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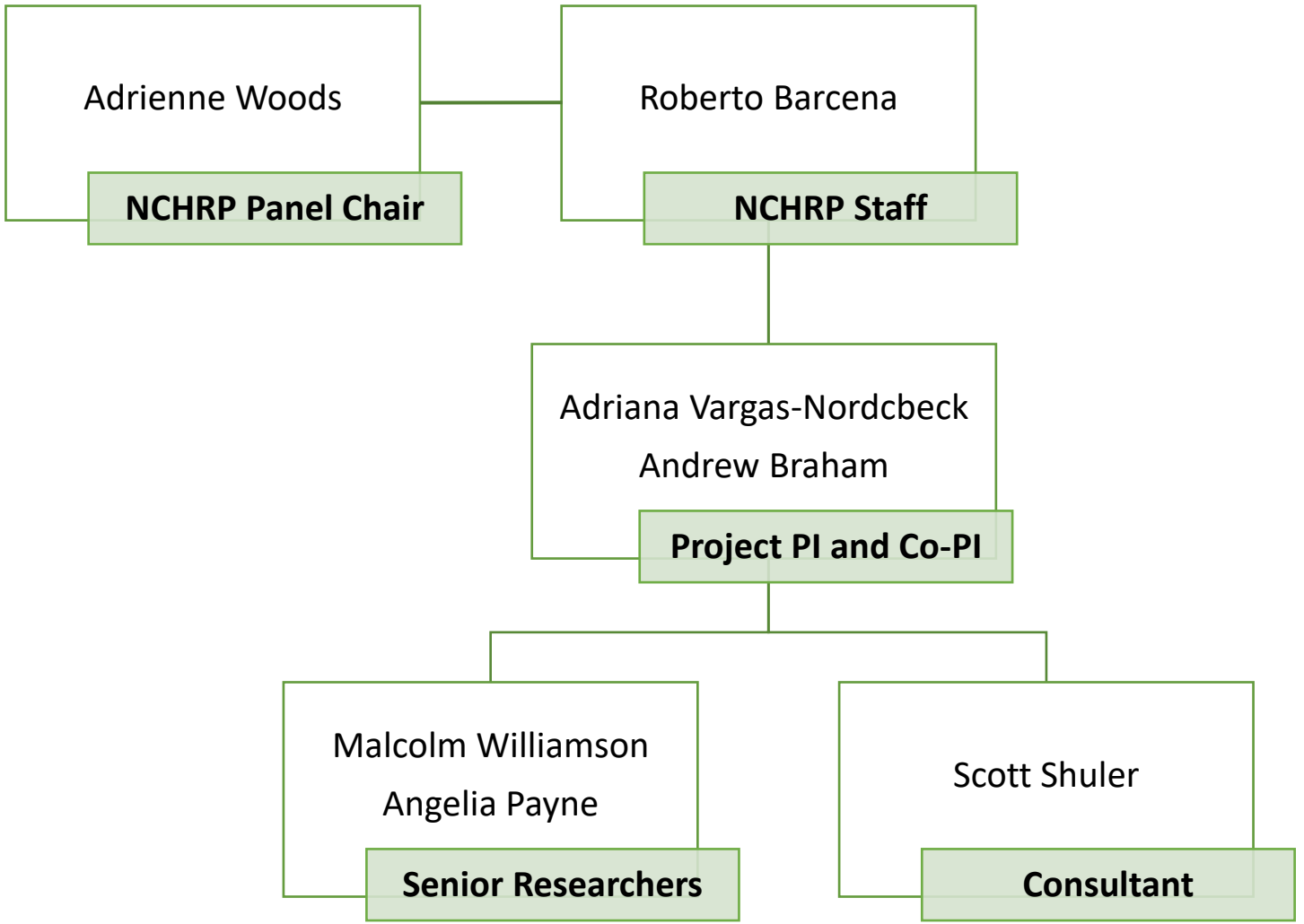
Development of a Field Test to Determine Chip Seal Aggregate Embedment

NCHRP Project No. 10-124

Kickoff meeting

Research Team



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Background

- Chip seals are popular pavement preservation treatments
  - Seal fine cracks in underlying pavement
  - Prevent water intrusion
  - Aggregate protects the asphalt layer and provides a skid-resistant surface

Treatment	Expected Performance	
	Treatment Life (yr)	Pavement Life Extension (yr)
Chip seal		
Single course	3–7	5–6
Double course	5–10	8–10

(Peshkin et al. 2011)

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Background

- Design Methods
  - Hanson
  - Kearby/Modified Kearby
  - McLeod
  - New Zealand
  - Austroads
  - South Africa
  - United Kingdom (Road Note 39)

Chip Seal Design Method	United States (%)	Canada (%)
Kearby/Modified Kearby	7	0
McLeod/Asphalt Institute	11	45
Empirical/past experience	37	33
Own formal method	19	0
No formal method	26	22

(Gransberg and James, 2005)

Background

- Chip Seal Design

Determine:

Grade, type, and application rate for a bituminous binder

Given:

Aggregate size and type, surface condition of existing pavement, traffic volume

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Background

- Design methods target embedment rate
  - Typically 50-70%

Correct asphalt quantity, voids 50% to 70% filled

Insufficient asphalt, screenings not firmly held

Excess asphalt submerges chips and causes bleeding

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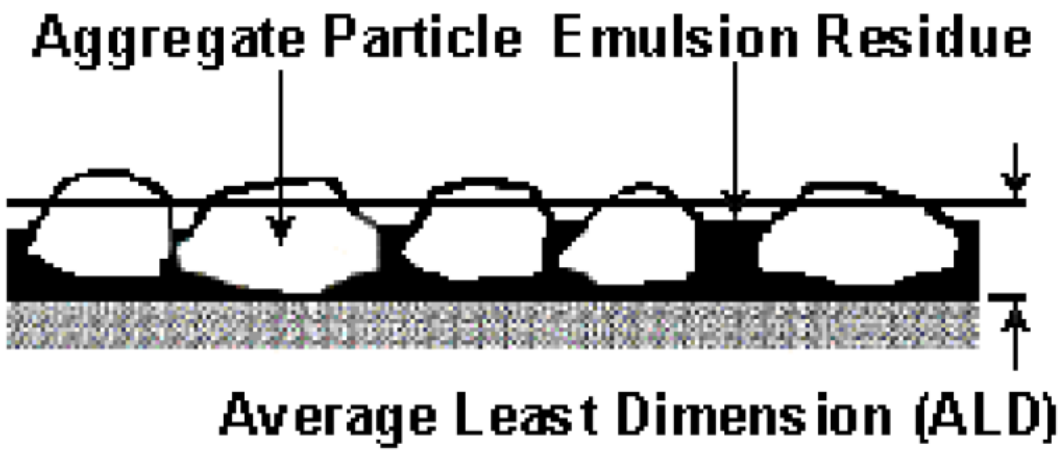
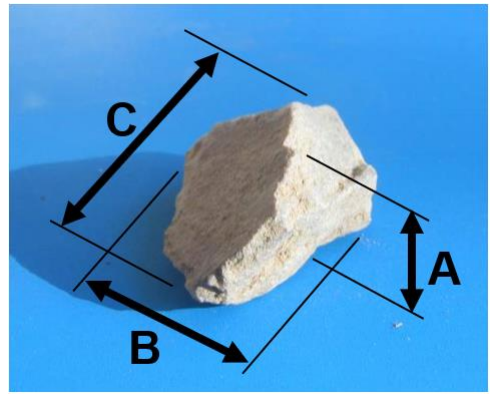
Background

- Percent embedment (PE) is the percentage of the average least dimension (ALD) of the aggregate enveloped by the binder



ALD can be measured directly or computed based on particle size distribution and Flakiness Index



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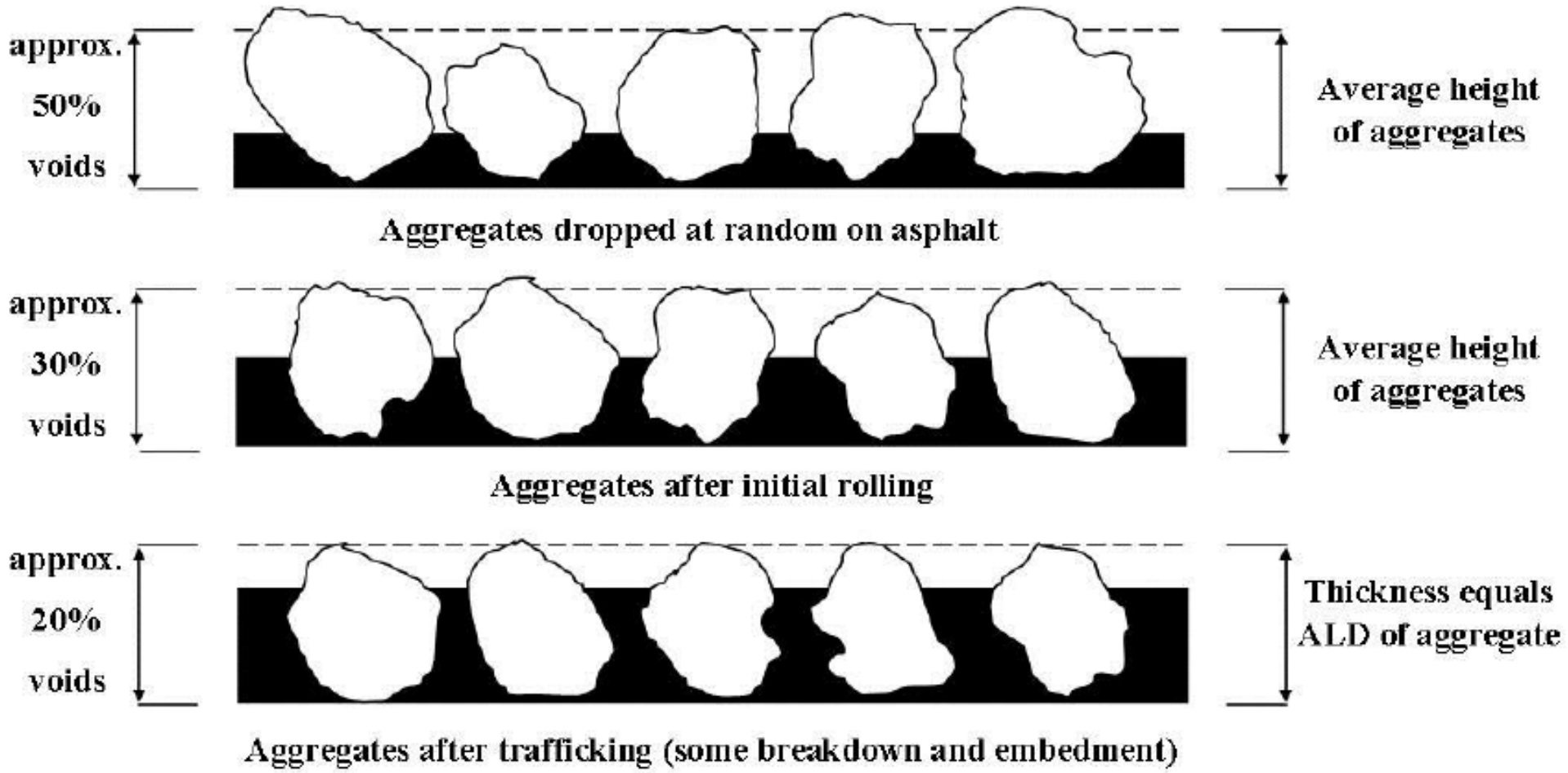
Background



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Background

- Proper embedment is a key component but field verification is not standardized
  - Inspectors often rely on visual inspection

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Objective

- **Identify, adapt, or develop** a rapid field test method(s) to determine the percentage embedment depth of a uniformly placed chip seal of known aggregate gradation.

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Research Approach

Phase I

- Task 1: Literature Review
- Task 2: Preliminary Evaluation
- Task 3: Interim Report 1

Phase II

- Task 4: Development of Work Plan
- Task 5: Interim Report 2

Phase III

- Task 6: Work Plan Execution
- Task 7: Interim Report 3
- Task 8: Technical Memorandum

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Phase I

- Gather information about relevant research, methodologies, tools, and technologies that have been used or could be used in determining the actual percent embedment of chip seal aggregate
  - Published and unpublished documents
  - Agency specifications
  - Interviews with key stakeholders

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Phase I

Task 1: Literature Review

- Several methods identified from preliminary review
  - Volumetric (sand patch)
  - Laser-based (CTM, profiler)
  - Digital image analysis
  - Light-based (LiDAR, photogrammetry, structured light scanning)

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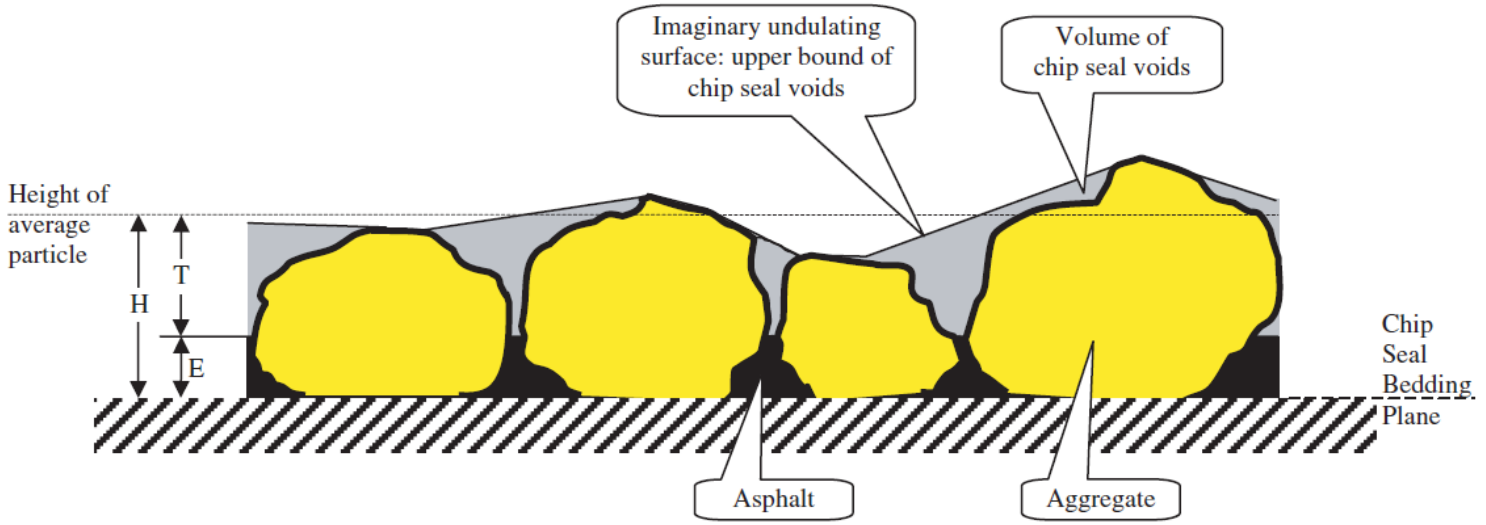
Phase I

Volumetric approach



(Shuler et al. 2011)

$$E = \frac{H - T}{H} \times 100$$

E: embedment, %
H: average particle height (or ALD)
T: mean texture depth from sand patch test

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Phase I

Laser-based methods

Circular Texture Meter (CTM)

Laser Texture Scanner (LTS)

Vehicle-mounted laser system

Macrotexture Laser Scanner

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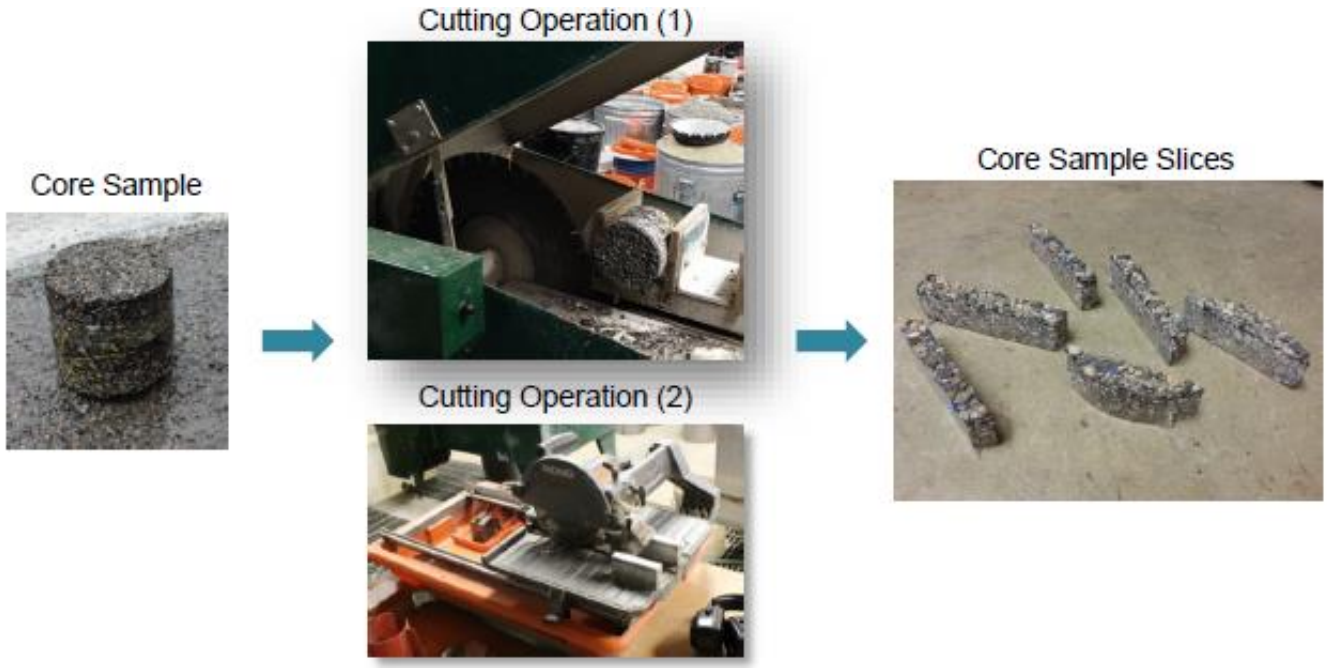
Phase I

Data Image Analysis



(Kutay et al. 2016)

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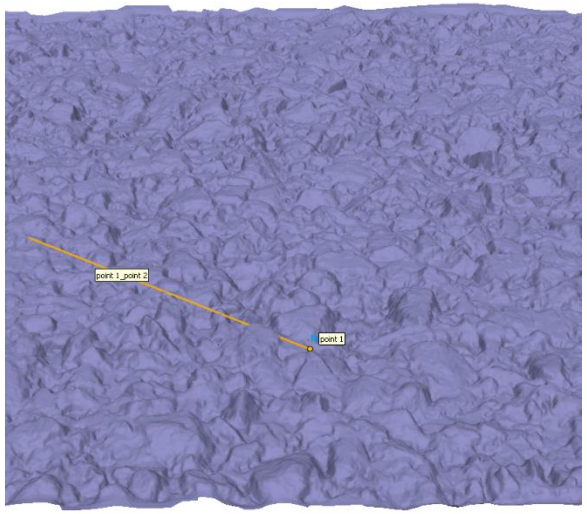
Phase I

Light-based methods



Nikon D3300 – photo and processed 3D surface

Smartphone 3D model (made with Polycam)

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Phase I

Task 2: Preliminary Evaluation

- Stage 1 – rate tests based on equipment requirements, availability, simplicity, cost, accuracy, testing time, and analysis.
  - Identify “desirable” tests
- Stage 2 – conduct laboratory testing
  - One “standard” material (known, constant dimensions)
  - One chip seal aggregate
  - Evaluate accuracy and precision of each test
  - Identify ~ 4 tests to move forward

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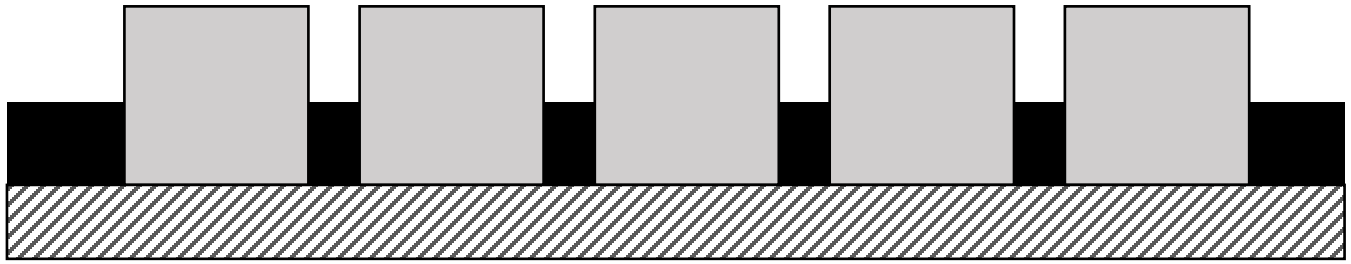
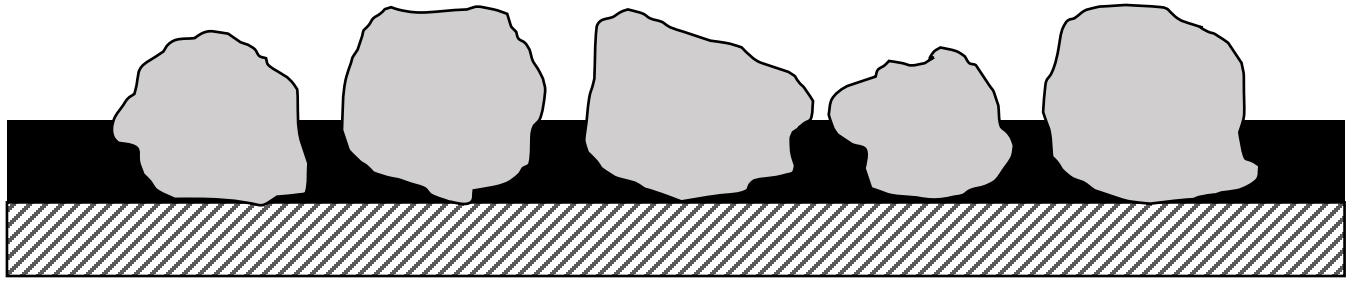
Phase I



Standard material
(known, uniform dimensions)



Chip seal aggregate

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Phase I

Task 3: Interim Report 1

- Synthesis of critical literature review
- Results of preliminary evaluation
- Recommendations of test for further evaluation

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Phase II

Task 4: Develop Detailed Work Plan

- Select 4 promising tests
  - Will range in complexity
  - High priority given based on simplicity and practicality
  - May develop correlations so simpler methods can be used in place of more resource and time-consuming approaches with a reasonable degree of confidence

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Phase II

Task 4: Develop Detailed Work Plan

Variable	Level Categories
Binder type	• Asphalt emulsion • Hot-applied asphalt binder
Residual binder application rate	• 0.20-0.24 gal/sy • 0.24-0.28 gal/sy • 0.26-0.32 gal/sy
Aggregate size	• 6.4 mm • 9.5 mm • 12.5 mm
Aggregate color	• Light • Medium • Dark

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Phase II

Task 4: Develop Detailed Work Plan

Variable	Level Categories
Location	• Laboratory • Field
Evaluation test	• Volumetric (sand patch) • Laser-based (CTM) • Light-based (structured light scanner) • Light-based (smartphone)

Research team will define test matrix.

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Phase II

Task 4: Develop Detailed Work Plan

- Field evaluation – at least six field projects

Region	Possible State	Notable Characteristics
Southeast	Texas	Wet-no freeze climate, extensive use of hot-applied binder
	Alabama or South Carolina	Wet-no freeze climate, use of lightweight aggregate
Midwest	North Dakota or South Dakota	Dry-freeze climate, typically low traffic applications
Rocky Mountain West	New Mexico	Dry-no freeze climate, use of RAP aggregate
	Arizona	Dry-no freeze climate, high traffic applications
Northeast	Massachusetts or New Hampshire	Wet-freeze climate, use of rubber chip seals

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Phase II

Task 5: Interim Report 2

- Detailed work plan describing the experimental matrix, including specific test methods selected for laboratory and field evaluation, and variables considered.

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Phase III

Task 6: Execute Work Plan

- Laboratory and field testing
  - Lab – determine applicability, accuracy, and variability under controlled conditions
  - Field – validate results during construction of chip seal projects.
    - May introduce additional factors

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Phase III

Task 6: Execute Work Plan

- Develop and incorporate approach to assess chip seal performance based on percent embedment
  - Conduct wheel loaded test (HWTD, TWPD)

Materials	Binder application rate	Performance Evaluation	
		Aggregate loss	Bleeding
• Two aggregate sources (different sizes) • One binder source (hot-applied or emulsified asphalt)	• Low • Medium • High (based on recommended ranges by aggregate size)	• % loss by weight of aggregate	• Macrotexture and visual assessment

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Phase III

Task 7: Interim Report 3

- Results from evaluation described in the work plan.
- Recommended test(s) to determine aggregate embedment in chip seals.
- Framework for developing an incentive and disincentive program to maximize the performance of chip seals.
- Appendix with draft test procedure(s) for review and consideration by the AASHTO Committee on Materials and Pavements (COMP).

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Phase III

Task 8: Technical Memorandum

- Recommendations for implementation.
- List of organizations with the expertise and resources to lead the implementation effort.
- Obstacles or challenges and strategies to overcome them.
- Recommended methods to evaluate the effectiveness of the implementation.

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Schedule

Phase	Task	Month																																						
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
I	1-Literature and Practice Review		★																																		
	2-Preliminary Evaluation																																				
	3-Interim Report 1								X																												
	Panel Review																																				
	Interim Meeting																																				
II	4-Develop Detailed Work Plan																																				
	5-Interim Report 2													X																							
	Panel Review																																				
	Interim Meeting																																				
III	6-Execute Work Pland																																				
	7-Interim Report 3																																			X	
	8-Technical Memorandum																																			X	
	Panel Review																																				
	Final Meeting																																				
Amplified Work Plan (AWP)		X																																		
Monthly Progress Report (MPR)			X	X	X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Quarterly Progress Report (QPR)				X			X			X			X			X			X			X			X			X			X			X			X

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Questions?

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