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TRB Webinar: Use of Recycling Agents in Asphalt Concrete Mixtures

March 13, 2023

1:00 – 2:30 PM

PDH Certification Information

1.5 Professional Development Hours (PDH) – see follow-up email

You must attend the entire webinar.

Questions? Contact Andie Pitchford at TRBwebinar@nas.edu

The Transportation Research Board has met the standards and requirements of the Registered Continuing Education Program. Credit earned on completion of this program will be reported to RCEP at RCEP.net. A certificate of completion will be issued to each participant. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the RCEP.

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Purpose Statement

Asphalt mixtures containing recycled asphalt materials (RAM) may benefit from the use of a recycling agent (RA) to improve cracking resistance. This webinar will describe existing practices for use of RAs in asphalt mixtures with RAM. Presenters will review *NCHRP Synthesis 586: Use of Recycling Agents in Asphalt Concrete Mixtures* and share key findings and major challenges for agencies that are looking to start or continue using the materials. Presenters will also share surveys and interviews from state departments of transportation (DOTs) and Canadian Provincial Transportation Agencies.

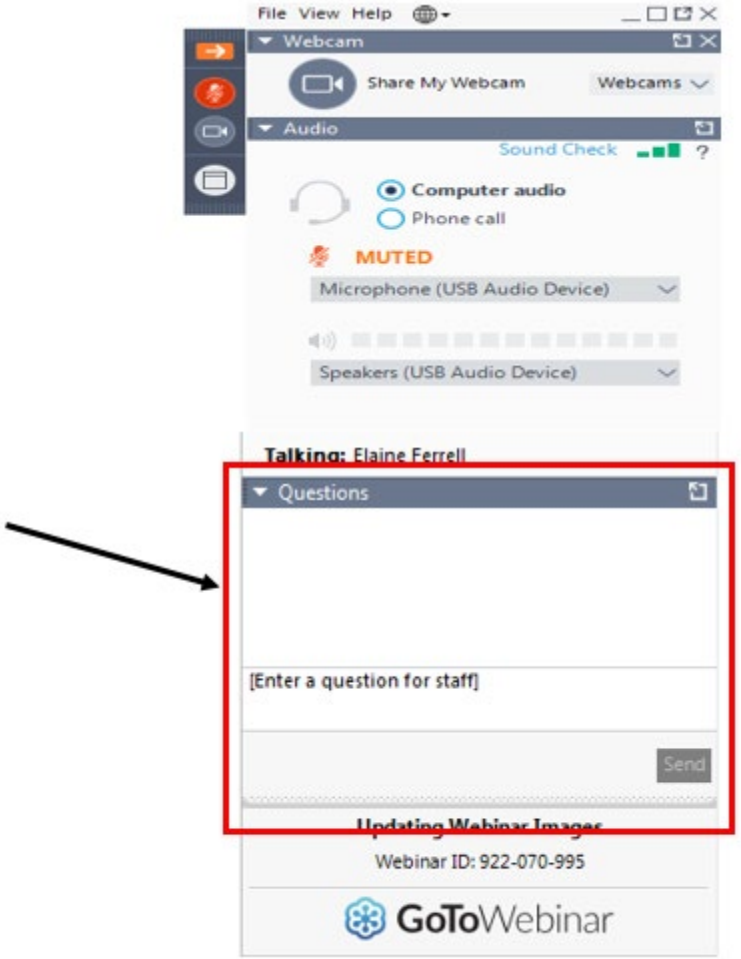
Learning Objectives

At the end of this webinar, you will be able to:

- Describe the current practices and challenges in the use of RAs

Questions and Answers

- Please type your questions into your webinar control panel
- We will read your questions out loud, and answer as many as time allows



Today's presenters

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Use of Recycling Agents in Asphalt Concrete Mixtures NCHRP 20-05, Topic 52-17

Runhua Zhang, University of Wisconsin
Eshan V. Dave, University of New Hampshire
Jo E. Sias, University of New Hampshire

Moderating:
Adam Hand, University of Nevada Reno

Agenda

- Introduction — *Runhua Zhang*
- Literature Review — *Runhua Zhang*
- Agency Survey Results — *Eshan Dave*
- Case Examples — *Jo Sias*
- Key Takeaways and Challenges — *Jo Sias*
- Question and Answer Session — *Adam Hand*

Motivation for Synthesis Project

- FHWA has highlighted the importance of using RAM in the highway construction industry:
  - Increase mixture overall stiffness
  - Preserve the natural environment, reduce waste
  - Reduce mixture production cost
- Mixtures containing RAM have higher cracking susceptibility
  - Need RA to restore the RAM properties
  - Use of RA allows higher RAM content in mix

RA Functions

- RA definition: *"A material with chemical and physical characteristics selected or designed to restore or rejuvenate the properties of aged asphalt to desired specifications"*
- RA functions:
  - Decreasing RAM stiffness for construction purposes and mixture field performance
  - Restore RAM's flexibility for improved durability and cracking properties
  - Provide/activate RAM binder to coat the recycled and virgin aggregates
  - Provide/activate RAM binder to satisfy mix design volumetric requirements

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RA Type

- ASTM D4552-20 *(Standard Classification for Hot-Mix Recycling Agents)*:
  - Depends on viscosity
  - RA 0, RA 1, RA 5, RA 25, RA 75, RA 250 and RA 500
- NCAT classification system *(based on source or chemical composition)*:

Classification (NDOT)	Category	Generic Types (Examples)	Source Description
Class I	**Paraffinic Oils**	Waste Engine Oil (WEO) Waste Engine Oil Bottoms (WEOB) (Valero VP 165®, Storbit®)	Refined used lubricating oils
Class II	**Aromatic Extracts**	Aromatic Oils (Hydrolene®, Reclamite®, Cyclogen L®, ValAro 130A®)	Refined crude oil products with polar aromatic oil components
Class III	**Napthenic Oils**	(SonneWarmix RJ™, Ergon HyPrene®)	Engineered hydrocarbons for asphalt modification
Class IV	**Triglycerides & Fatty Acids**	Waste Vegetable Oil Waste Vegetable Grease Brown Grease Oleic Acid	Derived primarily from vegetable oils
Class V	**On purpose bio-based products**	(Kraton Sylvaroad™ RP1000, Hydrogreen®, Cargill Anova®, CA4®)	Derived from vegetable oils and/or tall oil, a paper industry by-product.

RA Dosage

- Dosage recommended by the **manufacturers**:
  - typically <5% of total weight of asphalt binder in mixture
- Dosage determined by the **blending charts**:
  - Using viscosity/penetration blending chart
  - Using the PG system:
    - ✓ *Minimum dose to ensure sufficient low-temperature cracking resistance (e.g. PGLT);*
    - ✓ *Maximum dose to ensure adequate rutting resistance (e.g. PGHT)*
  - NCHRP 09-58 method:
    - ✓ *Dosage = ($PGHT_{Blend} - PGHT_{Target}$)/Slope Rate*

Current Methods and Practices for Evaluation of RA Treated Asphalt Binders

- **Analytical Methods:**
  - Evaluate the chemical composition and functional group
  - *SARA Separation; Size Exclusion Chromatography (SEC); Fourier-Transform Infrared (FTIR) Spectrometer*
- **Morphology Analysis Methods (Microscopy Techniques):**
  - Observation and quantitative analysis of the asphalt microscale morphology
  - *Infrared Microscopy; Fluorescence Microscopy; Atomic Force Microscopy (AFM)*
- **Thermal Analysis Methods:**
  - Evaluate enthalpy related transitions and thermal behaviors
  - *Differential Scanning Calorimetry (DSC); Thermogravimetric Analysis (TGA)*
- **Binder Performance Tests:**
  - *PG Tests; Multiple Stress Creep Recovery (MSCR) Test; Linear Amplitude Sweep (LAS) Test*

Current Methods and Practices for Evaluation of RA Treated Asphalt Mixtures (1/2)

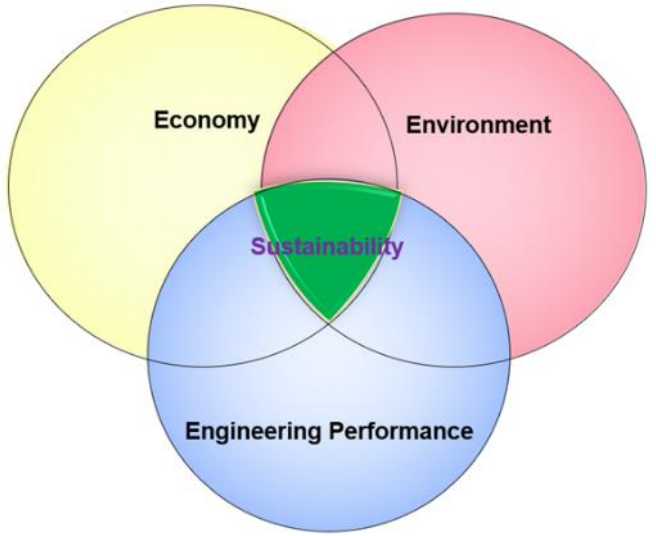
- **Stiffness and Linear Viscoelasticity:**
  - Test Methods: *Resilient Modulus (Mr) Test; Complex Modulus (E*) Test*
  - *RAs can effectively **reduce the stiffness** of the asphalt mixtures with RAM*
- **Permanent Deformation:**
  - Test Methods: *HWTT; APA; FN*
  - *Most RAs increase the **rutting susceptibility** of asphalt mixtures*
- **Intermediate-Temperature Cracking Performance:**
  - Test Methods: *Flexural Bending Beam (4FBB); CT-Index; SCB; DTCF*
  - *RA with proper type and dose can **improve the intermediate temperature cracking properties** of asphalt mixtures with RAM*
- **Low-Temperature Cracking Performance:**
  - Test Methods: *DCT; Low-temperature IDT*
  - *Low-temperature cracking performance of asphalt mixtures with RAM **depends on the type and dose** of study RA*

Current Methods and Practices for Evaluation of RA Treated Asphalt Mixtures (2/2)

- **Moisture Susceptibility:**
  - Test Methods: *HWTT; TSR; |E*| and Mr Ratio*
  - *Addition of RA could **increase the moisture susceptibility** of asphalt mixtures with RAM*
- **Performance Simulation and Prediction Models/Programs:**
  - *AASHTOWare Pavement ME; MnPAVE; TxACOL/S-TxACOL; FlexPAVE*
  - *Only **a few studies** have used these models for evaluation of RA treated asphalt mixtures:*
    - ✓ ***No consensus** on how RAs impact asphalt pavement performance*
- **Long-term Performance of RA Treated Asphalt Materials:**
  - Beneficial effects of some RAs **are diminished with subsequent aging**
  - *RAM binders/mixtures with **organic/bio-based RAs are more susceptible to aging** than those containing petroleum-based RAs*

Sustainability Assessment Related to Use of RAs

- FHWA defines "**sustainable pavement**" as:
  - **Meets basic human needs** (Performance – Testing)
  - **Uses resources effectively** (Cost effective – Life Cycle Cost Analysis（LCCA）)
  - **Preserves/restores surrounding ecosystems** (Environmentally friendly – (Life Cycle Assessment（LCA))



- **Significant research efforts** have employed LCA/LCCA analysis to evaluate the **RAM asphalt binders and mixtures**
- Only **a few studies** have used these methods to evaluate the asphalt material **containing RA products**
  - Limited to the **inventory** or **cradle to gate** analysis
  - RA treated asphalt mixes show the **lower environmental impact** and **production cost** primarily due to the **increased RAM content**

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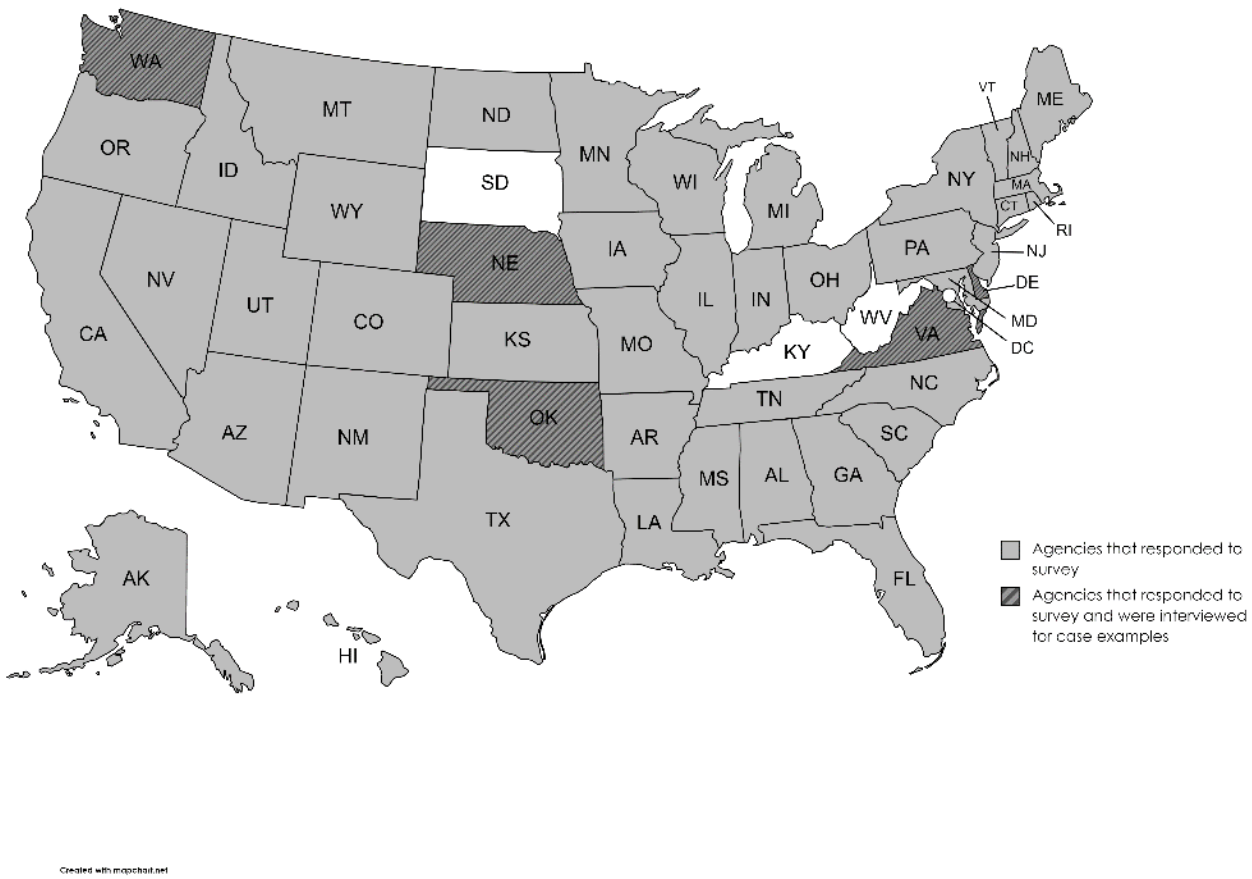
Survey Responses

~90% State Agencies



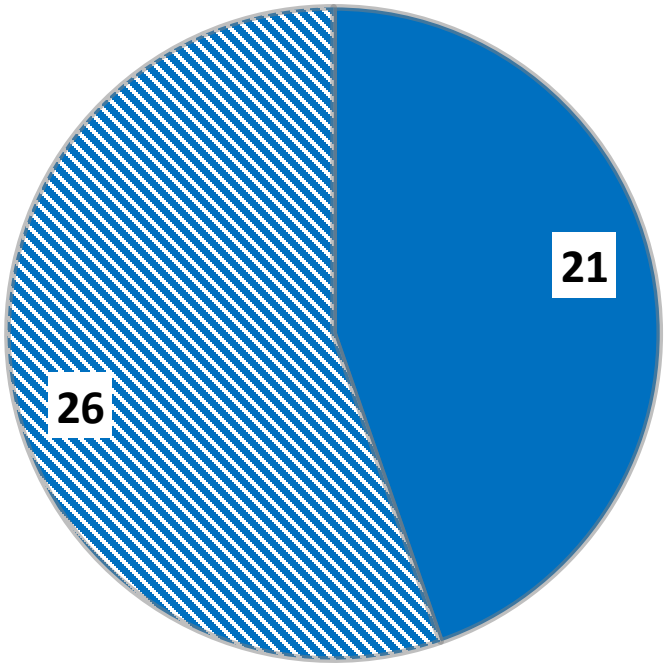
8 Canadian Provinces

Survey dates: Dec 2020 – Feb 2021

State of the Practice Survey

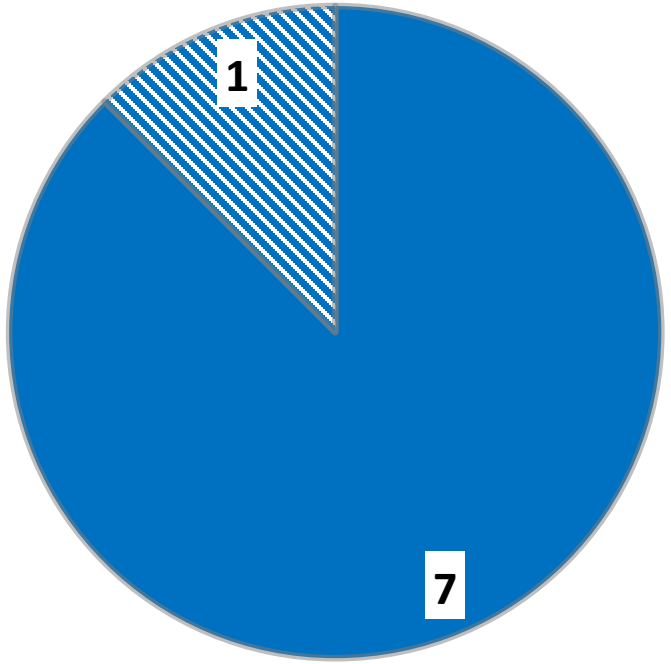
- This presentation focuses on providing high level summary, detailed results provided in the report
- Topics Covered:
  - Use of RAMs
  - Use of RAs
  - Methods of specifying type and dosage of RAs
  - Verification of RA dosage and quality assurance aspects
  - Other RA applications
  - Challenges and future plans

RAM Usage (Allowed) by Agencies

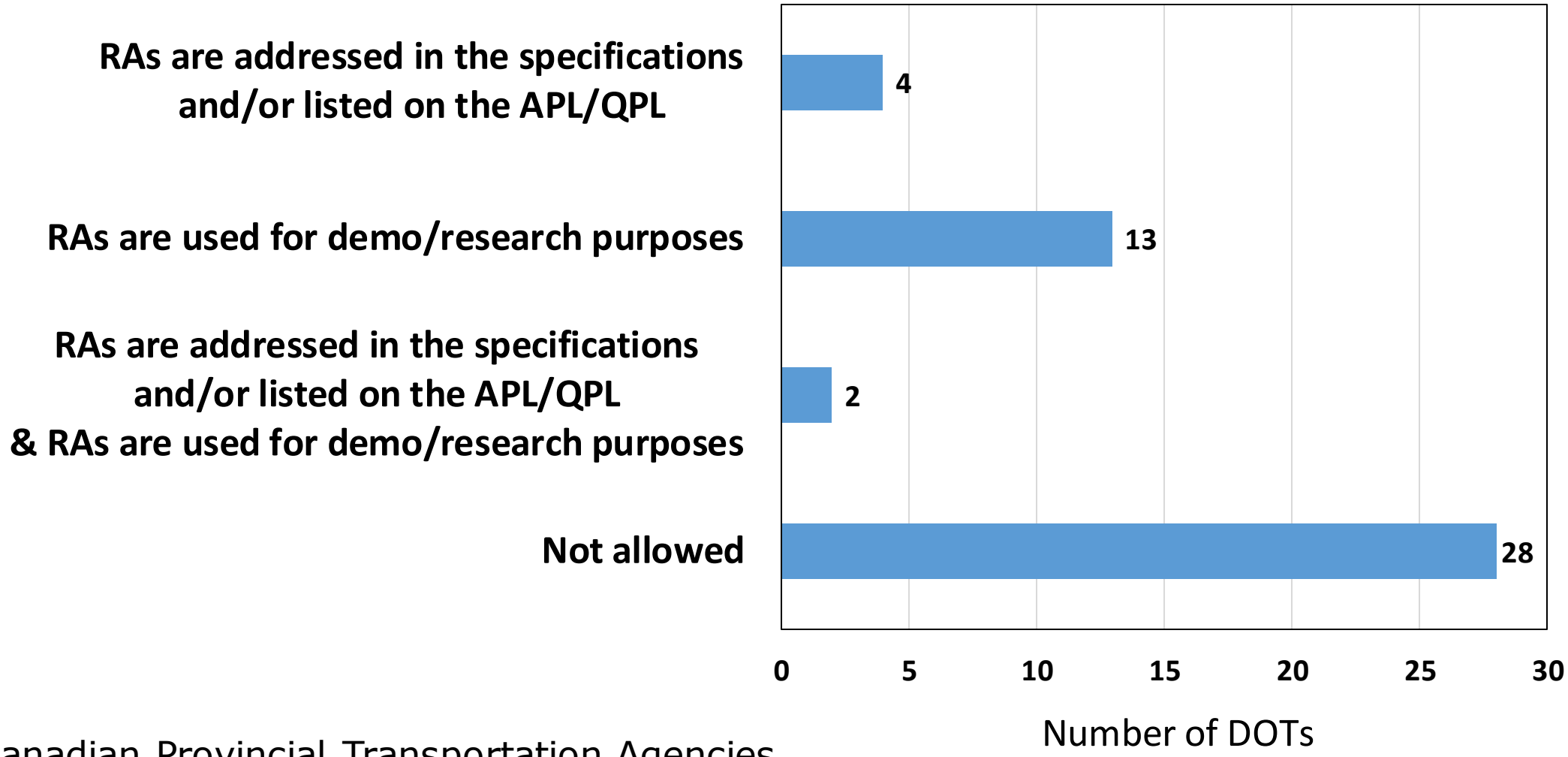


Use of RAP only

Use of RAP and RAS



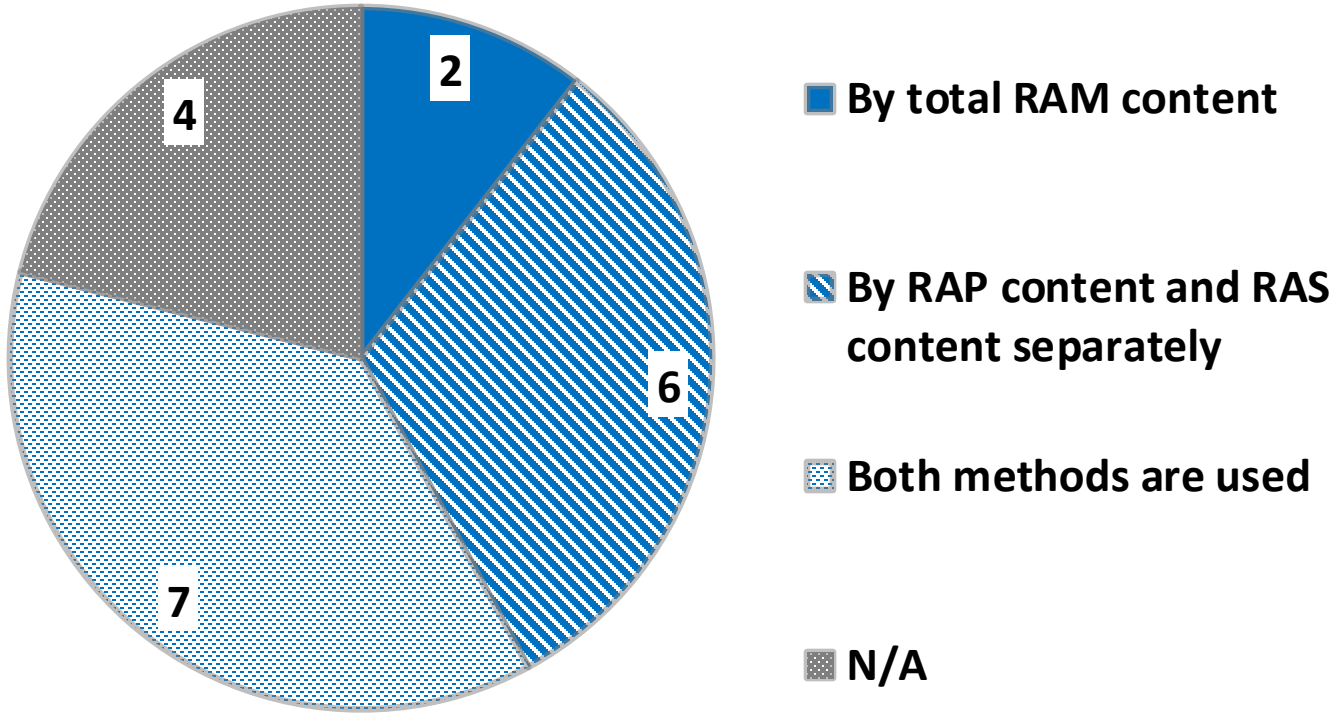
Usage of RAs



2 Canadian Provincial Transportation Agencies allow RAs through specification or APL/QPL

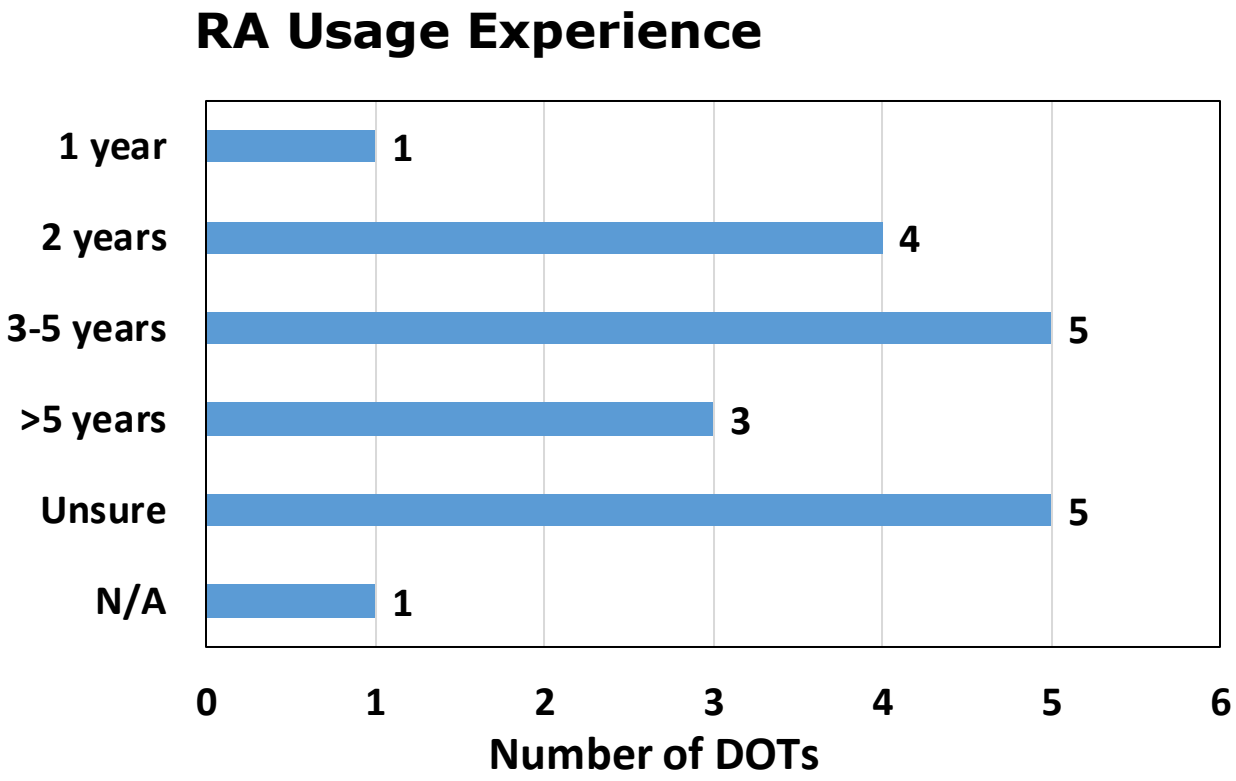
RAM Content Allowance by Agencies Using RAs

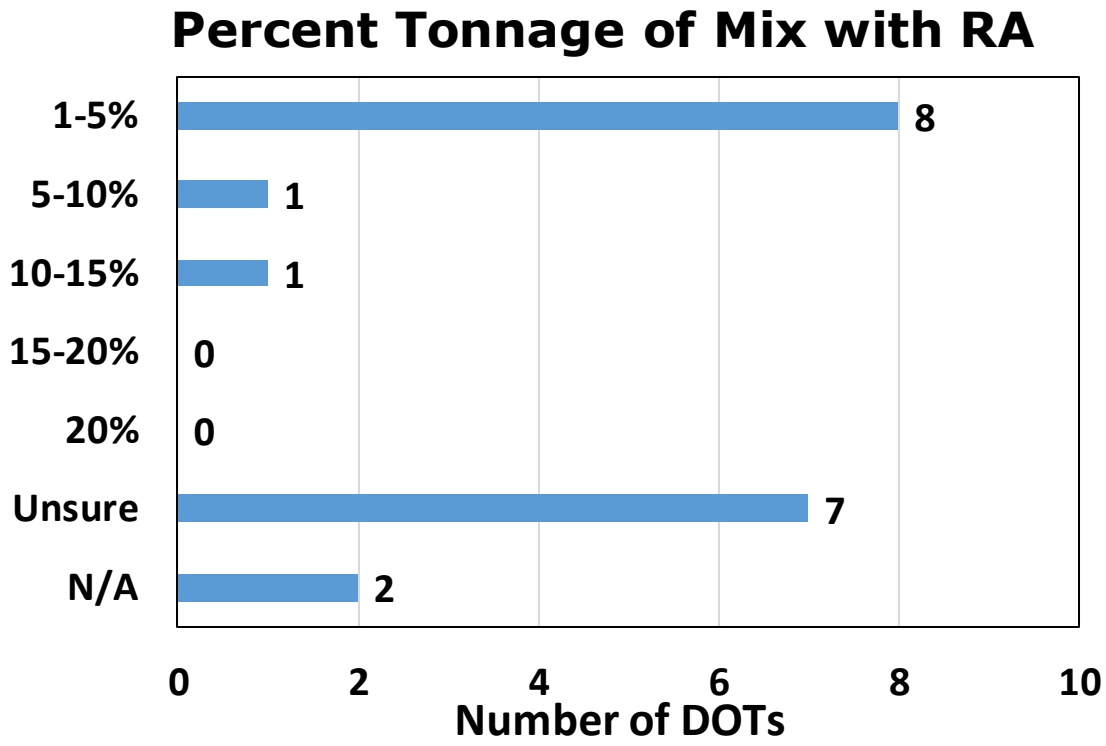
- Distribution of how agencies that allows RA specify the recycled asphalt content



- Typical and maximum RAM contents to be 0.2-0.3 recycled binder ratios (RBR) for most agencies

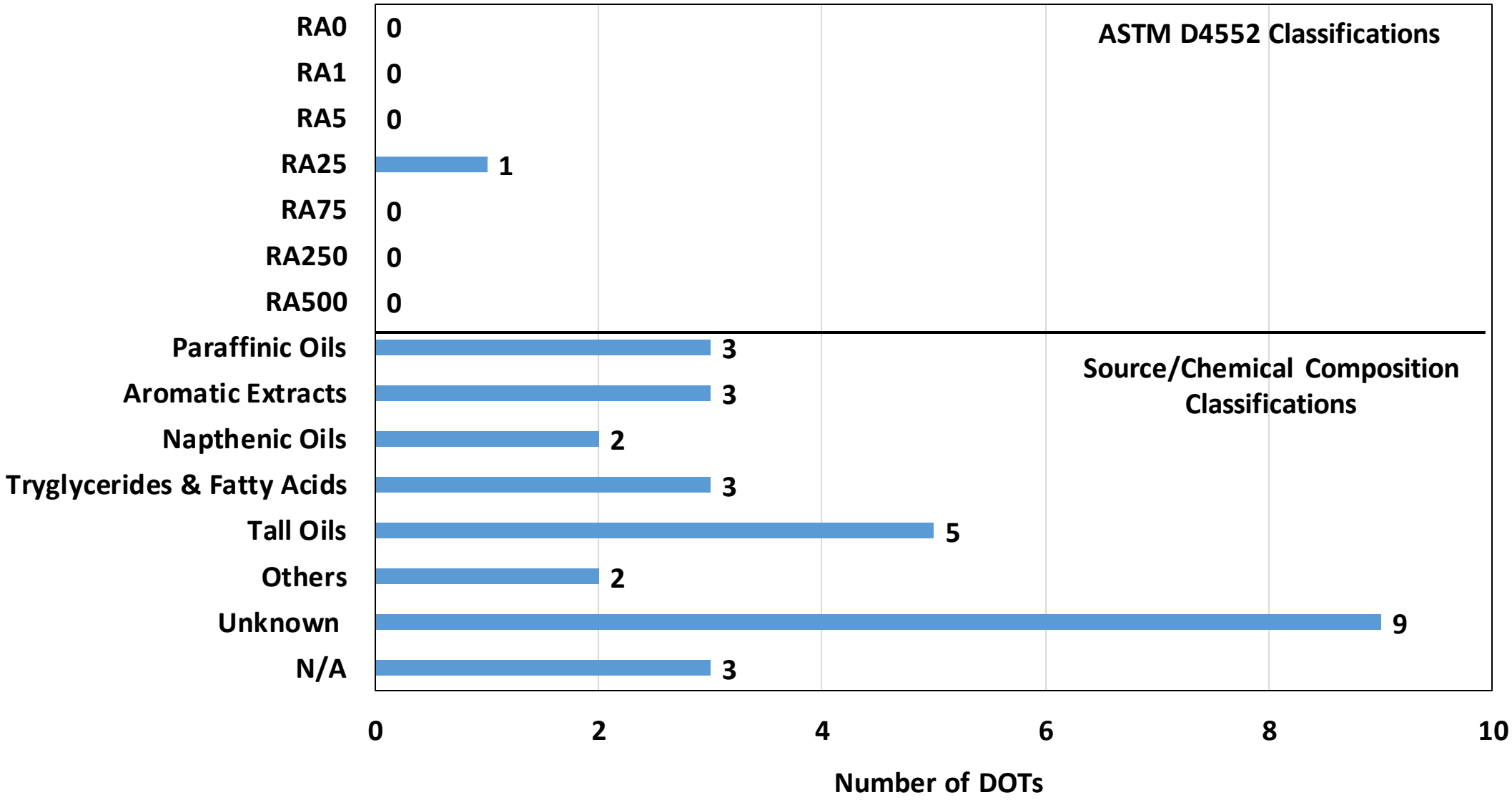
Number Years of RA Usage Experience and Percent of Asphalt Mixtures Treated with RAs



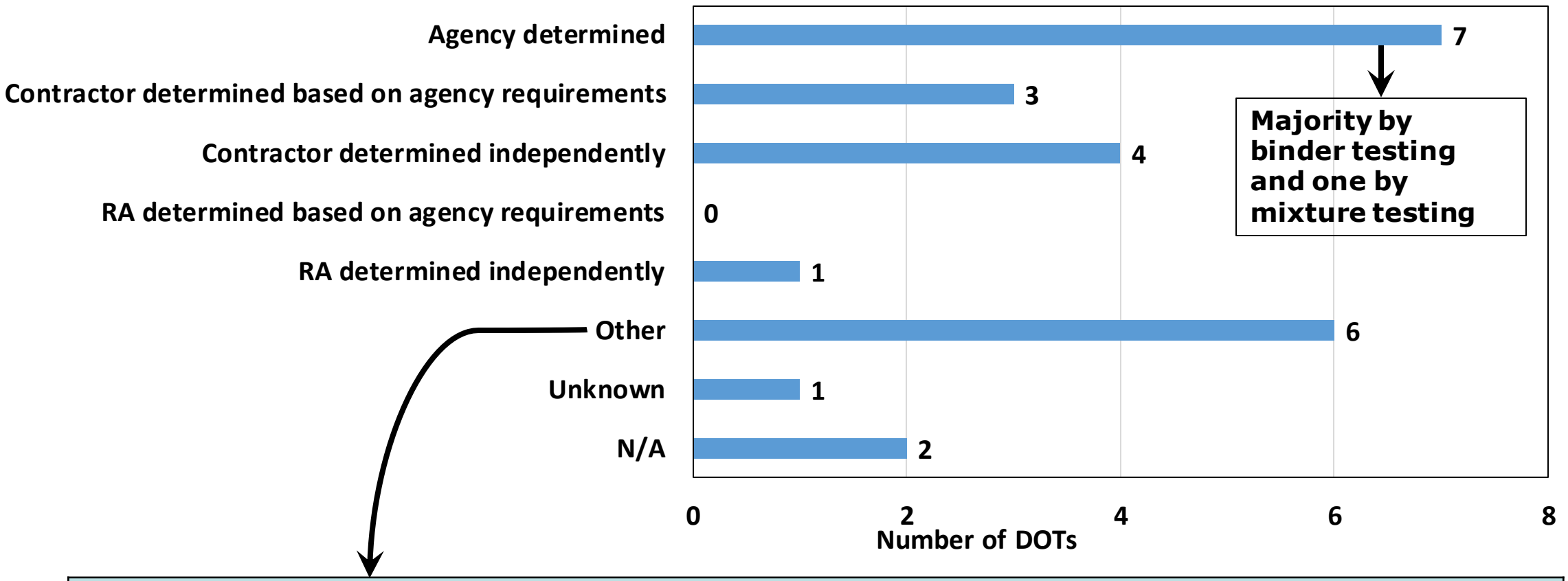


Survey dates: Dec 2020 – Feb 2021

Type of RA Usage by Agencies

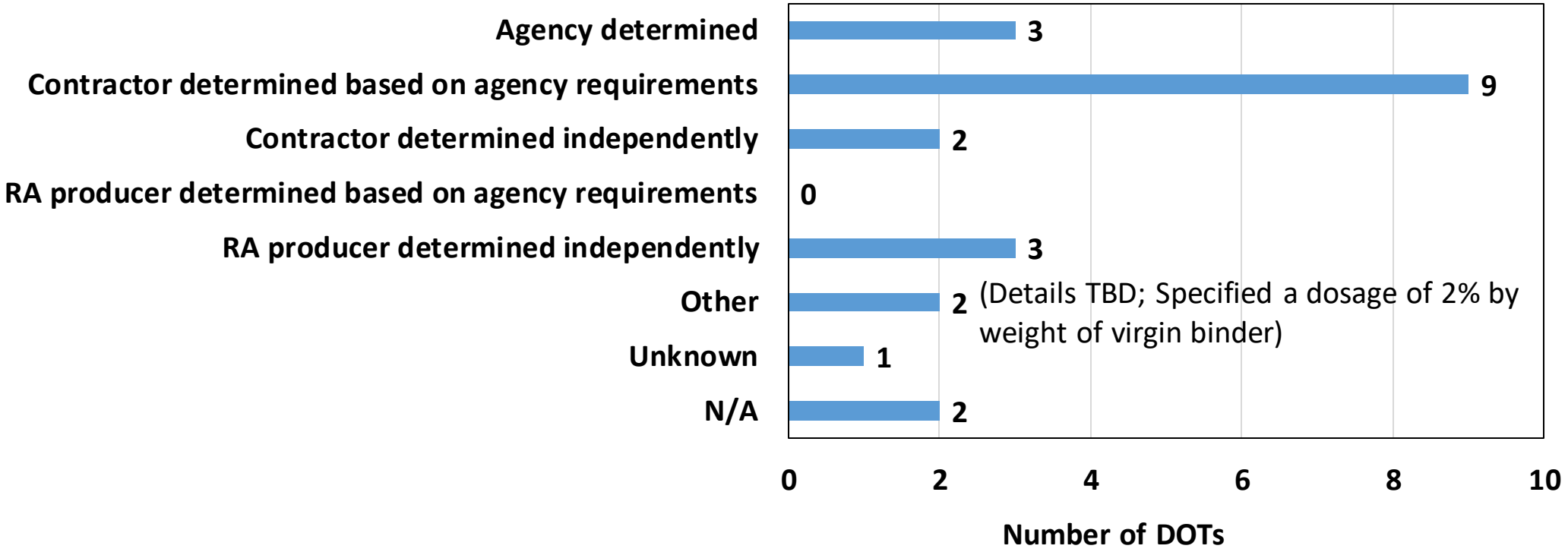


RA Type Selection



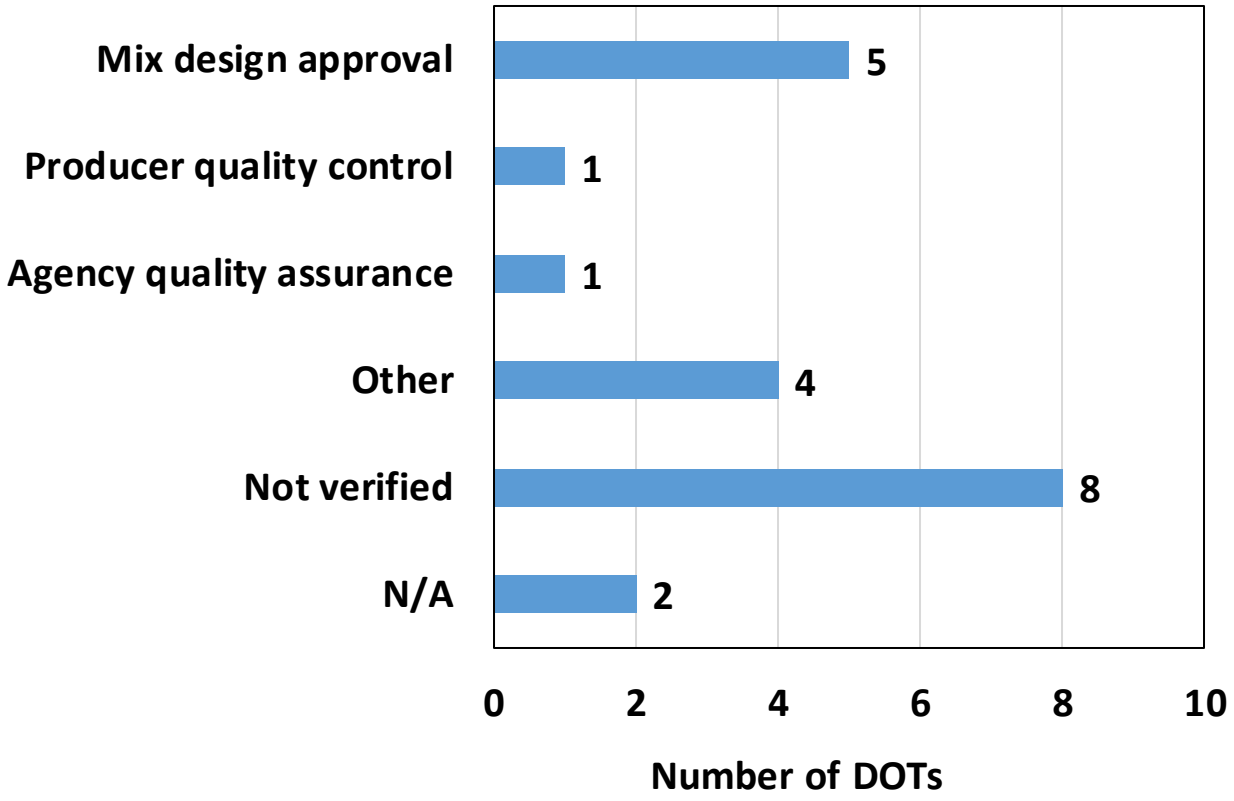
Contractor submits product information with mix design for approval
Based on the scenarios for current modifiers
Determined partially by the university research team
Contractors get approved after selecting a product
Determined by contractor and asphalt supplier
Haven't determined details

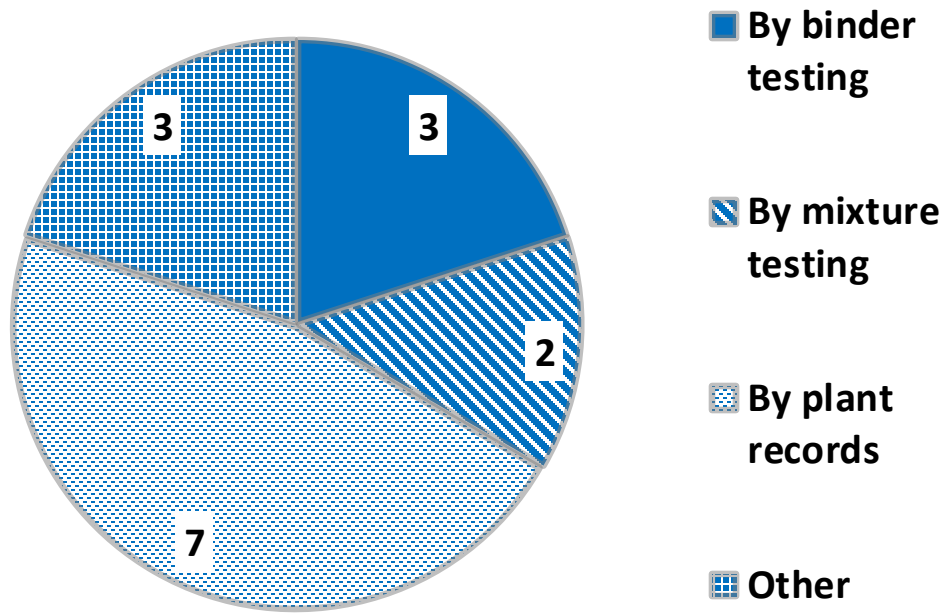
RA Dosage Selection



Reported Test Methods for RA Type and Dosage Determination	
Superpave PG Grading	AASHTO M 332
Multiple Stress Creep Recovery (MSCR) Test	AASHTO T 350
Hamburg Wheel Tracking Test (HWTT)	AASHTO T 324
Semi-Circular Bend (SCB) Test	LADOTD TR 330-14
Cracking Tolerance Index (CT-Index)	ASTM D8225

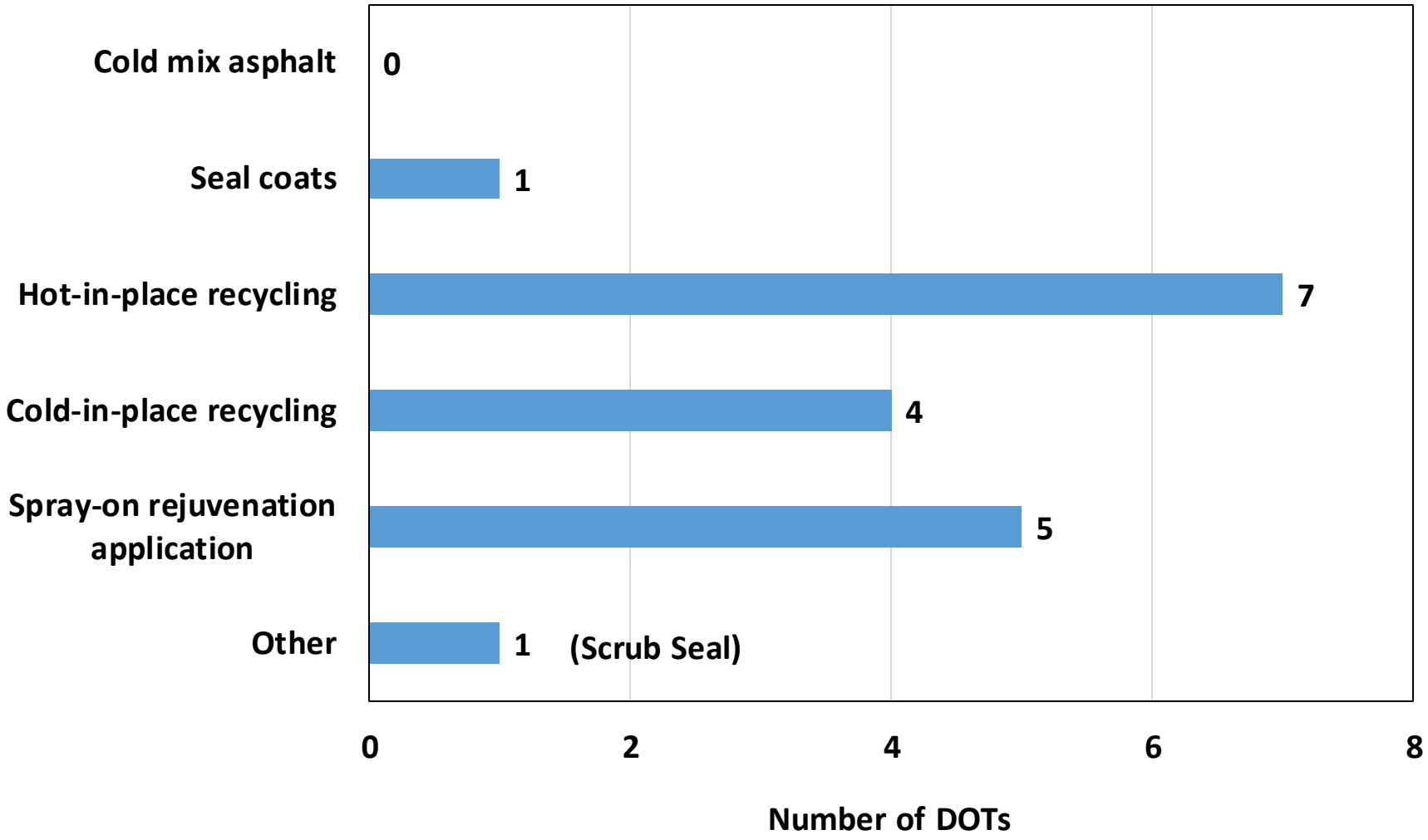
Verification of RA Dosage: When and How



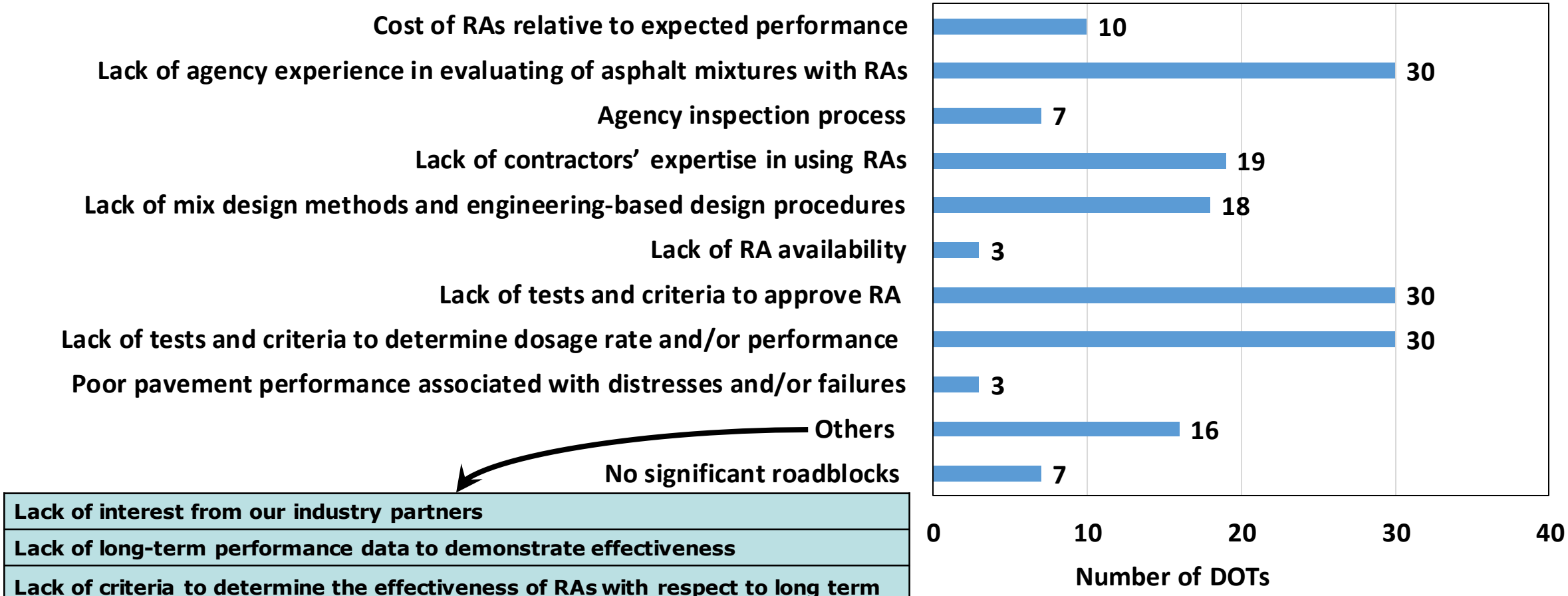


14/17 agencies indicated no changes to QA process when RAs are used, 3 indicated that they are unsure about QA process changes

Other Applications of RAs



Knowledge Gaps and Roadblocks to Use of RAs



Lack of interest from our industry partners
Lack of long-term performance data to demonstrate effectiveness
Lack of criteria to determine the effectiveness of RAs with respect to long term performance
Lack of ideas/thoughts to initiate the use of RAs
Lack of long-term life cycle cost analysis of mixtures with RAs.
The time it takes to perform additional testing when RAs are used
Need specs in place to show how to determine dosage
Lack of consistency in RAM in general

State of the Practice Survey Summary

- RA usage still limited to less than half of the state agencies (as of spring 2021)
- Majority of agencies still evaluating RAs on research basis; however, few have well developed APL/QPL criteria
- For agencies that allow RA usage:
  - Selection of RA type varies (agency selection versus contractor)
  - Majority have procedures for RA dosage
  - Dosage verification process varies
- Lack of agency experience with RAs, tests and criteria for RA approval and for dosage are biggest roadblocks to use of RAs

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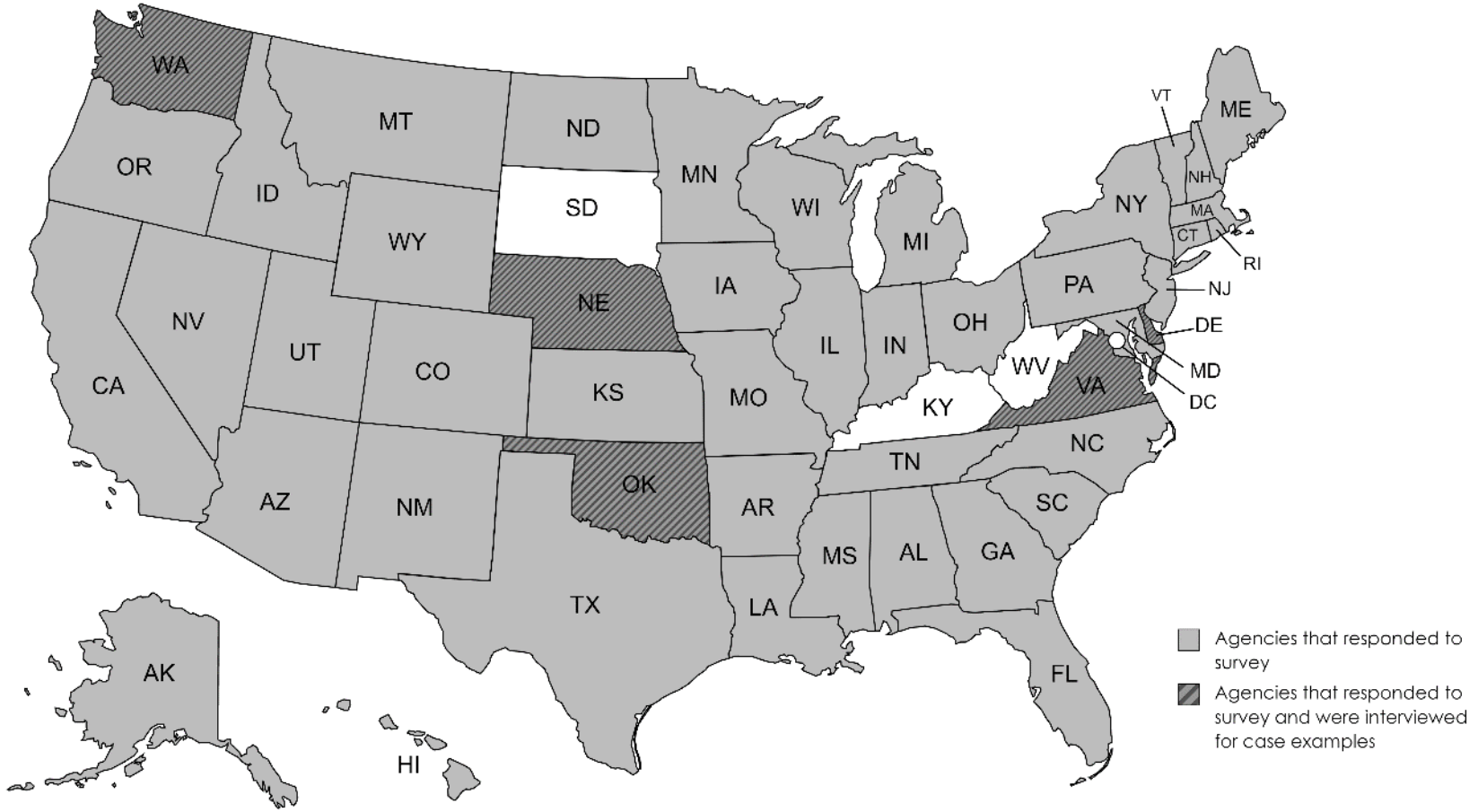
Case Examples

- Interviews conducted in spring of 2021
- 5 agencies
  - Delaware
  - Nebraska
  - Oklahoma
  - Virginia
  - Washington



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Case Example: Delaware DOT

- RAS and RAP content specified separately
  - Amount depends on traffic volume and PG binder
  - In-house "RAP Calculator" based on blending charts
- One RA product has been used by one contractor in test sections with RBR above 0.3
  - Improvements to lab measured properties, good field performance to date, dosage and type determined by contractor
- CT-Index, Texas OT, APA testing in lab
- STA: 2hrs compaction temp; LTA: 8-12hr at 95˚C
- Four test sections in NCHRP 20-44 (24) Study
- Considering requiring RA in high RBR mixtures

Case Example: Nebraska DOT

- Only allow use of RAP, require PGLT of -34 and WMA
- RA use in research and demonstration projects only
- Developed RA classification system based on source/chemical composition
- Binder and mixture testing in lab
  - DSR, BBR, FTIR, AFM, SARA
  - SCB, Flow Number
- STA: 2-4 hrs compaction temp; LTA: up to 6xPAV evaluated, considering using 2xPAV standard
- No premature failures or concerns to date

Nebraska RA Classification System

Negligible Impact	Large Impact
Moderate Impact	Cautionary
	Advisory

Types			Characterization													
			Effectiveness								Cautionary		Advisory			
			Benefits								Limitations		Potentially Necessary Modifications and Enhancements			
Classification	Category	Description	Lowers Low Temperature Grade	Lowers High Temperature Grade	Effects Rut Resistance	Improves Low Temperature Crack Resistance (standard aging)	Improves Low Temperature Crack Resistance (extended aging)	Improves Mid Temperature Crack Resistance	Colloidal Index Improvement	Typical Dosage Rates	Moisture Damage Susceptibility	Degradation from Extended Aging	Anti-stripping to Improve Moisture Damage Resistance	Antioxidants for Extended Aging and Oxidation Damage Resistance	Comments	
Class III	Napthenic Oils	Engineered hydrocarbons for asphalt modification, generally moderate aromatic content and a low paraffin (wax) content								12-18%					Compatibility testing is recommended	
Class IV	Triglycerides & Fatty Acids	Derived from vegetable and plant oils. It contains other chemical elements in addition to triglycerides and fatty acids (e.g., soybean oil, corn oil, cotton seed oil, palm oil)								3-10%					Formulations need to provide moisture damage resistance	

Case Example: Oklahoma DOT

- Only RAP allowed
  - Non-surface mixtures only
  - Amount depends on PG binder
- RA use in demonstration projects only
  - Type and dosage determined by contractor/producer to meet specified PG
- CT-Index, HWTT, Cantabro testing in lab, preliminary thresholds have been established for BMD
- STA: 2hrs compaction temp: LTA: 2xPAV and 3xPAV for info only
- No premature distress observed to date

Case Example: Virginia DOT

- RAP and RAS specified separately
  - Amount depends on mix location in structure and PG binder
- RAs in demonstration and research projects only
  - Three types of RAs have been used
  - RA type and dosage determined by contractor for BMD requirements
- CT-Index, APA, Cantabro lab testing: thresholds established
- STA: 2-4 hrs compaction temp; LTA: 8hrs at 135˚C
- No premature distress observed

Case Example: Washington State DOT

- RAP and RAS content specified separately
  - Sequestered stockpiles for RAS and RAP > 0.2
- Two RA products have been used
  - Blended binders must meet superpave PG requirements
  - Generally pre-blended at terminal, dosage determined by contractor/supplier
- DSR, BBR, MSCR for binders; IDT strength and HWTT mixtures
- STA: 4hrs at 135C; LTA: 2xPAV, 95˚C and 135˚C on mix for info only
- Premature distress in HIR/CIR applications, no issues observed in HMA applications

Summary from Case Examples

- Wide range of RAM contents allowed
- Various RA products have been used for research and demonstration projects
- Variety of guidance in terms of RAM limits, testing, dosage determination
- Binder and/or mixture testing used for evaluation
- Lack of experience in evaluating RAs and lack of appropriate tests and criteria are primary roadblocks

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Key Takeaways

- Use of RAM widespread, RAs relatively new for most
- Most (60%) agencies do not allow use of RAs on routine basis
- Performance of RAs affected by type, dosage, dispersion/diffusion into RAM
- Blending charts most commonly used to determine dosage
- No or minimal changes to QA processes with RAs
- Wide range of binder and mixture tests used to evaluate properties and performance
- Loss of effectiveness over time is primary concern, but less evaluation of LTA has been conducted
- LCA/LCCA generally has not been conducted

Primary Challenges

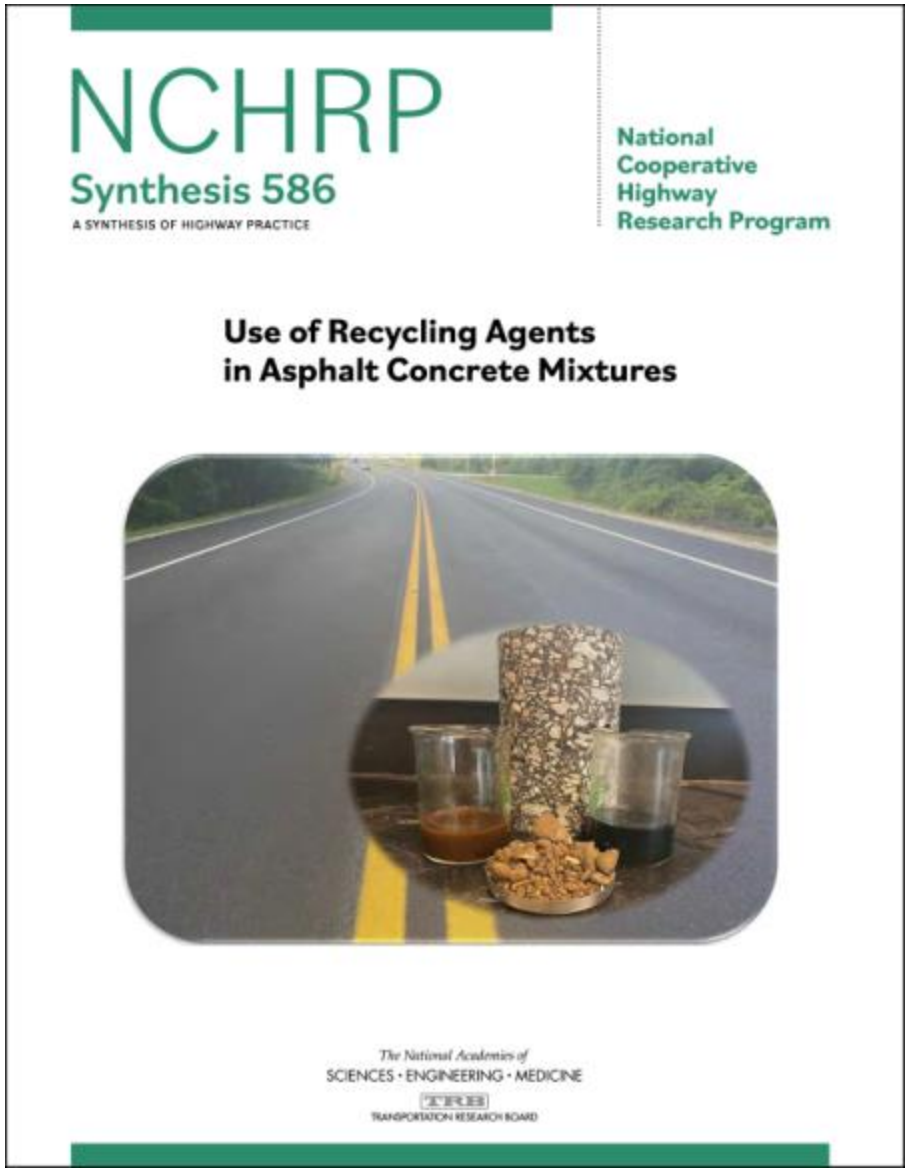
- Lack of agency experience in evaluating asphalt mixtures with RAs
- Lack of tests and criteria to approve RAs
- Lack of tests and criteria to determine dosage rate and/or performance

Knowledge Gaps and Future Needs

- Appropriate aging conditioning protocols – existing approaches need to be evaluated for applicability to RAs
- Need to evaluate long term effectiveness
- Validation via field performance over time
- Standard method of classification based on chemical composition needed
- Role of binder activation and diffusion
- Challenges with binder testing – extraction and recovery of blends and impact of solvents
- Quantify sustainability measures of RA materials via LCA/LCCA

Acknowledgements

- NCHRP Synthesis 586: Use of Recycling Agents in Asphalt Concrete Mixtures
- DOI: 10.17226/26601
- Project 20-05 Topic 52-17
- Thank you:
  - Ms. Jo Allen Gause
  - Project Panel



Questions

Moderated by

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Today's presenters

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Upcoming events for you

March 16

TRB Webinar: The Jury is Still Out—The Latest on Recycled Plastic Waste in Asphalt

April 19

TRB Webinar: Guide Specifications—Constructing Slurry Seals, Scrub Seals, and Tack Coats

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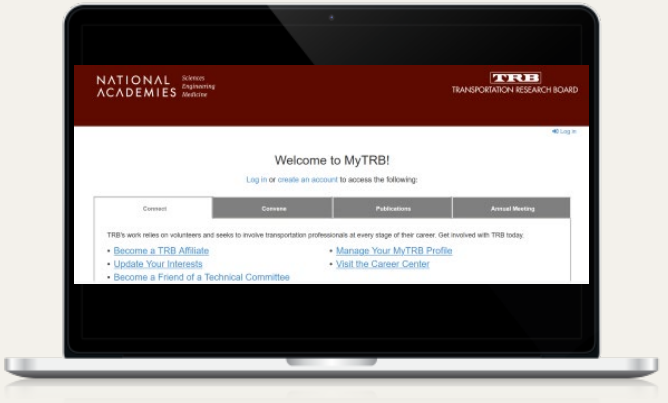

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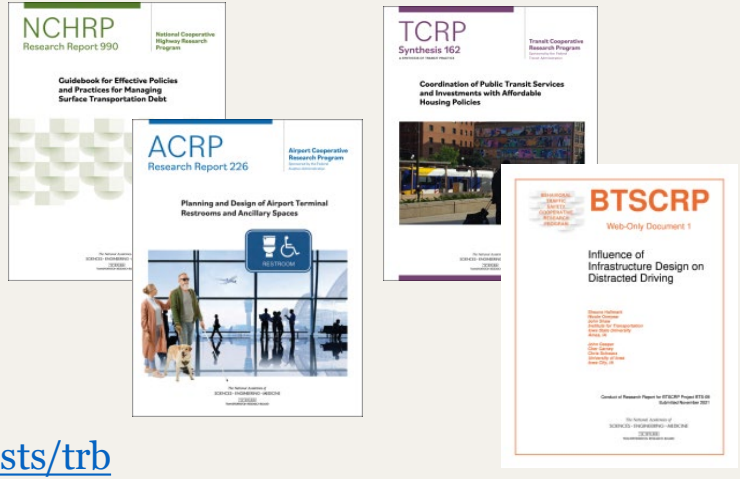

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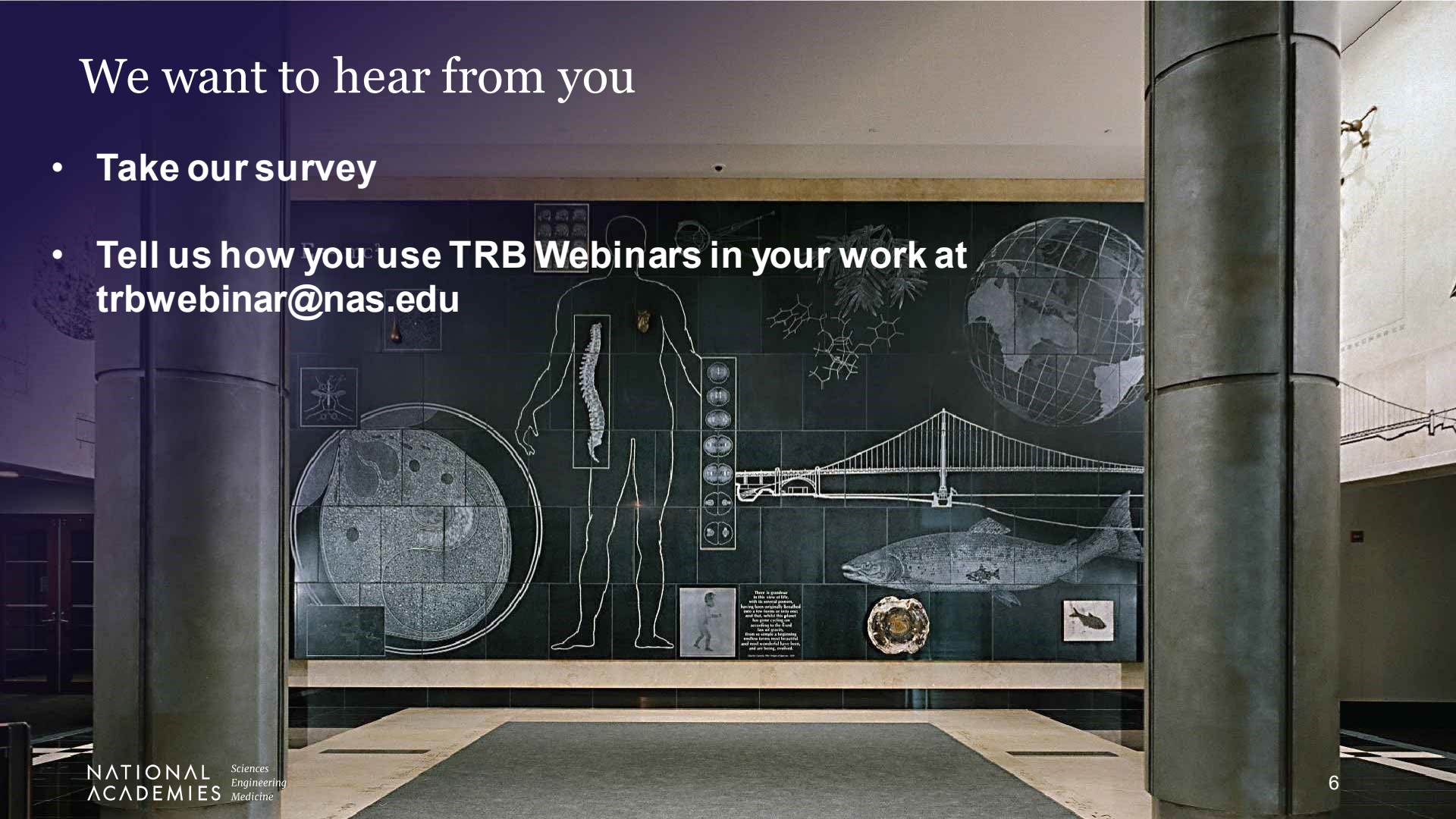

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