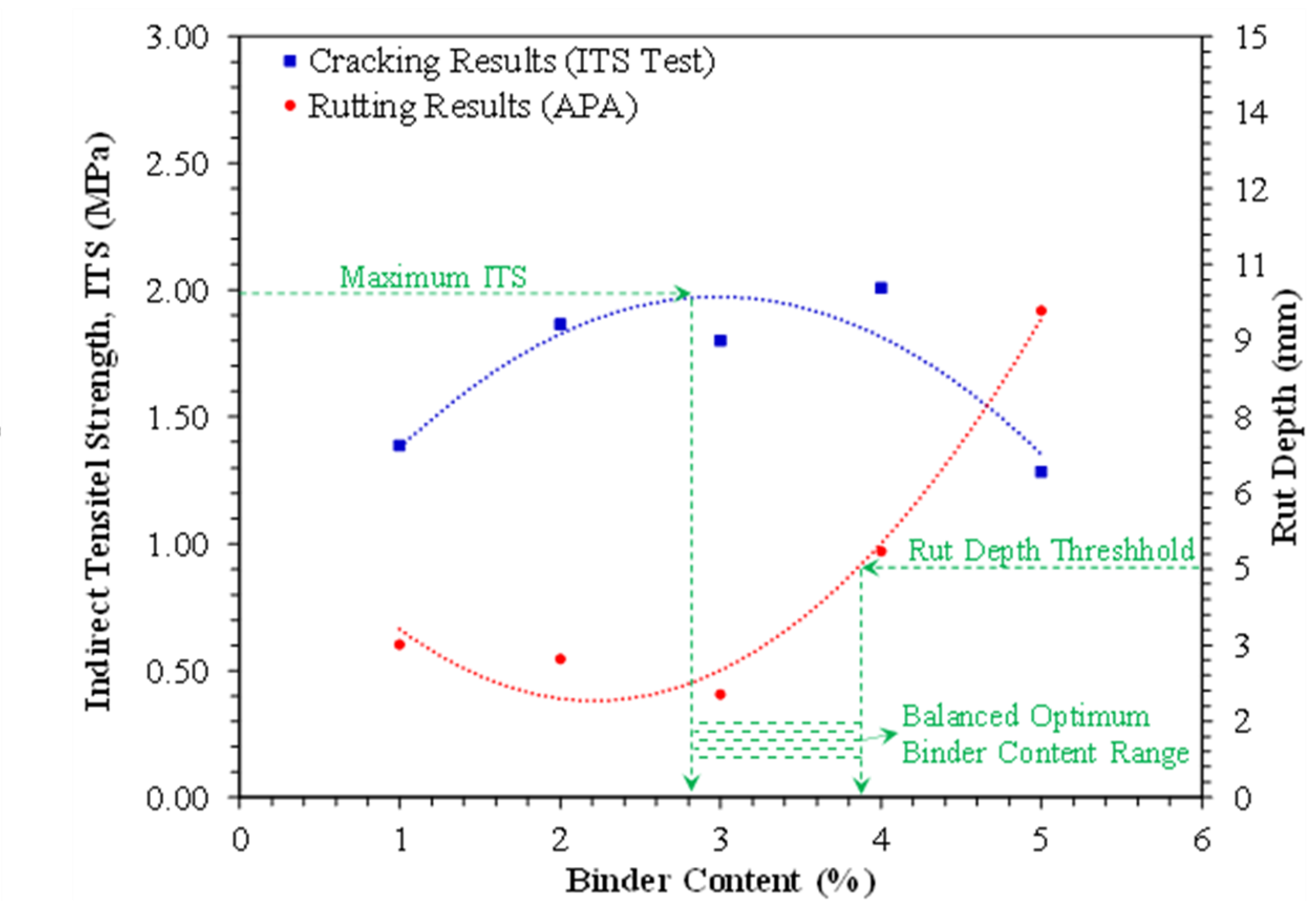
**Cracking Test**



**Rutting Test**



**Rut Depth vs SCB-FE**



**Rut Depth vs ITS**

Mixture	Binder Content	AVG	COV
CIR with Emulsion at 30 Gyrations	3.20 2.40 2.50 2.70	16.1%	
CIR with Emulsion at 70 Gyrations	2.93 2.93 2.78 2.88	3.0%	
CIR with Foamed Asphalt at 30 Gyrations	2.70 2.55 2.60 2.62	2.9%	
CIR with Foamed Asphalt at 70 Gyrations	2 2.8 2.95 2.58	19.8%	

## Preliminary Conclusions

- 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 → **Rutting parameter should be considered.**