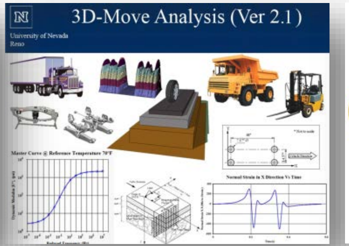






ARC Deliverables/Products Presentation and Workshop

http://www.arc.unr.edu/

Western Regional Superpave Center (WRSC)
University of Nevada, Reno

Washington, DC – January 15, 2015

ARC
Asphalt Research Consortium

11:05 – 11:30: Pavement Engineering Software: Pavement Response Model to Dynamic Loads (3D-Move).

11:35 – 12:00: Rutting Performance of Asphalt Mixtures Under Critical Conditions.

1:00 – 1:25: Mix Design for Cold in-Place Recycling (CIR).

1:30 – 1:55: Pavement Engineering Software: Thermal Cracking Analysis Package (TCAP).

ARC Deliverables/Products Presentation and Workshop

Mix Design for Cold in-Place Recycling

Superpave Mix Design for CIR Mixture

- No performance-related mix design
  - Proctor test, Hveem procedure, Marshall stability.
- No fully established mix design procedure using Superpave Gyratory Compactor.
- Initial water and emulsion contents based on experience.
- Moisture sensitivity test and raveling test are the most common performance tests.

Proposed CIR Mix Design Method

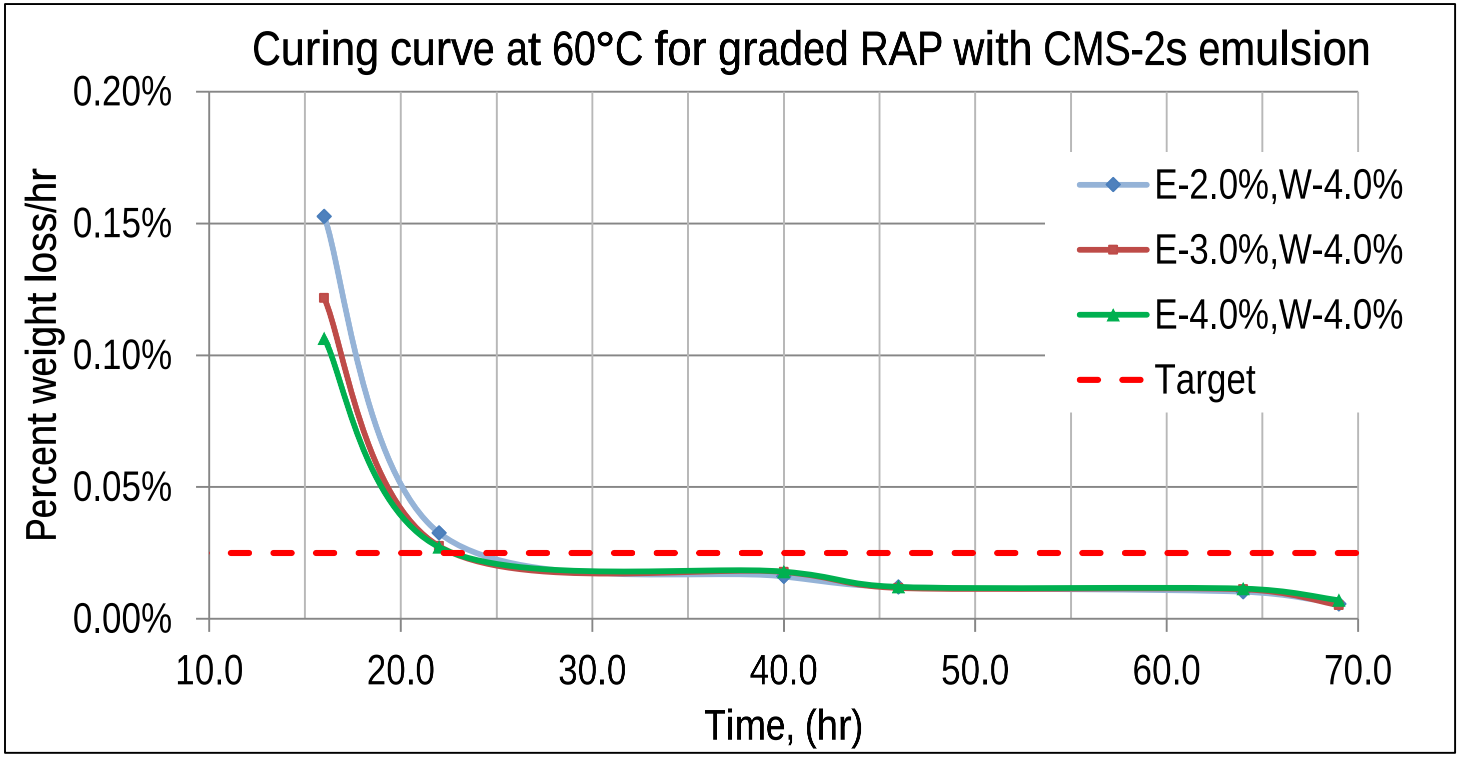
1. Selection of Reclaimed Asphalt Pavement (RAP).
2. Selection of emulsified asphalt.
3. Determination of theoretical maximum specific gravity .
4. Determination of required number of gyrations.
5. Determination of curing time.
6. Determination of Optimum Emulsion Content (OEC) and Optimum Water Content (OWC).
7. Evaluation of moisture susceptibility.
8. Evaluation of resistance to raveling.
9. Evaluation of performance properties.

Number of Gyrations

- Select initial water and emulsion content
- Target AV = 13±1%; height = 115±5mm
- Approach
  - Trial samples to reach target air voids & height
  - Initial water content: 2 – 6%
  - Emulsion content: 1 – 3%
  - Compacted to 100 gyrations
  - The required number of gyrations was selected to reach the target specimen height and air voids.
  - If the target specimen height is not achieved at the target air void, the weight of the mixture is adjusted.

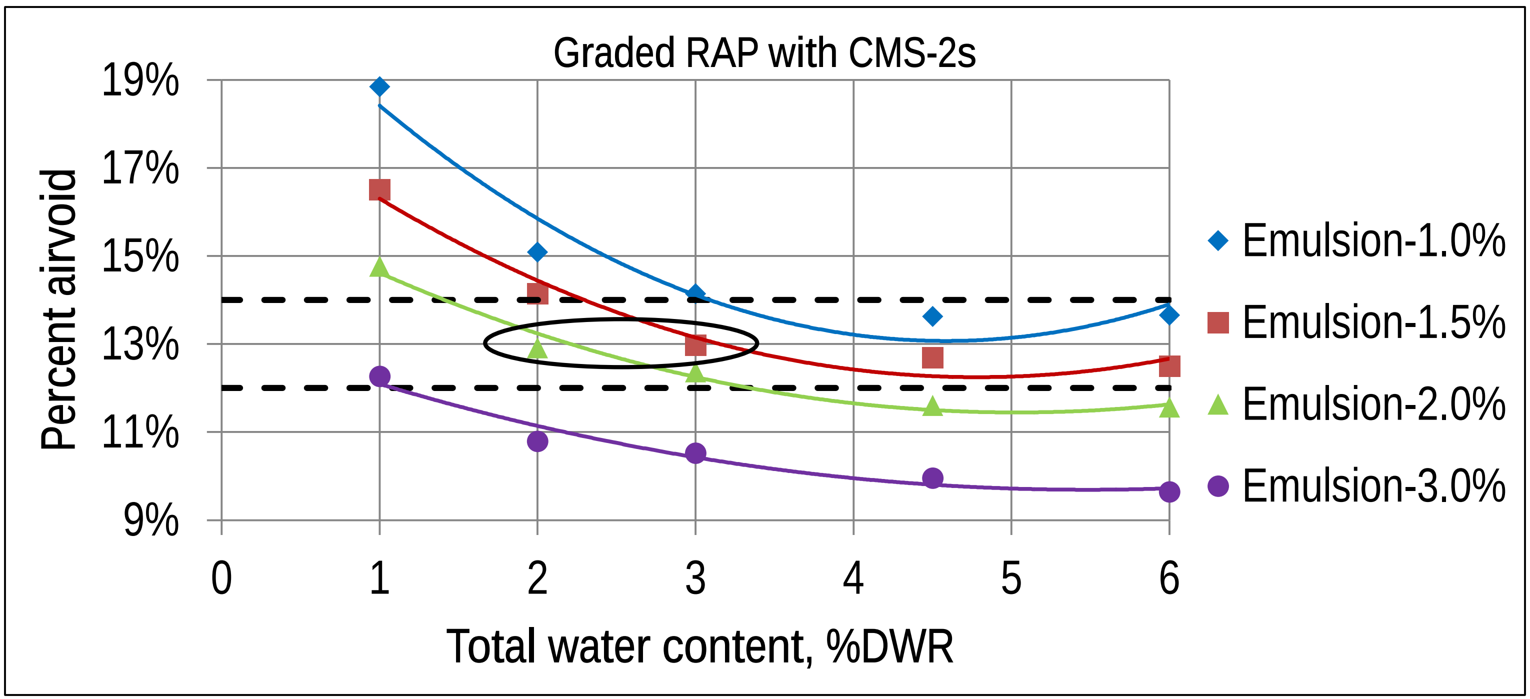
Curing Time for CIR

- Time to reach a constant mass ≅ *0.025% mass loss/hr*
- 24 hrs curing at 60°C.



OEC and OWC

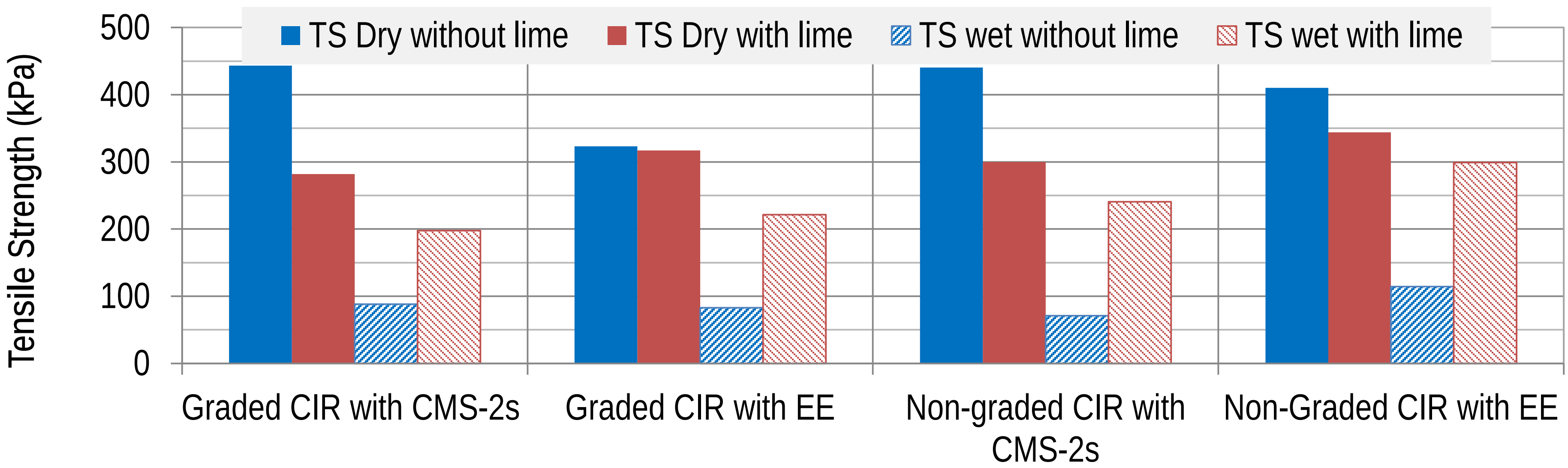
- 4 levels of emulsion content (1.0,1.5,2.0,2.5)
- 4 levels of water content (1.0,2.0,3.0,4.0)
- Allow ± 0.5% of OWC for variations in the field
- Select 2 Combinations that best meet the criteria

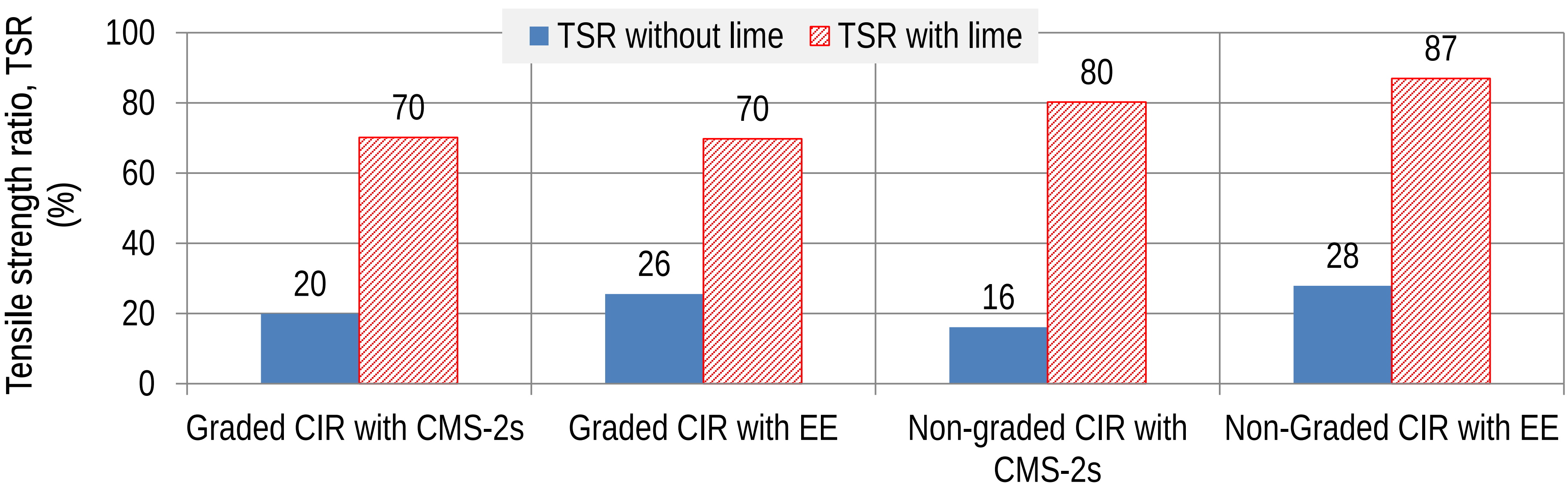


OEC and OWC

Type of Mixes	Type of Emulsion	No of gyration for Mix Design	Design Emulsion Content, %	Design water Content, %
Graded RAP with 1.5% lime	CMS-2s	30	1.5	3.0
			1.5	4.0
	Engineered emulsion for CIR	10	2.0	3.0
			2.0	4.0
Non-graded RAP with 1.5% lime	CMS-2s	35	2.0	2.0
			2.0	3.0
	Engineered emulsion for CIR	20	2.0	3.0
			2.5	3.0

Moisture Susceptibility of CIR Mixtures





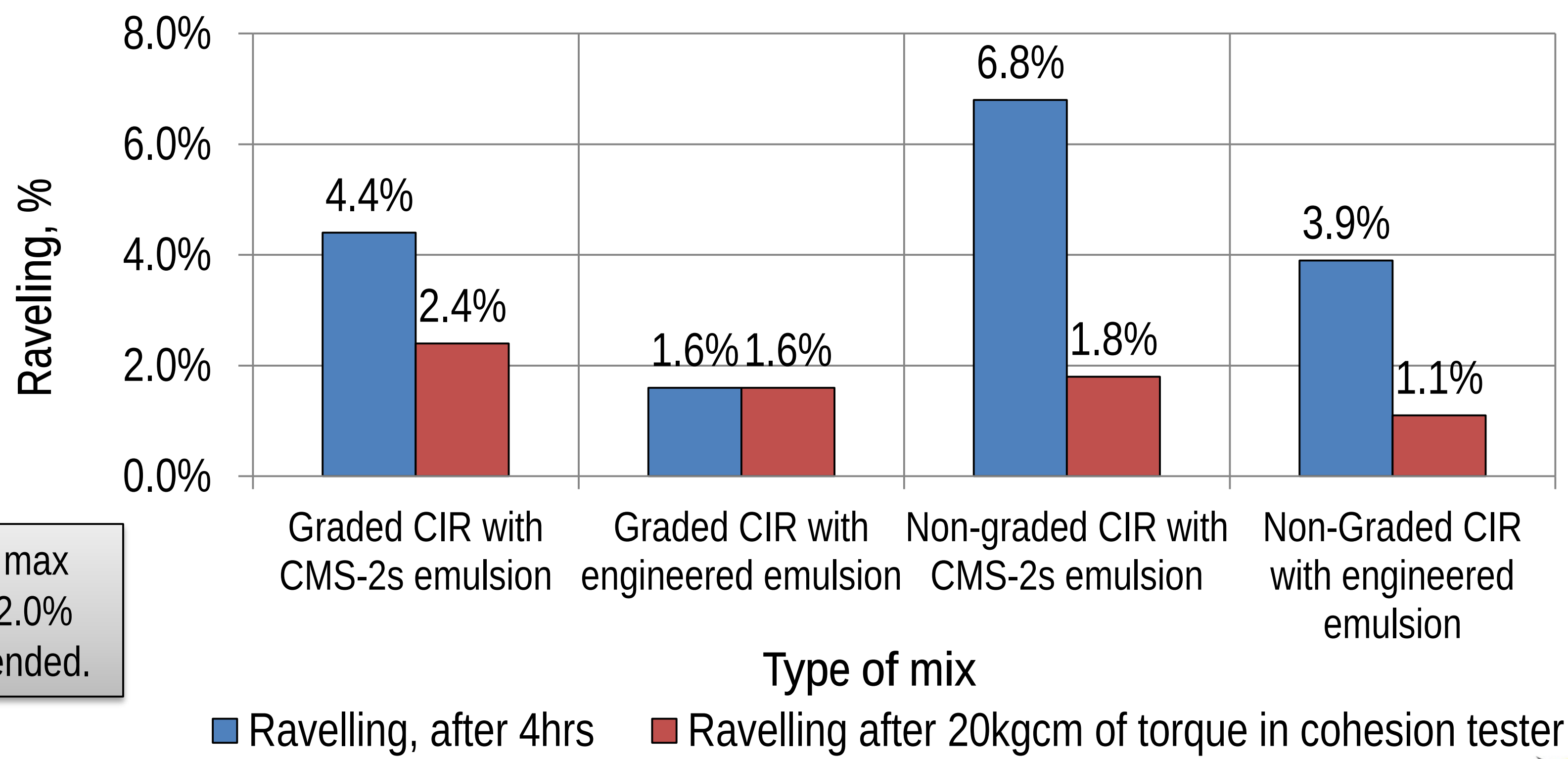
Resistance to Raveling and Cohesion Development

- Resistance to Raveling (ASTM D7196)
  - 150mm diam. by 70±5mm SGC samples
  - Compacted to 20 gyrations
  - Cured for 4 hrs at ambient condition
  - Abraded for 15 mins
  - Measured mass loss

- Cohesion development
  - Cohesion tester (for slurry and chip seals)
  - Pneumatically actuated 25mm rubber foot
  - Pressure of 193 kPa
  - Torque applied by turning wrench by 90°-120°
  - Time required to reach 20 kgcm

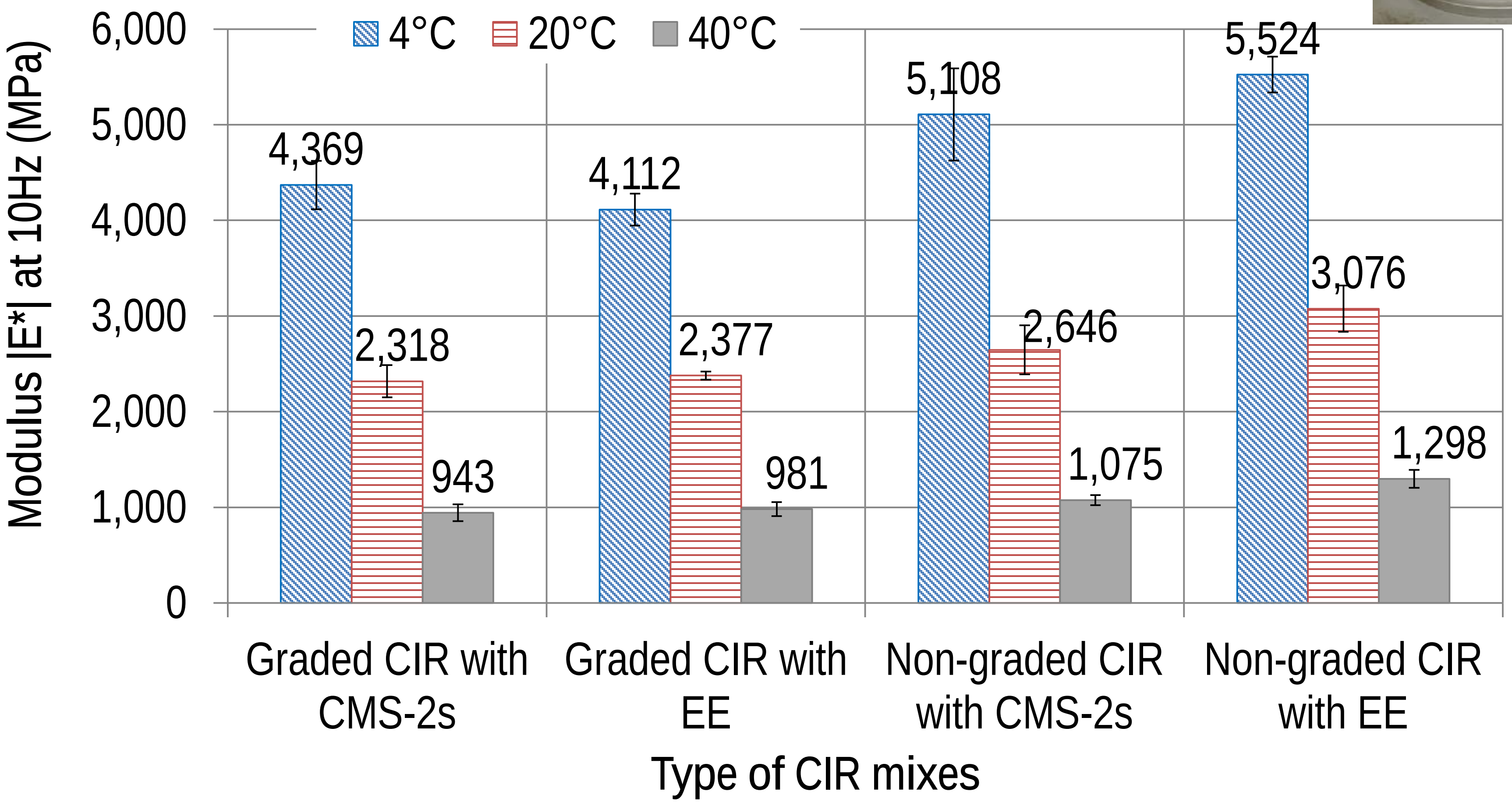
Resistance to Raveling and Cohesion Development

Time required to reach cohesion criteria, hrs	5.0	4.5	5.5	4.5



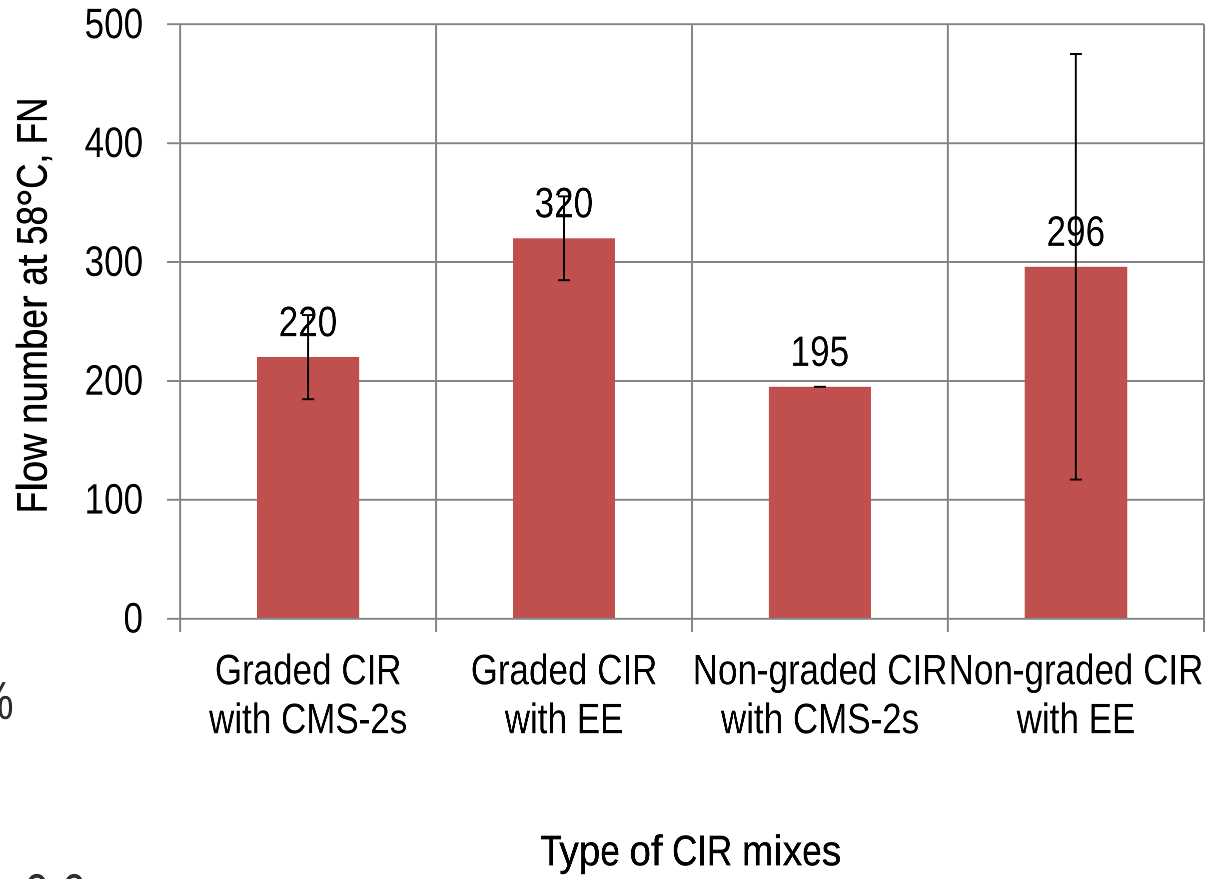
Typically, a max raveling of 2.0% is recommended.

Performance Properties of CIR Mixes
Stiffness



Notes: Cured for 48hrs at 60°C; Target air voids of 10.0 ± 1.0%

Performance Properties of CIR Mixes
Rutting Resistance



- Cured for 48hrs at 60°C
- Target air void of 10.0±1.0%
- Temperature: 45, & 58°C
- σ_d = 70psi; σ_c = 10psi
- Pulse time: 0.1s; Dwell time: 0.6s

Findings & Recommendations

- Addition of 1.5% of lime by weight of RAP improved moisture resistance and reduced resistance to raveling.
- CIR mixes had similar moduli values and were comparable to conventional HMA.
- CIR mixes showed good resistant to rutting when designed appropriately.
- Non-graded mixes showed big variations in test results.

Findings & Recommendations

- The proposed CIR mix design method can potentially be used for designing performance-related CIR mixes.
  - The mix design is being validated.
- The curing time of dynamic modulus/RLT samples need to be standardized to represent either early or the later part of the CIR pavement life.
- Fatigue performance and low temperature performance of CIR mixes need to be evaluated.

Thank You!

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Thank You!