EARLY OPENING OF CONCRETE PAVEMENTS TO TRAFFIC

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THE PROBLEM

- Traffic-opening criteria
  - empirical
  - overly conservative (Crovetti and Khazanovich, 2005)
  - causing unnecessary construction delays and cost
- Concrete strength measurements
  - indirect (based on strength of cast aside beams or cylinders), or destructive (coring)
  - expensive

ACPA GUIDELINES

- Opening Criteria:
  - Allow use of concrete strength criteria without concrete age restrictions.
  - Channel initial traffic loads away from slab edges.
  - Restrict use to automobile traffic during early-age period.

ACPA GUIDELINES (1994)

Slab Thickness in. (cm)	Foundation Support psi/in (kPa/cm)	Modulus of Rupture for Opening, psi (Mpa), to support Estimated ESALs Repetitions to Specified Strength				
		100	500	1000	2000	5000
8 (20.3)	100 (271)	370 (2.55)	410 (2.83)	430 (2.96)	450 (3.10)	470 (3.24)
	200 (543)	310 (2.14)	340 (2.34)	350 (2.41)	370 (2.55)	390 (2.69)
	500 (1357)	300 (2.07)	300 (2.07)	300 (2.07)	300 (2.07)	310 (2.14)
8.5 (21.6)	100 (271)	340 (2.34)	370 (2.55)	380 (2.62)	400 (2.76)	430 (2.96)
	200 (543)	300 (2.07)	300 (2.07)	320 (2.21)	330 (2.28)	350 (2.41)
	500 (1357)	300 (2.07)	300 (2.07)	300 (2.07)	300 (2.07)	300 (2.07)
9 (22.9)	100 (271)	300 (2.07)	300 (2.07)	320 (2.21)	260 (2.48)	390 (2.69)
	200 (543)	300 (2.07)	300 (2.07)	300 (2.07)	300 (2.07)	320 (2.21)
	500 (1357)	300 (2.07)	300 (2.07)	300 (2.07)	300 (2.07)	300 (2.07)
9.5 (24.1)	100 (271)	300 (2.07)	300 (2.07)	300 (2.07)	330 (2.28)	350 (2.41)
	200 (543)	300 (2.07)	300 (2.07)	300 (2.07)	300 (2.07)	300 (2.07)
	500 (1357)	300 (2.07)	300 (2.07)	300 (2.07)	300 (2.07)	300 (2.07)
10 (25.4)	100 (271)	300 (2.07)	300 (2.07)	300 (2.07)	300 (2.07)	320 (2.21)
	200 (543)	300 (2.07)	300 (2.07)	300 (2.07)	300 (2.07)	300 (2.07)
	500 (1357)	300 (2.07)	300 (2.07)	300 (2.07)	300 (2.07)	300 (2.07)
10.5 (26.7)	100 (271)	300 (2.07)	300 (2.07)	300 (2.07)	300 (2.07)	300 (2.07)
	200 (543)	300 (2.07)	300 (2.07)	300 (2.07)	300 (2.07)	300 (2.07)
	500 (1357)	300 (2.07)	300 (2.07)	300 (2.07)	300 (2.07)	300 (2.07)

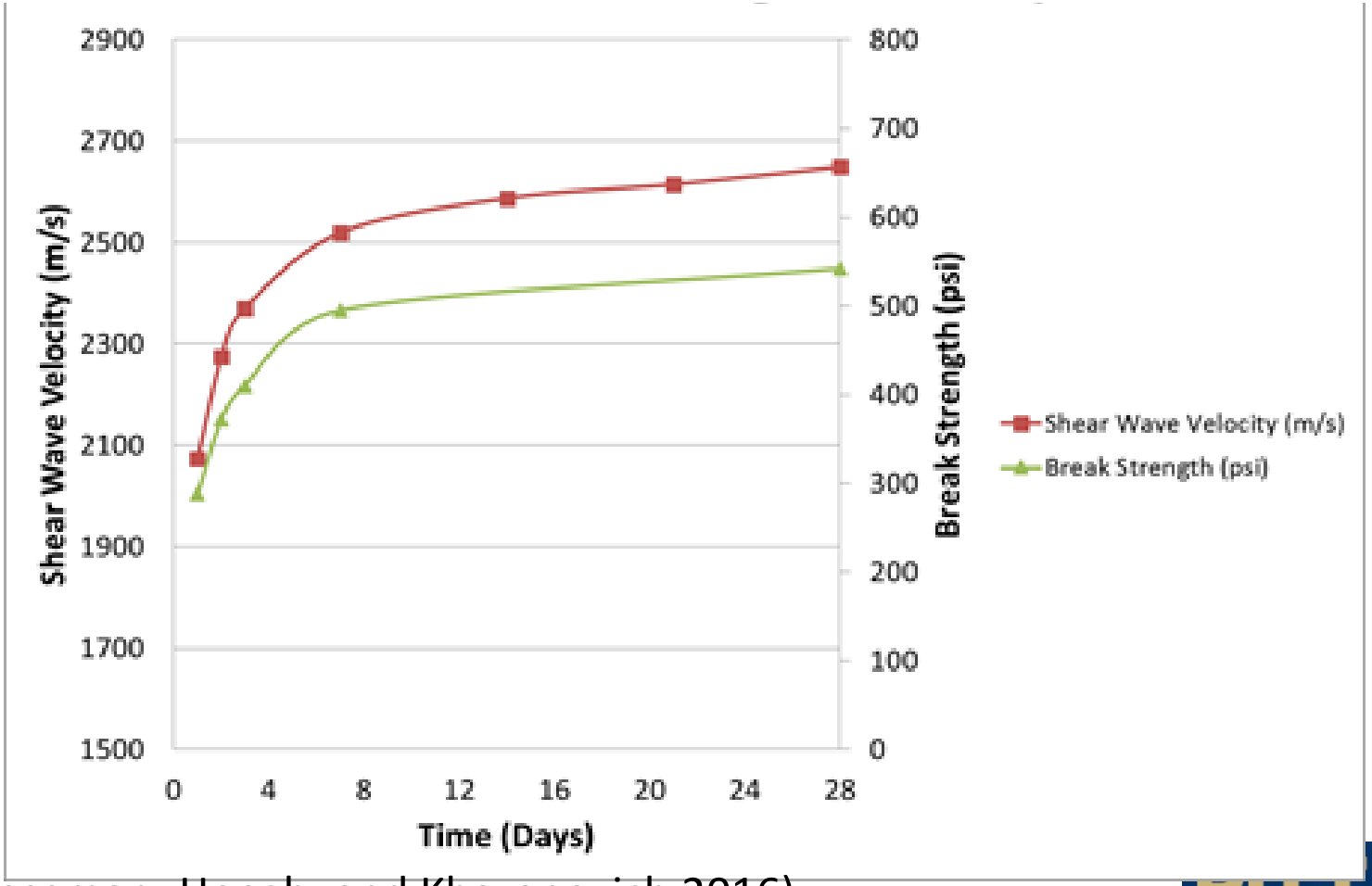
MINNESOTA DOT DATA

Age of beam	# of beams tested	Mean flexural strength (psi)	Standard deviation
1	35	355.34	105.31
2	185	453.46	75.94
3	396	487.43	81.42
4	297	495.47	74.76
5	213	520.53	73.87
6	149	520.73	81.34
7	1247	554.19	81.57
28	1532	670.68	91.96

ACPA GUIDELINES

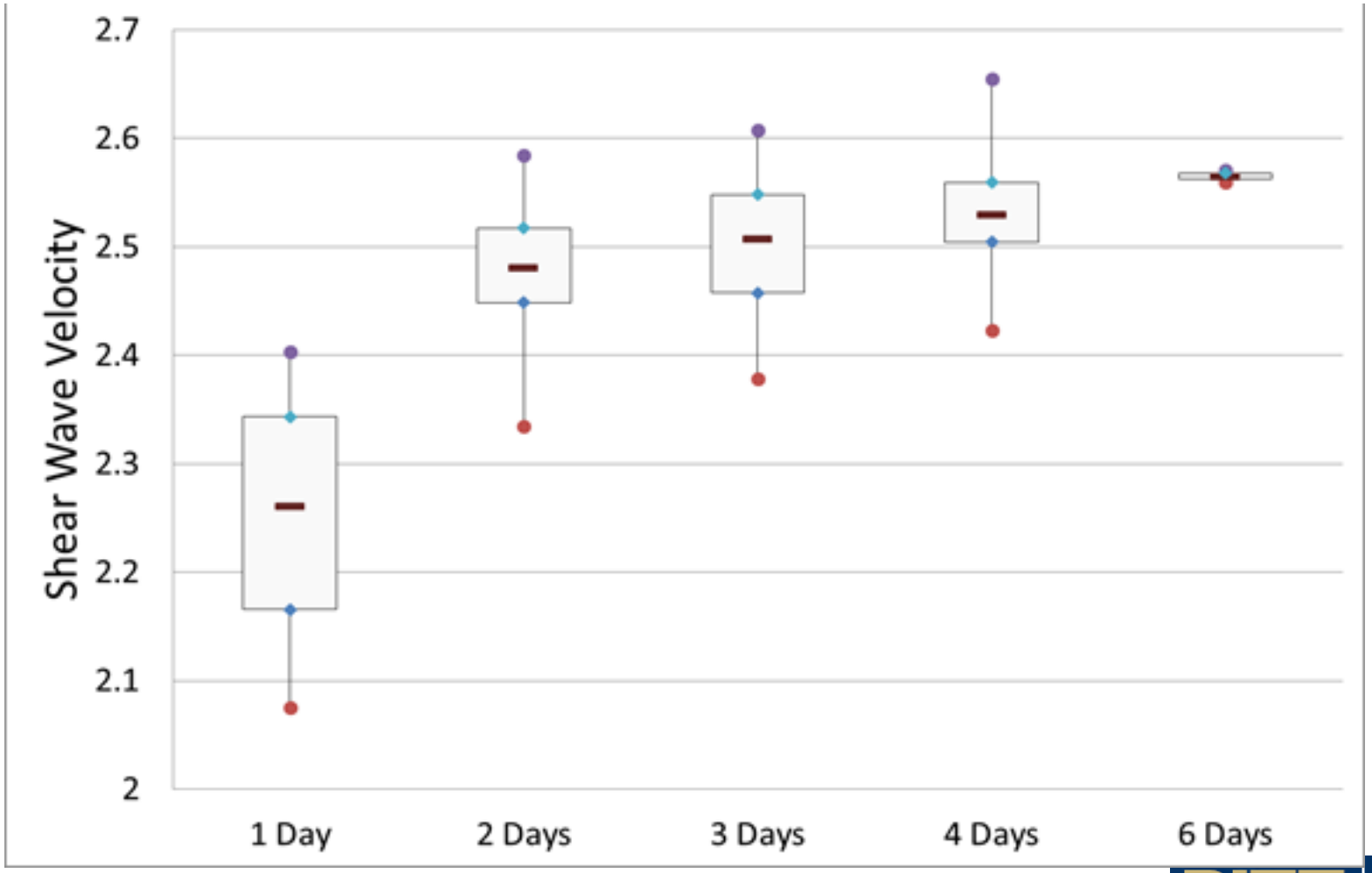
- Strength testing
  - Use nondestructive methods to supplement cylinders/beams for strength testing.
  - Use concrete maturity or pulse-velocity testing to predict strength.

USE OF SHEAR WAVE VELOCITY FOR FLEXURAL STRENGTH PREDICTION



(Freeseman, Hoegh, and Khazanovich 2016)

SHEAR WAVE VELOCITY VS CONCRETE AGE



(Freeseman, Hoegh, and Khazanovich 2016)

RESEARCH APPROACH

- Develop an innovative procedure for monitoring concrete early age development and mechanistic-based procedure for prediction of the effect of early traffic opening on long-term damage accumulation
- Quantify the cost and benefits of the early traffic opening

RESEARCH OBJECTIVE

- Develop a strategy that can be implemented by the IRISE members for optimal timing of traffic opening.

APPROACH - TASKS

Task A: Literature review

Task B: Laboratory and field testing

Task C: Develop mechanistic-empirical model

Task D: Conduct traffic simulation

Task E: Final Report

TASK A. LITERATURE REVIEW

- The current criteria for traffic opening (ACPA 1994, 2001)
- Mechanistic models for opening to traffic

(Crovetti and Khazanovich 2005; Freeseman, Hoegh, and Khazanovich 2016)

- Non-destructive methods for evaluation of concrete strength development and concrete damage assessment

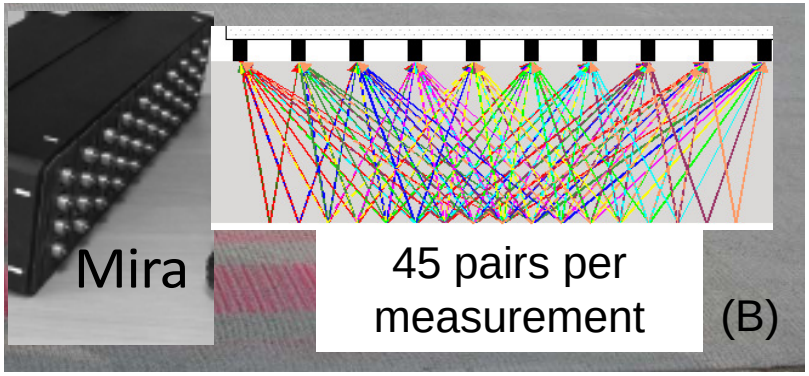
COMPANION STUDY: NRRA PROJECT EVALUATION OF LONG-TERM IMPACTS OF EARLY OPENING OF CONCRETE PAVEMENTS

MnROAD test data will be available for this project

TASK B. LABORATORY AND FIELD TESTING

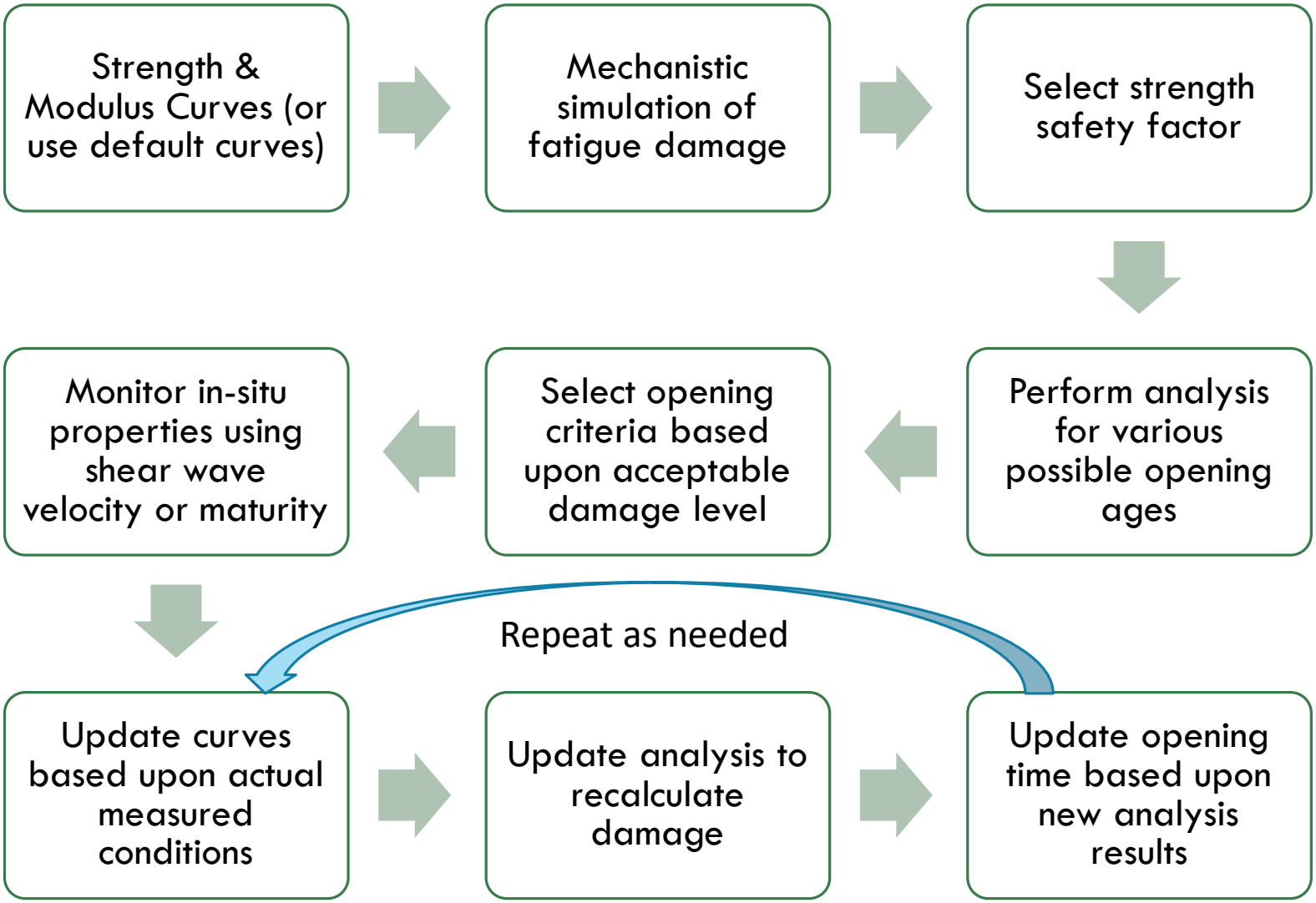
- Field testing:
  - Collect concrete cylinder and beam specimens on a concrete paving project
  - Measure maturity during the first 7 days
  - Conduct ultrasound tomography testing after 1, 2, 3, and 7 days
- Laboratory testing
  - Compressive and flexural strength after 1, 2, 3, 7, and 28 days
  - Shear wave velocity testing on the beams
  - Maturity measurements

TASK B. LABORATORY AND FIELD TESTING



Ultrasound tomography testing

TASK C. DEVELOP MECHANISTIC-EMPIRICAL MODEL



TASK D. CONDUCT TRAFFIC SIMULATION

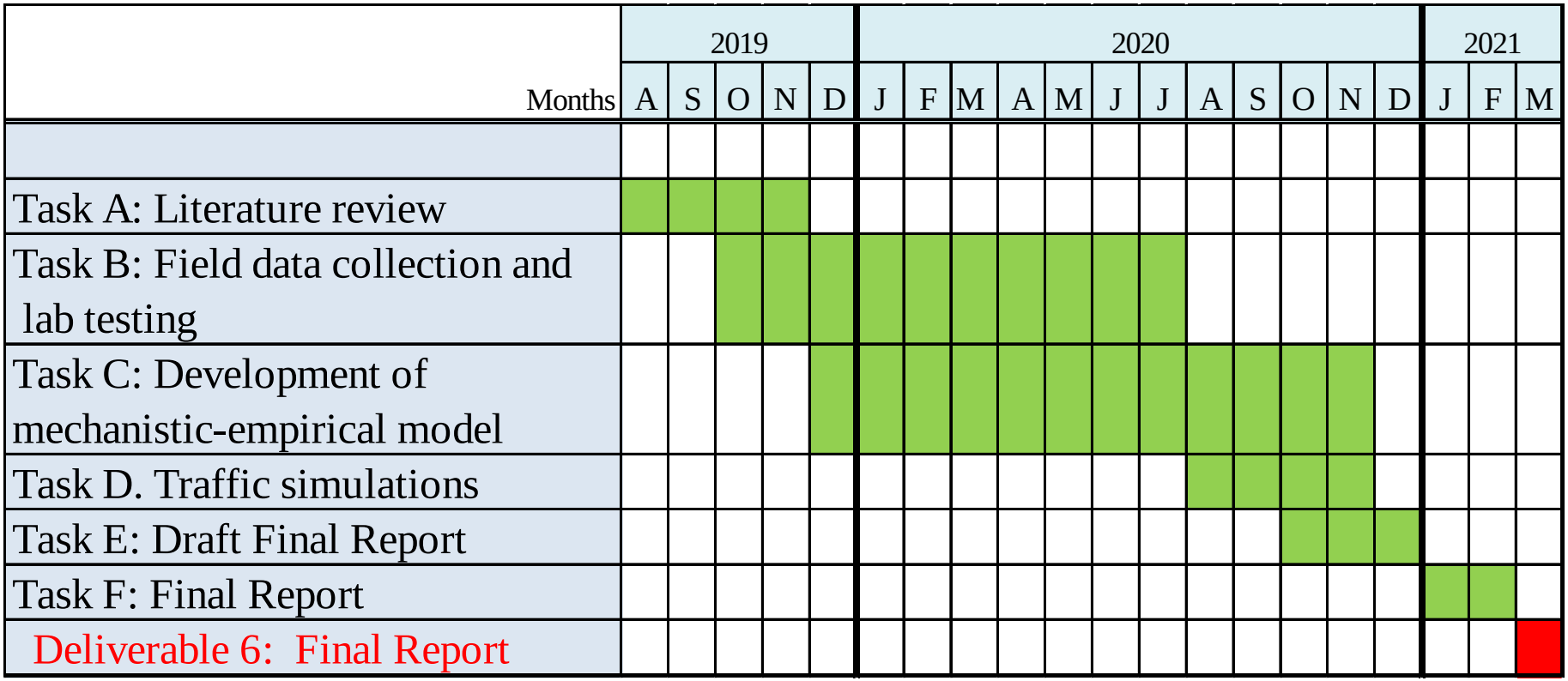
- A case study will be selected
- Traffic simulations for various scenarios of early traffic opening will be conducted
- Benefits in reducing user cost will be quantified

TASK E. DRAFT FINAL REPORT
TASK F. FINAL REPORT

A final report will be prepared to document project activities, findings, and recommendations.

The final report will also include recommendations for implementation of the procedure developed in this study.

SCHEDULE


2019
2020
2021
Months
A S O N D J F M A M J J A S O N D J F M
Task A: Literature review
Task B: Field data collection and lab testing
Task C: Development of mechanistic-empirical model
Task D. Traffic simulations
Task E: Draft Final Report
Task F: Final Report
Deliverable 6: Final Report

APPLICATION OF RESEARCH PRODUCT

- Reduction of construction time and cost
- Reduction of traffic congestion and user cost