Effect of Temperature on Resilient Modulus of Recycled Unbound Aggregates

Ali Soleimanbeigi, Ryan F. Shedivy, James M. Tijum, Tuncer B. Edil

Group Assignment Seminar
– Presentation and Review

Nicolas CAPELLI
Guillaume DILLÉ

Contents

- Presentation of the paper
  - Materials
  - Parameters
  - Tests
  - Results
- Review of the paper

Presentation of the paper (1/3)

- 2 Materials:
  - **RAP:** Recycled Asphalt Pavement
    - Old pavement

  - **RCA:** Recycled Concrete Aggregates
    - Old roads
    - Old buildings
    - Old concrete structures

Materials

TABLE 1 Index Properties of RAP, RCA, and Class 5 Aggregates

Material	Source	d_{10} (mm)	d_{50} (mm)	C_u	C_c	G_s	AB (%)	AC (%)	w_{opt} (%)	γ_{dmax} (kN/m^3)	Fines (%)	USCS
Class 5	MN	0.08	1.0	21	1.4	2.57	-	-	8.9	20.1	9.5	GW-GM
RCA	CA	0.31	4.8	22	1.4	2.32	5.0	-	10.4	19.9	2.3	GW
	TX	0.43	13.3	38	6.0	2.27	5.5	-	9.2	19.7	2.1	GW
	NJ	0.18	2.0	28	0.3	2.31	5.4	-	9.5	19.8	4.3	SP
	MI	0.4	9.7	35	3.9	2.37	5.4	-	8.7	20.8	3.2	GP
RAP	CO	0.35	2.2	9	0.7	2.23	3.0	5.9	5.7	20.7	0.7	SP
	TX	0.72	5.4	11	1.1	2.34	1.3	4.7	8.1	20.3	1.0	GW
	NJ	1.00	4.9	6	1.3	2.37	2.1	5.2	6.5	20.4	0.7	GW
	MN	0.3	1.6	7	0.7	2.41	1.8	7.1	6.7	20.8	2.5	SP

Note: d_{10}: effective particle size (particle size for which 10% of the sample is finer than d_{10}); d_{50}: average particle size (particle size for which 50% of the sample is finer than d_{50}); C_u: coefficient of uniformity (d_{60}/d_{10}); C_c: coefficient of curvature ($C_{30}^2/(C_{10} \times C_{60})$); G_s: specific gravity; USCS: Unified Soil Classification System; AC:Asphalt Content; AB:Absorption; MN:Minnesota; CA:California; NJ:New Jersey; CO:Colorado; TX:Texas.

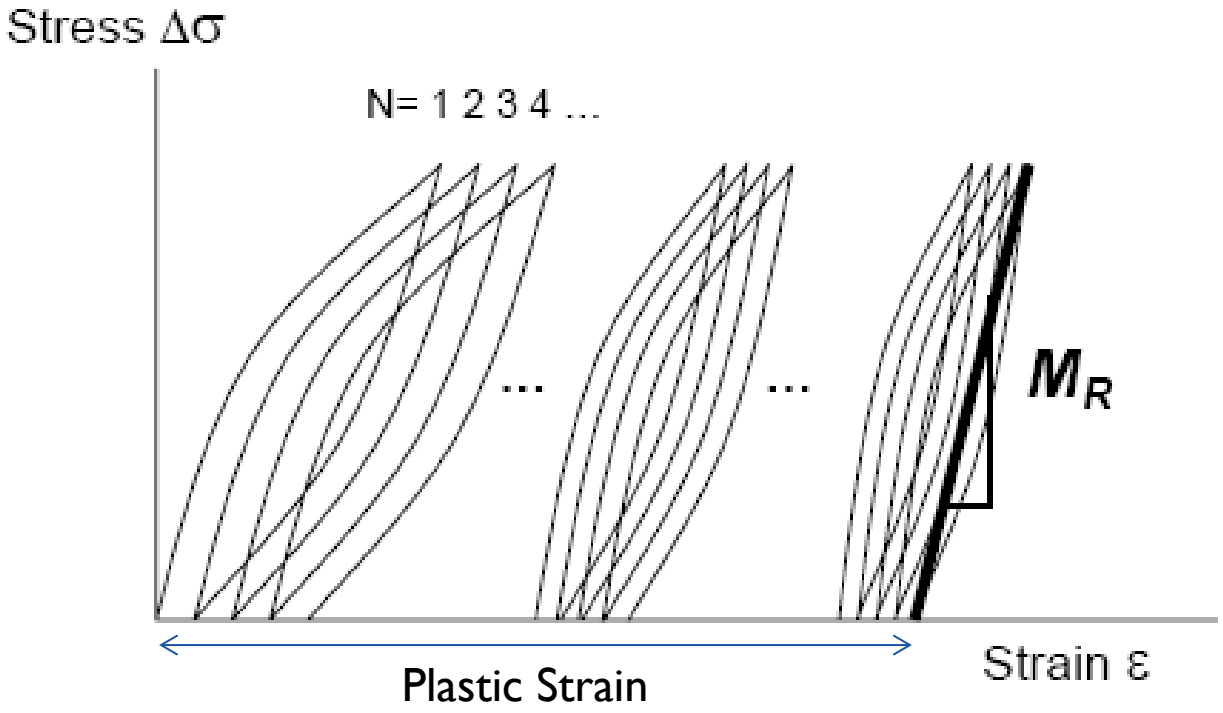
- 1 Class 5
- 4 samples of RCA
- 4 samples of RAP

Legend gradation USCS:

- *GW: well-graded gravel*
- *GM: silty gravel*
- *GP: poorly graded gravel*
- *SP: poorly graded sand*

Presentation of the paper (2/3)

- 2 Parameters:
  - **Resilient Modulus:** Important characterisitic for the pavement design
  - **Plastic Strain:** Important to characterise rutting



Presentation of the paper (3/3)

- 3 Tests :
  - Temperature-Controlled Resilient Modulus
  - Field Tests
  - Freeze-Thaw

Test 1: Temperature-Controlled Resilient Modulus

- Procedure *NCHRP 1-28A*.
- Tests conducted at 4 differents temperatures: 7, 23, 35 and 50 °C.
- Measure the strain inside the sample
- Establishing the resilient modulus

$$M_R = \frac{\sigma_{dN}}{\epsilon_r}$$

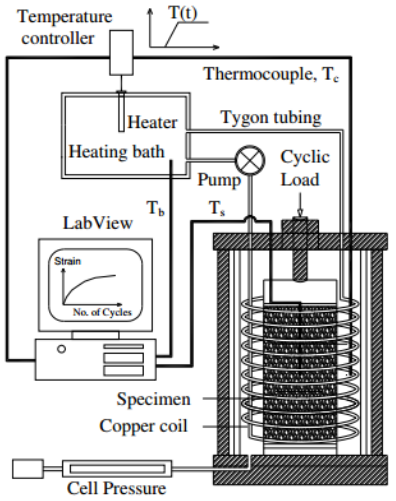
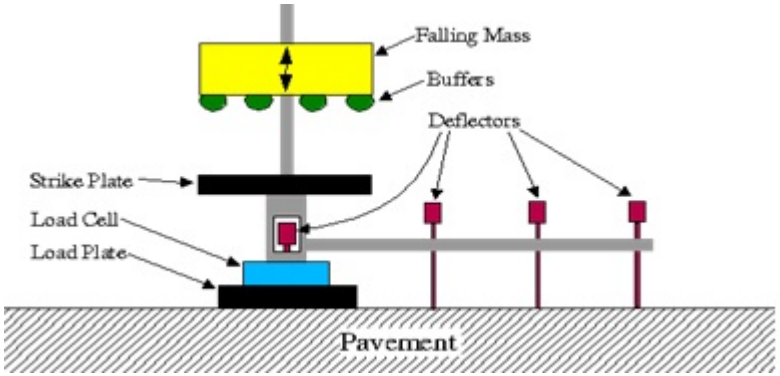


FIGURE 1 Schematic of temperature-controlled resilient modulus cell

Test 2: Field Tests

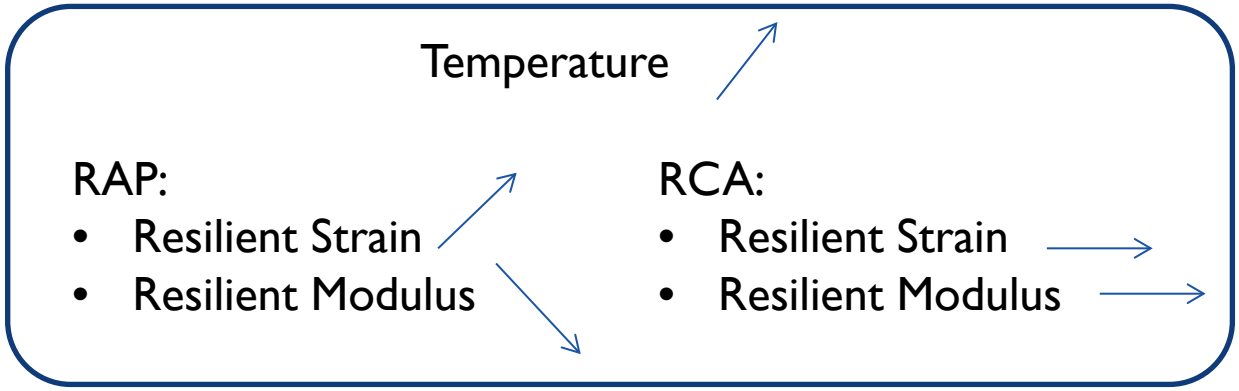
- Falling Weight Deflectometer (FWD)
- Done in Albertville, Minnesota.
- From Fall 2010 to Spring 2012: 5 measurements.

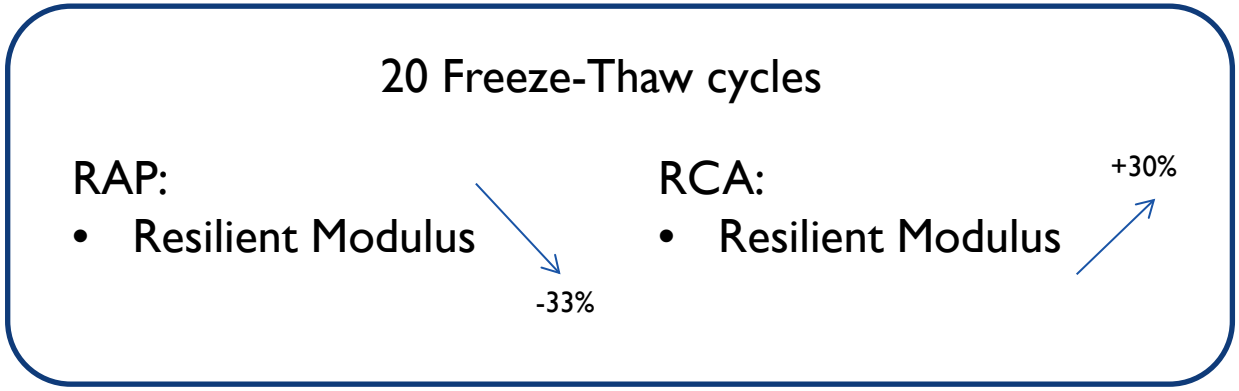


Test 3: Freeze-Thaw Cycles

- Number of F-T cycles tested: 5, 10 and 20.
- 24 hours freezing and 24 hours thawing.

Results (1/2)

- Recycled Aggregates have **comparable** or even **better properties** than Classical Aggregates.
- 

- 

- Installation of RAP better in summer

Results (2/2)

- From the field test (FWD): $\frac{E_{FWD}}{E_{FWD_O}} = e^{-0.011(T-T_o)}$

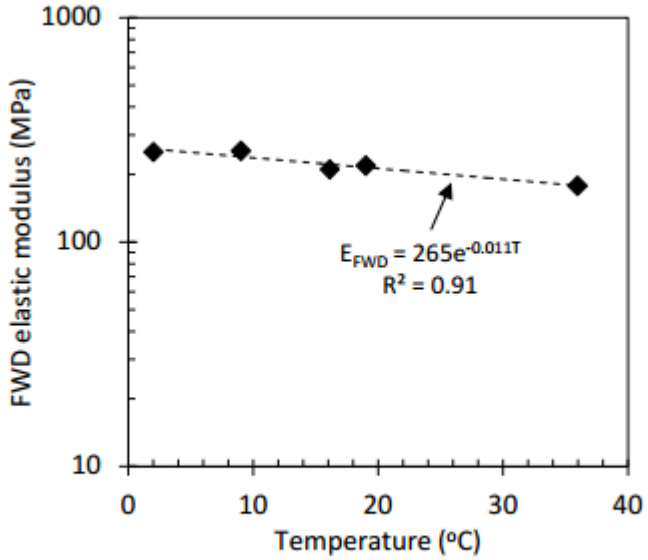


FIGURE 7 Variation of field modulus with pavement surface temperature

Review (1/5)

- Global view of the paper:
  - Organized and written in a clear way.
  - Conclusion concise and precise.
  - Approach interesting for technical society.

- Methodology and Tests:
  - Standardized procedure used.
  - Well described equipments and materials.

Review (2/5)

- Presentation of data and results:

202 and onto the MnROAD mainline, which is 5.6 km long by 2 lanes wide. The pavement profile is
203 shown in Fig.2. Testing was performed using a trailer-mounted Dynatest model 1000 FWD. A

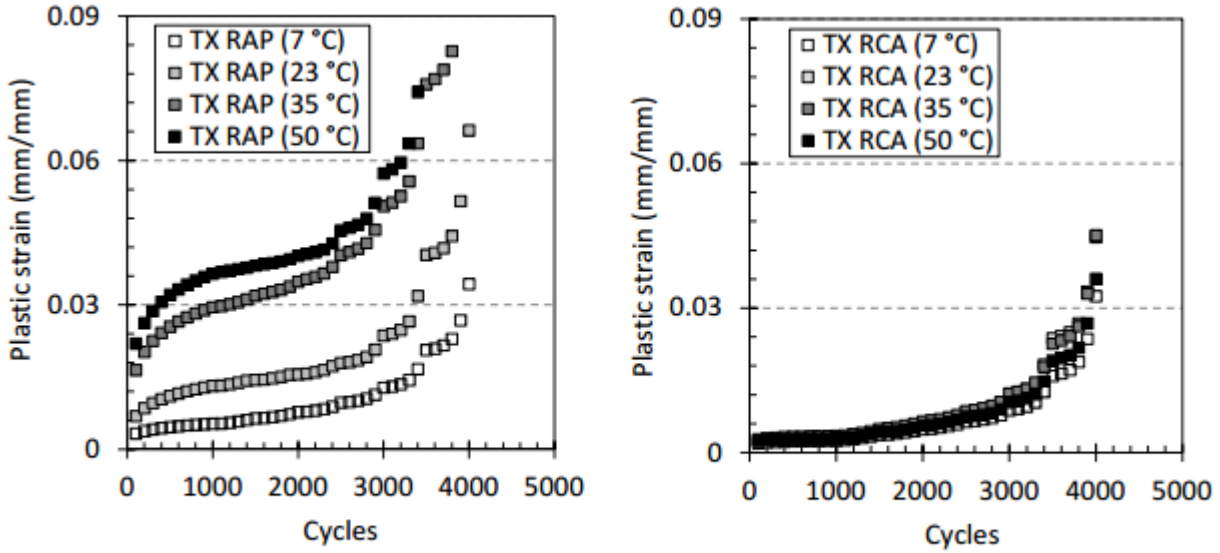


FIGURE 2 Cumulative plastic strain versus number of cycles at different temperature for TX RAP (a) and TX RCA (b)

151 Table 2 summarizes the testing program conducted in this study. NCHRP 1-28A
152 Procedure IA was followed for laboratory M_R testing. The materials used in this study are

Review (3/5)

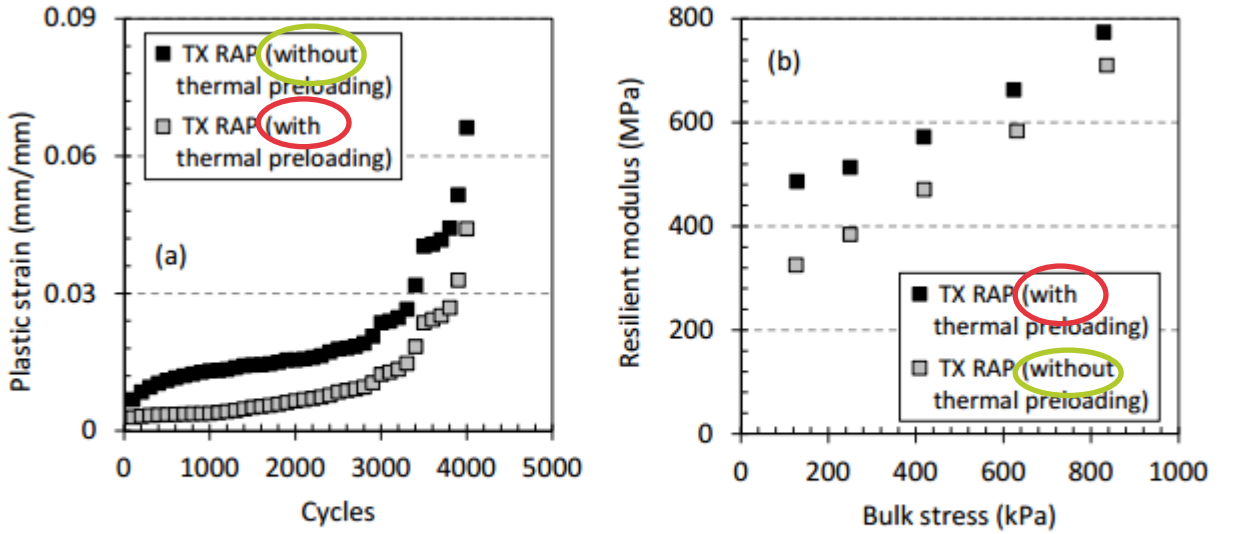
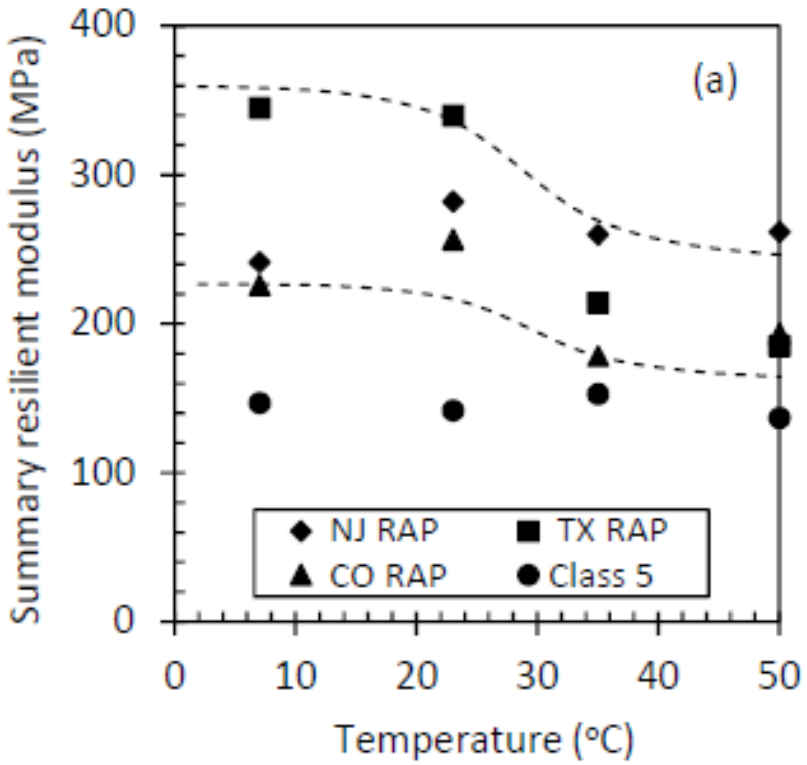
- Presentation of data and results:
  - 

FIGURE 5 Effect of thermal preloading: plastic strain versus number of cycles (a) and resilient modulus versus bulk stress (b)

Review (4/5)

- Presentation of data and results:
  - 

No explanation for the differences between RAP materials themselves (gradation?, …)

263 of RAP. The most noticeable reduction in M_R of RAP occurred within the temperature range of
264 23 °C to 35 °C where the M_{RS} decreased by 26% on average. Increasing temperature reduces

Review (5/5)

- Explanations:
  - Clear explanation for some results.
  - Some other result: no attempt of explanations or hypothesis.

- Hypothesis:
  - No discussion for some hypothesis.

Conclusion

- Some corrections are needed.
- But should be published.

Questions?