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Asphalt Construction Program

Asphalt Plant Technician Certification
An Update/Refresher Course
for
Asphalt Plant Certification

February 10, 2022

Presented by

Northeast Center of Excellence for Pavement Technology

NECEPT

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Website: www.superpave.psu.edu

Email: superpave@psu.edu

Covers PENNDOT Certification Program

Click on Training to Access Course Information:

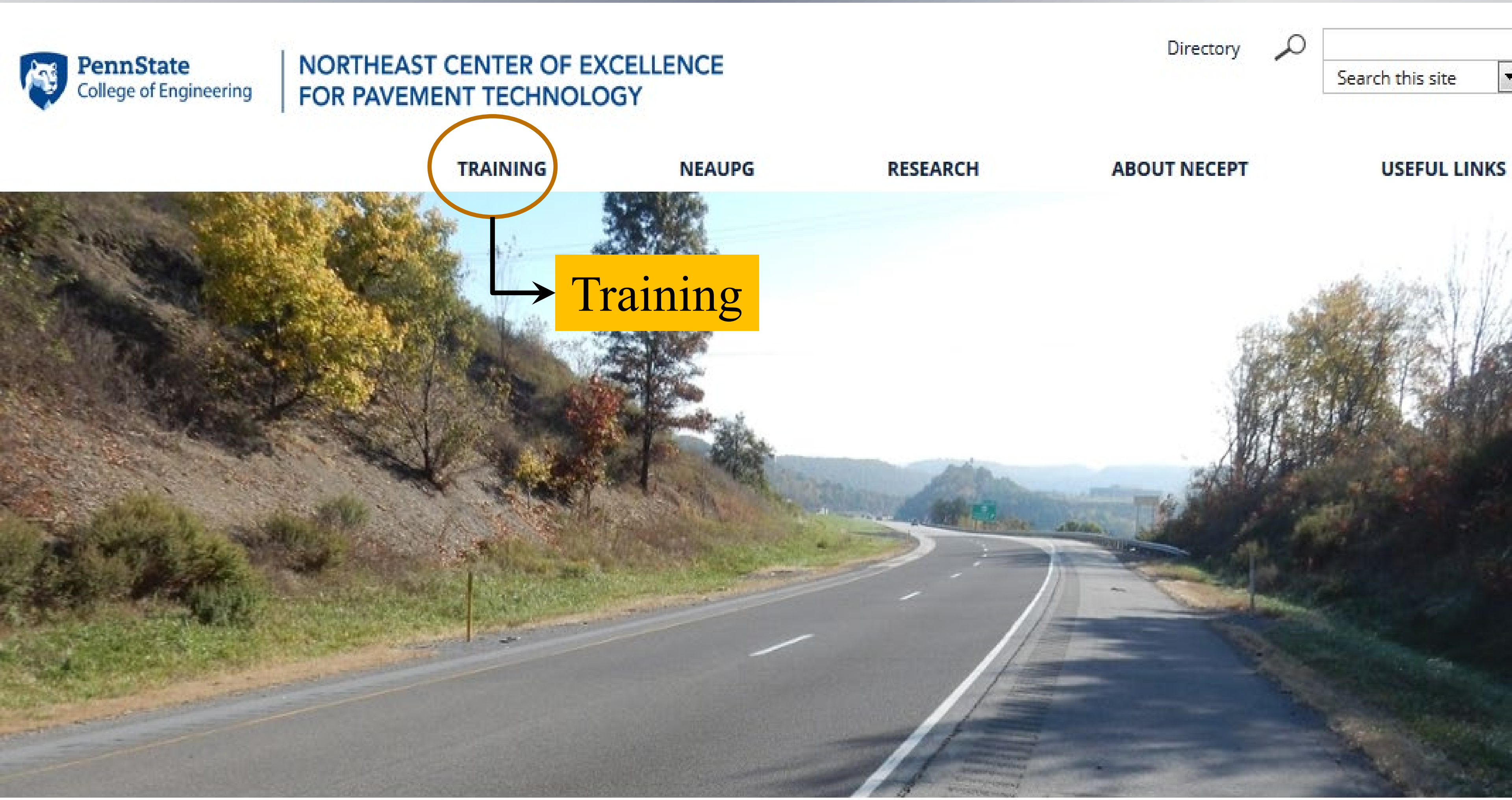
Courses, Registration, Schedule & Agenda, Pub 351, FAQ

PennState College of Engineering | NORTHEAST CENTER OF EXCELLENCE FOR PAVEMENT TECHNOLOGY

Program Assistant

(814-863-1293)

On-Line Registration



Introductory Topics

- Housekeeping Items
- Certification Categories
- Certification Requirements
- On-Line Registration
- Course Objective
- Course Agenda
- Acronyms

Housekeeping

1. Attendance and Participation
2. Course Schedule and Breaks
3. Quiz at the end of each Module
4. Access to Course Material

1. Attendance and Participation

- Attendance in the course through Zoom is <u>required.</u>
- Participants' webcams will be off.
- Participants' microphones will be off.
- Have your speakers ON.
- Questions can be asked through Zoom.

2. Course Schedule and Breaks

- Finish by 4:30 P.M.?
- Short 5-to-10 Minute Breaks at the End of each Module (after quiz)

3. Quiz at the end of each module

- Short Quiz – Self Graded
- 5 to 10 Questions
- 5 to 7 minutes
- REQUIRED:
  - Must answer **85** percent of questions
  - Not graded for correct or wrong answers

NOTE: At the end of the module, take the quiz first before taking a break.
The quiz time is limited and will not be reopened.

4. Access to Course Material

Course Material:

is available at the NECEPT Website.

some of the modules will be added after the course.

Go to **www.superpave.psu.edu**

Look under “Training”

Certification Categories

- Asphalt Field Technician
- Asphalt Plant Technician Level I
- Asphalt Plant Technician Level II
- Concrete Field Testing Technician
- Aggregate Technician
- PG Asphalt Binder Technician
  - (Binder Course is through NETTCP)

Certification Publications

- Asphalt: PennDOT Pub 351

- Concrete: PennDOT Pub 536

- Aggregate: PennDOT Pub 725

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Certification Requirements

Covered in Publication 351

BITUMINOUS OR ASPHALT TECHNICIAN CERTIFICATION PROGRAM

BITUMINOUS OR ASPHALT PLANT AND FIELD TECHNICIANS

Initial Certification Requirements
Certification Renewal Requirements
Registration Procedures
Performance Review and Code of Ethics
Course Administration

November 2018 Edition

pennsylvania
DEPARTMENT OF TR... PUB 351 (11-18)
www.penndot.gov

PUB 351 (10-16)

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PennDOT Publication 351

- Publication 351 Covers
  - Requirements for Initial Certification
  - Requirements for Recertification
  - Application Procedure
  - Exam Review & Retests
  - Code of Ethics
  - Covers both plant and field tech certification
- Certification Program developed to satisfy requirements of Code of Federal Regulations, 23 CFR, Part 637, QA Procedures for Construction

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PennDOT Publication 351
Code of Ethics

- 1. Beneficence/Autonomy: demonstrate concern for the welfare and dignity of the recipients of the services, including Department personnel.
- 2. Competence: maintain high standards of professional competence
- 3. Public Information: provide accurate information about Asphalt technician services
- 4. Professional Relationships: function with discretion and integrity in relation with colleagues and other professionals.

Renewal/Recertification Asphalt Level I Plant Technician

Pub 351: Section XII (**Option A)**

- Must have been Level I certified for previous 5 years
- Must have **500 documented hours experience** in asphalt lab or plant performing QC/QA testing or inspection since date of last certification
- Must have **sign-off from supervisor** or from a Level II Tech in company.
- Must have **sign-off from PennDOT** DME/DMM Within the previous 5 years, must have attended :
  - Two NECEPT Plant Technician Update/Refresher Courses, or….
  - One NECEPT Update/Refresher Course and one acceptable asphalt-related conference, seminar, or workshop

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Renewal/Recertification
Asphalt Level II Plant Technician

Pub 351: Section XIII (Option A)

- Must have been Level II certified for previous 5 years
- Must have **500 documented hours experience** in asphalt lab or plant performing QC/QA testing or inspection since date of last certification
- Must have **sign-off from supervisor** or from a Level II Tech in company.
- Must have **sign-off from PennDOT** DME/DMM Within the previous 5 years, must have attended :
  - Two NECEPT Plant Technician Update/Refresher Courses, or….
  - One NECEPT Update/Refresher Course and one acceptable asphalt-related conference, seminar, or workshop

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Accepted Asphalt-Related Annual Conferences, Seminars, and Workshops

- Annual APC Conferences
- Annual PAPA Conference
- Annual PAPA Regional Technical Meetings
- Annual Asphalt Pavement Conference from any MARTCP states
- Mid-Atlantic States QAW
- Nationally Recognized Conferences or Courses (NAPA, NCAT, NEAUPG, …)
- PennDOT pre-approved Department or Industry sponsored training

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Accepted Asphalt-Related Annual Conferences, Seminars, and Workshops

Abbreviations for Terms

- APC: Associated Pennsylvania Contractors
- PAPA: Pennsylvania Asphalt Pavement Association
- MARTCP: Mid-Atlantic Reciprocity Certification Program states
- QAW: Quality Assurance Workshop
- NAPA: National Pavement Association
- NCAT: National Center for Asphalt Technology

Course Objectives

This is a course for renewal of certification as an Asphalt Plant Level I or Level II Technician.

The course objectives are

- To review the latest changes in PennDOT Specs
- To discuss latest issues and topics related to asphalt pavement materials, design, and construction

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Plant Technician Certification Renewal
Course Agenda

- 1. Update on PennDOT Specifications
- 2. Update on PennDOT Bulletin 27
- 3. Use of Rejuvenators in Asphalt Mixture
- 4. Segregation in Asphalt Mixtures
- 5. Update on Asphalt Binders and Mixtures Testing/Design
- 6. Performance Based Testing for Asphalt Mixtures
- 7. Use of Crumb Rubber Modifier in Asphalt Mixtures

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ACRONYMS

01. AASHTO: American Association of State Transportation Officials (www.transportation.org)
02. AET: Asphalt Emulsion Tack
03. AI: Asphalt Institute (www.asphaltinstitute.org)
04. ATPBC: Asphalt Treated Permeable Base Course
05. DME/DMM: District Materials Engineer/District Materials Manager
06. ESAL: Equivalent Single Axle Load
07. FHWA: Federal Highway Administration (www.fhwa.dot.gov)
08. HMA: Hot Mix Asphalt
09. JMF: Job Mix Formula
10. LTS: (PennDOT) Laboratory Testing Section

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ACRONYMS

11. MTV: Materials Transfer Vehicle
12. NAPA: National Asphalt Paving Association (www.asphaltpavement.org)
13. NECEPT: Northeast Center of Excellence for Paving Technology (www.superpave.psu.edu)
14. NMAS: Nominal Maximum Aggregate Size
15. OSHA: Occupational Safety and Health Administration (www.osha.gov)
16. PAPA: Pennsylvania Asphalt Pavement Association (www.pahotmix.org)
17. PG: Performance Grade
18. PTM: Pennsylvania Test Method

    (ftp://ftp.dot.state.pa.us/public/pdf/BOCM_MTD_LAB/PUBLICATIONS/PUB_19/PTM_TOC.pdf)
19. QC/QA: Quality Control / Quality Assurance
20. RPS: Restricted Performance Specifications

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ACRONYMS

21. PWL: Percent Within Limits
22. RAM: Reclaimed Aggregate Material
23. RAP: Reclaimed Asphalt Pavement
24. RAS: Recycled Asphalt Shingle
25. SGC: Superpave Gyratory Compactor
26. SRL: Skid Resistance Level
27. SMA: Stone Matrix Asphalt (Stone Mastic Asphalt)
28. TSR: Tensile Strength Ratio
29. VFA: Voids Field with Asphalt
30. VMA: Voids in the Mineral Aggregate
31. WMA: Warm Mix Asphalt

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Plant Technician Certification Program

An Update on

PennDOT Asphalt Specifications

Northeast Center of Excellence for Pavement Technology

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Your Role with PennDOT Specifications

- You must be
  - familiar with specifications that cover your project.
  - be aware of the effective change dates and your project let date.

Powers of Observation

- Do you think this is important for you as a certified plant technician?
- How would you rate yourself on a scale of 1 to 10, with 10 being the best!

FINISHED FILES ARE THE RESULT OF YEARS OF SCIENTIFIC STUDY COMBINED WITH THE EXPERIENCE OF MANY YEARS.

Can you read this?

I cdnuolt blveiee that I cluod aulaclty uesdnatnrd what I was rdanieg. The phaonmneal pweor of the hmuan mnid, aoccdrnig to a rscheearch at Cmabrigde Uinervtisy, it dseno't mtaetr in what oerdr the ltteres in a word are, the olny iproamtnt tihng is that the frsit and last ltteer be in the rghit pclae. The rset can be a taotl mses and you can still raed it whotuit a pboerlm. This is bcuseae the huamn mnid deos not raed ervey lteter by istlef, but the word as a wlohe. Azanmig huh? Yaeh and I awlyas tghuhot slpeling was ipmorantt! If you can raed this forwrad it

R34D 7H15

7H15 M3554G3 53RV35 70 PROV3 7H47 OUR M1ND5 C4N DO 1MPR3551V3 TH1NG5!
1N 7H3 B3G1NN1NG 17 WA5 H4RD. BU7 NOW, ON 7H15 LIN3 YOUR M1ND 15 R34D1NG 4UTOM471C4LLY W17HOU7 3V3N 7H1NK1NG 4BOU7 17. ONLY C3R741N P3OPL3 C4N R34D 7H15!

So,
Are you using your Powers of Observation?

Be observant to all aspects of the products you are working with.

Learn from you mistakes and mistakes of others.

Be knowledgeable of specifications and JMF.

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Publication 408/ Pub 408

Year (Version)	Effective Dates
2000	April 3, 2000 to September 30, 2003
2003	October 1, 2003 to April 1, 2007
2007	April 2, 2007 to March 31, 2011
2011	April 1, 2011 to March 31, 2016
2016	April 1, 2016 to April 2, 2020
2020	April 10, 2020 to October 6, 2023

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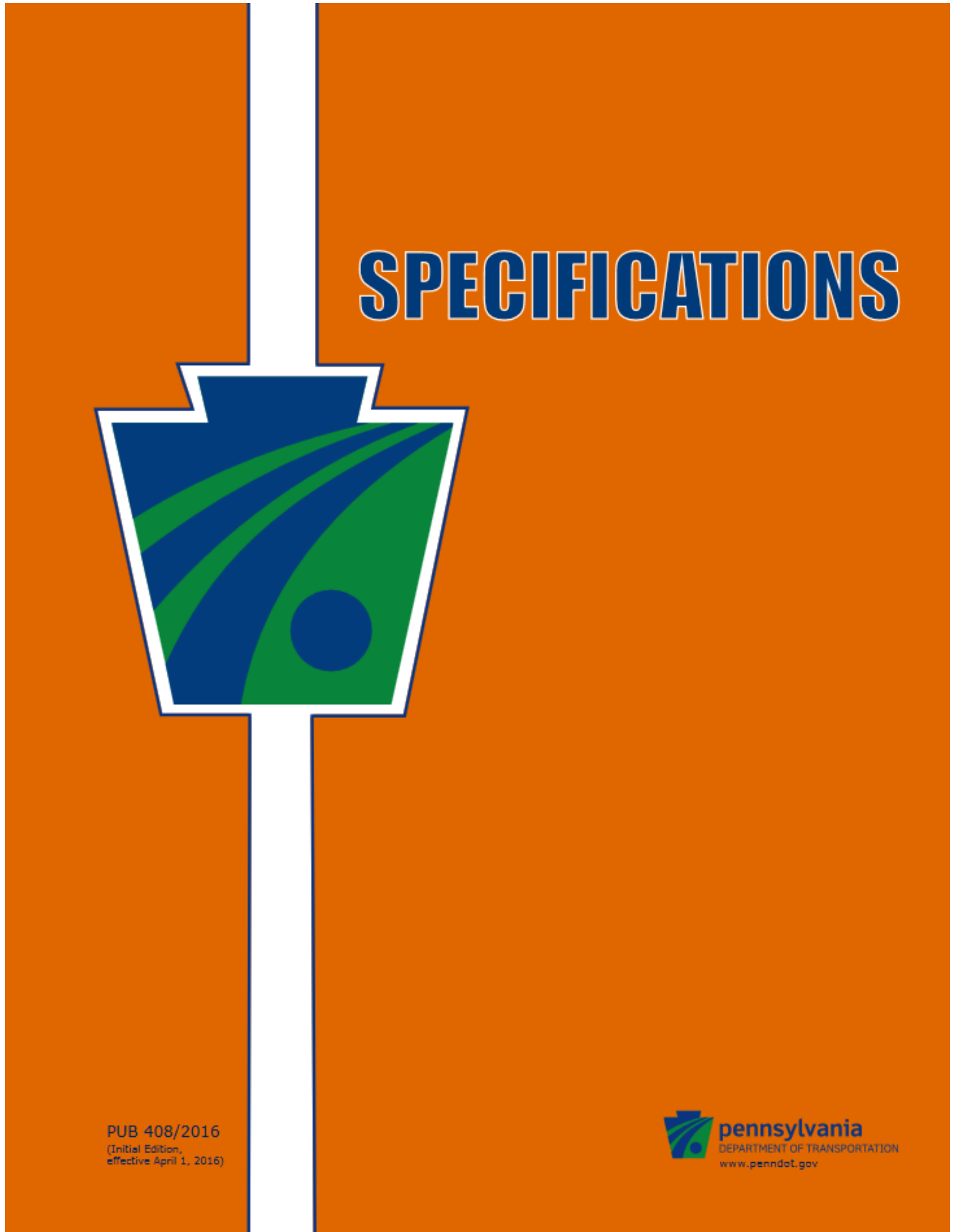
PennDOT Specifications (Publication 408)

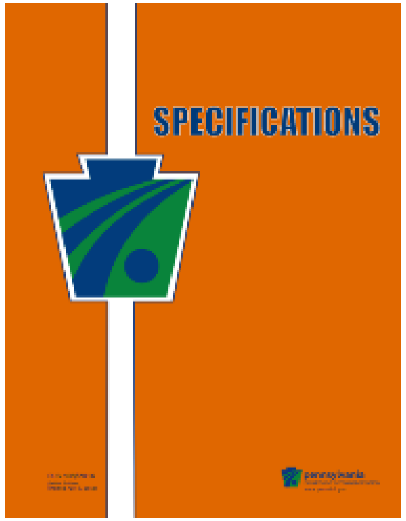
Pub 408/2016

(Effective April 1, 2016)



Publication 408/2016

Version	Effective Date
Initial Edition	**April 1, 2016**
Change No. 1	October 7, 2016
Change No. 2	April 7, 2017
Change No. 3	October 6, 2017
Change No. 4	April 6, 2018
Change No. 5	October 5, 2018
Change No. 6	April 5, 2019
Change No. 7	October 4, 2019



2016

What you need to know...

- **PennDOT Specifications Publication 408**

- **Sections covering Asphalt & the important aspects of these specifications**

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Publication 408/2020

- PennDOT Pub 408/2020 contains Construction Specifications
- Initial Edition, (Effective April 10, 2020)
- For PennDOT Projects Let after April 10, 2020
- PennDOT Website (Initial Edition): http://www.dot.state.pa.us/public/PubsForms/Publications/Pub_408/408_2020/408_2020_IE/408_2020_IE.pdf

PennDOT Specifications (Publication 408)

Pub 408/2020:

Change No. 3

(Effective October 8, 2021)

Go to: https://www.dot.state.pa.us/public/PubsForms/Publications/Pub_408/PUB%20408.pdf

Then, click on 2020 Version

Then, click on Change No. 3

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PennDOT Specifications (Publication 408)

Version	Effective Date
Initial Edition	April 10, 2020
Change No. 1	October 2, 2020
Change No. 2	April 9, 2021
Change No. 3	**October 8, 2021**
Change No. 4	April 1, 2022
Change No. 5	October 7, 2022
Change No. 6	April 14, 2023
Change No. 7	October 6, 2023

2020

Sections
of
Publication 408

Question:

How Many Sections Are There in Spec 408?

Answer:

Twelve

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Contents of Publication 408

- Sections 1 through 12
- Appendix A - Metric (SI) Information
- Appendix B – Standard Special Provisions
  - as set forth in the Bid Proposals
  - need further tailoring for use on specific projects
  - Includes seven indices (C, D, G, I, N, P, S)
- Appendix C – Designated Special Provisions
  - Standard documents previously included in PennDOT Bid Proposals.
- General Index (indexing the Publication)
- Change Letters and Indices

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Sections of Publication 408

- 100 - General Provisions
- 200 - Earthwork
- 300 - Base Courses
- 400 - Flexible Pavements
- 500 – Rigid Pavements
- 600 – Incidental Construction

Sections of Publication 408

- 700 - Materials
- 800 - Roadside Development
- 900 - Traffic Accommodation & Control
- 1000 - Structures
- 1100 - Manufactured Materials
- 1200 - Intelligent Transportation System Devices

Sections of Publication 408

- 100 - General Provisions
  - Abbreviations and definitions
  - Bidding requirements and conditions
  - Award and contract execution
  - Scope and control of work
  - **Control of materials (Section 106)**
  - Measurement of quantities
  - Payment
  - Several others

Sections of Publication 408

- 300 – Base Courses
  - SP Asphalt Mix Design & Construction, Base Course (**Section 313**)
  - Cold Mixes (**Sections 341 and 342**)
  - Asphalt Treated Permeable Base (**Section 360**)

Sections of Publication 408

- 400 – Flexible Pavements
  - SP Asphalt Mix Design & Construction, Plant Mixed Courses with PWL and LTS Testing (**Section 413**)
  - SP Mixture Design & Construction of Plant Mixed 6.3 mm Thin Asphalt Overlay Courses (**Section 412**)
  - SMA (**Section 419**)

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Sections of Publication 408

- 700 – Materials
  - Asphalt Materials (**Section 702**)
  - Aggregates (**Section 703**)

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Are You Following Me?

- PA Rank in the Nation
  - Population: **(5th)**
  - Population Density: **(9th)**
  - Road Miles: **(11th) - 2017 Data (FHWA)**

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Discussion
of
Specification Changes

Publication 408/2016

Version	Effective Date
Initial Edition	**April 1, 2016**
Change No. 1	October 7, 2016
Change No. 2	April 7, 2017
Change No. 3	October 6, 2017
Change No. 4	April 6, 2018
Change No. 5	October 5, 2018
Change No. 6	April 5, 2019
Change No. 7	October 4, 2019

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Relevant Sections Added in Pub 408 Since October 2016

Date	Section	Description
October 2016	420	Pervious Asphalt Pavement System
October 2016	489	Ultra-Thin Bonded Wearing Course
April 2018	412	6.3-mm Thin Asphalt Overlay
April 2020	313	Plant Produced Asphalt Mixes (base course) – Merging 309 and 311
April 2020	413	Plant Produced Asphalt Mixes (wearing and binder courses) – Merging 409 and 411
April 2022	314	Rich Base Courses* (CT: H-21-017)

* **Rich Base Course** will be included in **Change No. 4 of 408 Spec (2020 Edition)** in April 2022

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Relevant Sections Removed from Pub 408 within the Last 5 Years

Date	Section	Description
October 2017	422/430/431/439/440	Removal of FJ & FB mixtures for wearing and binder courses
April 2020	309	SP Asphalt Mixtures, HMA Base Course – Merged into 313.
April 2020	311	SP Asphalt Mixture, Warm Base Course – Merged into 313.
April 2020	320	Aggregate-asphalt Base Course.
April 2020	409	SP Asphalt Mixtures, HMA wearing and binder courses – Merged into 413.
April 2020	411	SP Asphalt Mixtures, WMA wearing and binder courses – Merged into 413.

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Major Asphalt Related Changes in 408 Since April 2017

Date	Section	Description
April 2017	411 (Now 413)	Use of Anti-strip Additive
October 2017	409 (Now 413)	Adding VMA Requirements for 4.75-mm Mixture
October 2017	419	Allowing Use of WMA in SMA
October 2017	460	New Tack with half of AET Water, and inclusion of non-tracking tacks, and revision of application rates.
October 2018	483	Emulsion class changed from CSS-1hPM to CQS-1hPM.
April 2019	409 (Now 413)	Acceptance by Certification can be used for parking lots
April 2019	409 (Now 413)	Change to Weather & Seasonal Limitations

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Major Asphalt Related Changes in 408 Since April 2017 (Continued)

Date	Section	Description
October 2019	**409 (Now 413)**	Minimum compacted depth changed from 1 ½" to 2" for 12.5-mm mix (to obtain cores for measuring and accepting density for standard specification)
October 2019	**409 (Now 413)**	Change of material for painting existing vertical surfaces
October 2020	**405**	Removing reference to "Correction Action" related to Longitudinal Joint Density
April 2021	**419**	Allow use of HOLA with SMA Mixtures
October 2021	**413**	Clarification on how to use Form TR-447 for entering Gmm for the Joint core.
October 2021	**341 and 342**	Use of Foamed Asphalt in addition to Emulsion in Cold Mixes
October 2021	**413**	Fixing sublot size once established

Other Major Asphalt Related Changes PennDOT Publications Since April 2017

Effective Date	Publication #	CT # or SSP	Comments
12/21/2020	**2 (POM)**	H-20-065	Report delivered material using Electronic Ticketing System
4/1/2021	**2 (POM)**	C-20-002	Check temperature from truck bed holes
October 2019	**13M**		Safety Edge
October 2020	**72M: RC-25M**		Safety Edge Drawings
Not Established yet		H-20-053	Virtual Asphalt Acceptance Testing (VAAT)
2/12/2021	**408/413**	c04132	LLAP Hamburg Tracking and Cracking Tolerances
Next Updated Version	**2 (POM)**	C-21-003	% Pavement for Defective Asphalt Pavement

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Other Asphalt Related
Standard Special Provisions

Effective Date	Publication #	CT # or SSP	Comments
4/10/2020	SSP	a10650	Min. Effective Asphalt for 9.5-mm or 12.5 mixtures
4/10/2020	SSP	Item 4413-0010	Mixture Design for Binder Course (Leveling) – Low Traffic, High RAP
4/10/2020	SSP	c10000	FB-1 and FB-2 for Maintenance Operations, 100% State Funded Projects, <75 trucks per day
4/10/2020	SSP	c10000	Modified FB for Maintenance Operations, 100% State Funded Projects, <75 trucks per day

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Standard Special Provision on Minimum Effective Asphalt Binder

G_{sb}	Superpave Mixes	
	9.5 mm	12.5 mm
2.250 to 2.274	6.2	5.8
2.275 to 2.324	6.1	5.7
2.325 to 2.374	6.0	5.6
2.375 to 2.424	5.9	5.5
2.425 to 2.474	5.8	5.4
2.475 to 2.524	5.7	5.3
2.525 to 2.574	5.6	5.2
2.575 to 2.624	5.5	5.1
2.625 to 2.674	5.4	5.0
2.675 to 2.724	5.3	4.9
2.725 to 2.774	5.2	4.8
2.775 to 2.824	5.1	4.7

Sections of Publication 408 Containing Asphalt Specifications (2020, Chg. 3)

106	Controls of Material Statistics
313	SP Asphalt Mixture Design & Construction of Base Courses
316	Flexible Base Replacement
341	Cold Recycled Asphalt Base Course (In-Place)
342	Cold Recycled Asphalt Base Course (Central Plant)
344	Full Depth Reclamation
360	Asphalt Treated Permeable Base

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Sections of Publication 408
Removal of Some Sections related to Base Courses

320	Aggregate Bituminous Base Course – REMOVED from SPEC
321	Aggregate-Cement Base Course– REMOVED from SPEC
322	Aggregate-Line Pozzolan Base Course– REMOVED from SPEC

Sections of Publication 408 Containing Asphalt Specifications (2020, Chg. 3)

404	Evaluation and Payment of Asphalt Pavement Ride Quality Incentive
405	Evaluation of Asphalt Pavement Longitudinal Joint Density, Payment of Incentive/Disincentive
410	SP. Mix Design, Stand. and RPS Construction of Plant-Mixed Asphalt Fine Graded Courses
412	6.3-mm thin asphalt overlays
413	Superpave Asphalt Mixture Design, Construction of Plant-Mixed Courses with PWL and LTS Testing

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Sections of Publication 408 Containing Asphalt Specifications (2020, Chg. 3)

419	SMA Design & RPS Construction of Wearing Course
420	Pervious Asphalt Pavement System
460	Asphalt Tack Coat
470	Asphalt Seal Coat
471	Asphalt Seal Coat using Precoated Aggregate
480	Asphalt Surface Treatment

Section 420 Q: Is RAP allowed in Pervious Asphalt Pavement? **Yes, up to 10%**

Section 460 Q: What is asphalt residue range for tack coat? **0.03 to 0.07 gal/yd^2**

Section 471 Q: How much asphalt residual for precoated agg.? **0.6 to 1.2% by weight of mix**

Section 480 Q: How is surface treatment different from seal coat? **It is 2 layers of seal coat.**

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Sections of Publication Containing Asphalt Specifications (2020, Chg. 3)

481	Asphalt Surface Treatment using Precoated Aggregate
482	Slurry Seal
483	Polymer-Modified Emulsified Asphalt Paving System (Micro Surfacing)
489	Ultra-Thin Bonded Wearing Course
496	Asphalt Concrete Pavement, 60-month Warranty

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Specification 2016

Initial Version and Changes 1 through 7

April 2016 – October 2019

Spec 408/2016- Section 420

Pervious Asphalt Pavement System

Change No. 1 (October 2016)

- Use of Pervious Pavements on Department Projects.
- Allows water to percolate and infiltrate through the pavement and underlying layers.
- Minimizes runoff
- It is a System! Includes different layers, different materials, and drainage outlets

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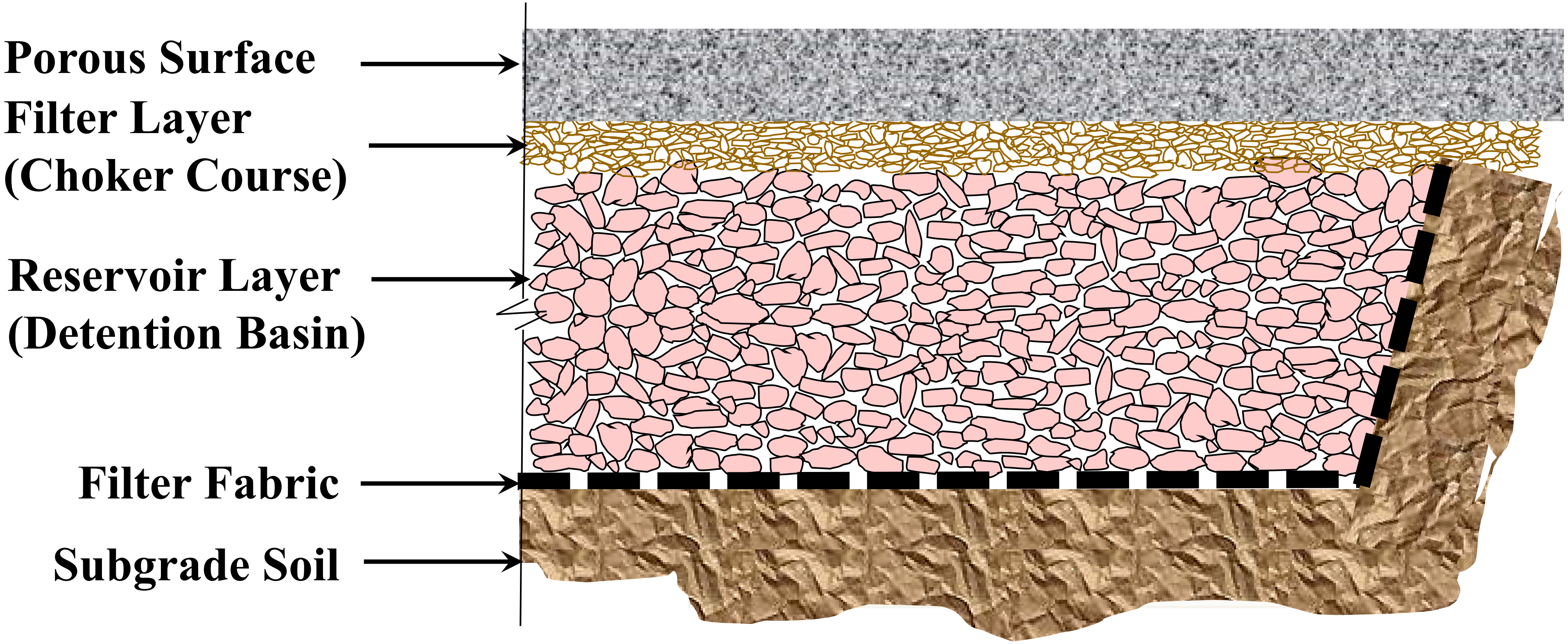
Spec 408/2016- Section 420

Pervious Asphalt Pavement System

Change No. 1 (October 2016)



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Spec 408/2016- Section 420

Pervious Asphalt Pavement System

Change No. 1 (October 2016)

- Materials
  - Type A Aggregate (for use in Asphalt Concrete)
  - AASHTO No. 3 for primary detention coarse aggregate, topped with AASHTO No. 57 as a choker and leveling coarse
  - Type A, Class 4, Geotextile
  - Edge Restraint to resist lateral roller forces

Spec 408/2016- Section 420

Pervious Asphalt Pavement System

Change No. 1 (October 2016)

- asphalt Materials
  - Pervious 9.5 mm wearing course, PG 70-22 or PG 76-22
  - Pervious 19.0 mm Binder course, PG 64-22
  - RAP limited to 10% of the mixture

NOTE the Change in 2020 Edition of Spec:

- Asphalt Binder Material
  - Pervious 9.5 mm wearing course, PG 64H-22 or PG 64E-22
  - Pervious 19.0 mm Binder course, PG 64S-22
  - RAP limited to 10% of the mixture

Spec 408/2020- Section 420

Pervious Asphalt Pavement System

Table B

Mixture Composition		
Gyrations	N_{design}	50
Air Voids	AASHTO D6752	16.0% - 20.0%
	AASHTO T 275	18.0% - 22.0%
	AASHTO T 269	18.0% - 22.0%
Draindown	AASHTO T 305	≤0.3%

NOTE the name Change in 2020 Edition of Spec:

"asphalt" replaced by "Asphalt"

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Spec 408/2016- Section 489

Ultra-Thin Bonded Wearing Course

Change No. 1 (October 2016)

- Ultra-thin bonded wearing course of HMA (UTWC) over polymer-modified emulsified asphalt membrane.
- Roll before temperature drops below 185ºF
- Minimum of 2 passes with a steel double-drum roller
- Minimum weight of roller: 8 tons
- Compact in static mode except at joints.
- Pneumatic-tire roller may be needed to prevent the "bridging" effect of the steel drum roller

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Spec 408/2016- Section 489

Ultra-Thin Bonded Wearing Course

Change No. 1 (October 2016)

Type	NMAS	Placement Rates (pounds per square yard)
A	6.3 mm (1/4 inch)	45 to 65
B	9.5 mm (3/8 inch)	55 to 80
C	12.5 mm (1/2 inch)	60 to 85

UTWC (typically **gap-graded**) is used to correct surface distresses.
Provides a smooth surface.
Excellent for surface with cracking and raveling.
Needs sound foundation.

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Spec 408/2016- Section 411

Superpave WMA

Change No. 2 (April 2017)

Using Anti-Strip Additives with WMA

- Incorporate a liquid anti-strip additive at the same dosage rate as the dosage rate for the HMA JMF.

- If the WMA Technology includes an anti-strip additive additional liquid anti-strip additive is not required in mixtures where the moisture sensitivity analysis cannot be performed as specified in Section 411.2(e)1. (now 413.2(e)1.)

- If the WMA Technology includes an anti-strip additive as part of its WMA Technology and moisture sensitivity analysis can be performed according to Section 411.2(e)1 add additional anti-strip additive or make other adjustments to the JMF and meet the specified moisture
- sensitivity requirements.

NOTE: The modified version of these are now in Section 413 of Spec 408/2020 Edition.
SEE NEXT SLIDE

Spec 408/2020- Section 413

Using Anti-Strip Additives

- Use either a compatible, heat stable, amine-based liquid anti-strip or a compatible alternate anti-strip additive.
- If the WMA Technology includes an anti-strip additive, perform susceptibility analysis. Add additional additive or make JMF adjustments if needed.

Spec 408/2016- Section 409

Superpave Mixes

Change No. 3 (October 2017)

Nominal Max Agg. Size (mm)	Each Specimen	Multiple Specimens
Air Voids at N_{des} (V_a)	±2%	±1.5%
Min. VMA% for 4.75 mm mixes	16.0	-
Min. VMA% for 9.5 mm mixes	15.0	-
Min. VMA% for 12.5 mm mixes	14.0	-
Min. VMA% for 19.0 mm mixes	13.0	-
Min. VMA% for 25.0 mm mixes	12.0	-
Min. VMA% for 37.0 mm mixes	11.0	-

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Spec 408/2016- Section 419

WMA in SMA

Change No. 3 (October 2017)

WMA can be used with SMA

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Spec 408/2016- REMOVALS
Change No. 3 (October 2017)

422	Bituminous Wearing Courses FJ-1 ad FJ-1C (Removed)
430	Bituminous Wearing Course FB-2 (Removed)
431	Bituminous Binder Course FB-2 (Removed)
439	Bituminous Wearing Course FB-1 (Removed)
440	Bituminous Binder Course FB-1 (Removed)

Now in Pub 447: Approved Products for Lower Volume Local Roads

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Spec 408/2016- Section 460

Tack Coat

Change No. 3 (October 2017)

- New Tack with half of the water of AET (faster curing)
- Inclusion of non-tracking tack coat
- Revision of application rates based on surface texture

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Section 412, Superpave Mixture Design, Construction of Plant Mixed Asphalt 6.3 mm Thin Overlay Courses

Change No. 4 (April 2018)

- Used in Thin Lifts (3/4” min, 1 ¼” max.)
- Useful Tool for Pavement Preservation
- An alternative to microsurfacing and seal coats.
- PennDOT sponsored a four-year research project to develop specifications and guidelines for 6.3-mm mixes (2012 to 2016).

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Section 412
6.3 mm Thin Overlay Courses

Change No. 4 (April 2018)

One-inch thick placed 6.3 mm, SR 220

Mixture Details

- PG **64E-22** binder required
- Coarse aggregate: Type A
- Sand fine aggregate must be from the same source as coarse aggregate with SRL rating in Bulletin 14
- **Q:** RAP or RAS in mix? **NO**

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Section 412
6.3 mm Thin Overlay Courses

Change No. 4 (April 2018)

Construction details:

- air and surface temperature > **50°F**
- MTV required, unless waived by Rep.
- Box samples from roadway, hopper, or screed
- Density acceptance by **Optimum rolling pattern or non-movement**

NECEPT

Section 412
6.3-mm Thin Overlay Courses

Change No. 4 (April 2018)

Critical points for success:

- Clean existing surface.
- Proper, uniform tack application
- Selection of compaction rollers
- Begin Rolling immediately.
- Time available for compaction is limited.
- Do not use pneumatic-tire rollers.

Spec 408/2016- Section 483 Microsurfacing
Change No. 5 (October 2018)

Class of Asphalt Materials Changed

Used to be CSS-1hPM (E-8CPM)

Now it is CQS-1hPM

NECEPT

Spec 408/2016- Section 409
SP Mixes
Change No. 6 (April 2019)

Added

parking lot mixes to acceptance by certification

Spec 408/2016 - Section 409

Change No. 6 (April 2019)

Major Change to the section on

Weather and Seasonal Limitations

Spec 408/2016 - Section 409
Change No. 6 (April 2019)

Weather and Seasonal Limitations

Place between **April 1 to October 15** for

- all PG 76-22 wearing courses, **(now PG 64E-22)**
- >10 million ESALs wearing courses,
- 4.75 mm wearing courses,
- wearing courses placed less than 1.5 inches (compacted)

Place between **April 1 to October 31** for other mixes

Spec 408/2016 - Section 409
Change No. 6 (April 2019)

Paving in extended season

- Submit requests in writing at least 14 days prior to work
- Group 1: **April 1 to November 15**
- Group 2: **March 1 to December 15**
- Density acceptance will be by pavement cores.
- Utilize a Material Transfer Vehicle (MTV) on any day when the paving length will exceed 1,500 linear feet.

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Spec 408/2016 - Section 409
Change No. 6 (April 2019)

Paving in extended season

Paving work completed during the fall portion of the Extended-Season will be subject to a spring evaluation and manual survey by the Department to be conducted by May 1.

Manual surveys will be conducted in accordance with Publication **336.**

Spec 408/2016 - Section 409
Change No. 7 (October 2019)

Minimum Compacted Depth to Obtain Cores for Measuring and Accepting Density

For Standard Specification

Mixture	Minimum Depth
9.5-mm Wearing Course	1 ½" (≈ 40 mm)
12.5-mm Wearing Course	2" (≈ 50 mm)
19-mm Wearing and Binder Course	2 ½" (≈ 60 mm)
25-mm Binder Course	3" (≈ 80 mm)

Spec 408/2016 - Section 409
Change No. 7 (October 2019)

Change of Materials for Painting
Existing Vertical Surfaces in Contact with an Asphalt Mix:

Paint existing vertical surfaces … in contact with asphalt mixtures with a uniform coating of either emulsified asphalt, consisting of PennDOT Material Class TACK or NTT/CNTT, applied in two or more applications, or hot asphalt material of the class and type designated for the bituminous course.

NTT: Non-Tracking Tack Coat (Anionic) & CNTT: Non-tracking Tack Coat (Cationic)

Removed the following materials for painting vertical surface:
Class E-6 (AASHTO SS-1 or CSS-1), E-8 (AASHTO SS-1h or CSS-1h), Class AET applied in two or more applications, or of the class and type designated for the asphalt course.

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Section 314: Rich Base Courses

New Section
In 408 (Change 4 of 2020 Edition).
Will be published in April 2022.

- Asphalt Rich Base Course (ARBC)
- Max. RAP $\leq$ 20% by weight of mix
- No RAS Allowed
- Mix Design Requirements for ARBC for all Traffic Levels:

Volumetric Mix Design Property	25 mm NMAS
N_{design}	50
Design Air Void	2.5
VMA for all Production QC Samples	13.0
VFA	80-85

NECEPT

413–Superpave Asphalt Mixture Design and Construction of Plant Mixed Courses with PWL and LTS Testing

- 413.1 Description
- 413.2 Materials
- 413.3 Construction
- 413.4 Measurement & Payment

Where most changes have occurred in Specs.

.2 Deals with Materials
.3 Deals with Construction

Section 413.2: MATERIALS

TABLE A

JMF – Composition Tolerance Requirements

Gradation	Single Sample (n=1)	Multiple Sample (n≥3)
Passing 12.5 mm (1/2 inch) and Larger	± 8.0 %	± 6.0 %
Passing 9.5 mm (3/8 inch) to 150 µm (No 100) Sieves (Inclusive	± 6.0%	± 4.0 %
Passing 75 µm (No. 200) Sieve	± 3.0%	± 2.0%
Asphalt Content		
19.0 mm asphalt mixtures and smaller	± 0.7%	± 0.4%
25.0 mm asphalt mixtures and larger	± 0.8%	± 0.5%

Section 413.2: Materials
Table A

Temperature of Mixture (F)				
Class of Material	**Type of Material**	**Chemical, Organic, Foaming Additives, Minimum**	**Mechanical Foaming Equip/Process Minimum***	**Maximum***
PG 58S-28	Asphalt Binder	215	230	310
PG 64S-22	Asphalt Binder	220	240	320
PG 64E-22	Asphalt Binder	240	260	330
All other binders	Asphalt Binder	The higher of 215 or the minimum temp. specified in Bulletin 25 minus 45F	The higher of 230 or the minimum temp. specified in Bulletin 25 minus 30F	As specified in Bulletin 25

* Outline in the Producer QC Plan and follow more restrictive temperature requirements provided by the WMA technology manufacturer or Technical Representative(s) for production and placement of the mixture. Determine the SGC compaction temperature for the production QC which yields the same target air voids as the designed JMF . Include the SGC compaction temperature in the Producer QC Plan. Compact the completed mixture in the SGC for QC volumetric analysis at the SGC compaction temperature according to the guidelines provided by the Technical Representative.

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Section 413.2:Materials
TABLE B

JMF – Volumetric Tolerance Requirements

Nominal Max Agg. Size (mm)	Each Specimen	Multiple Specimens
Air Voids at N_{des} (V_a)	±2%	±1.5%
Min. VMA% for 4.75 mm mixes	16.0	-
Min. VMA% for 9.5 mm mixes	15.0	-
Min. VMA% for 12.5 mm mixes	14.0	-
Min. VMA% for 19.0 mm mixes	13.0	-
Min. VMA% for 25.0 mm mixes	12.0	-
Min. VMA% for 37.0 mm mixes	11.0	-

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Section 413.2: MATERIALS

TABLE C

Mixture Acceptance

Acceptance Level	Acceptance Method
Certification Acceptance	Producer Certification of Mixture Section 413.2 (i) 2
Lot Acceptance	Mixture Acceptance Sample Testing Section 413.3(h) 2

Section 413.3(h) 2: Mixture Lot Acceptance

- Normal Lot Size: 2,500 tons, 5 equal sublots
- Each sublot: 500 tons
- Special circumstances may change the size of a completed lot:
  - Minimum possible number of sublots: 3
  - Maximum possible number of sublots: 7

Section 413.3(h) 2:
Sublot Size

(new as specified in Change 3 of Spec Edition 2020, (October 2021)

- Once the sublot size for each specific JMF has been established based on the project's plan quantity, the sublot size **will remain unchanged** throughout project completion.

- A completed sublot has a mixture acceptance box sample and either a core or other density acceptance measures

Section 413.3: Construction

- **TABLE D.** - Re-adjustment of Lot Size and Associated Number of Sublots
- **TABLE E.** - Density Limits for Partially Completed Lots
- **TABLE F.** - Density Acceptable Levels & Criteria
- **TABLE G.** - Minimum Mixture Compacted Depths

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Section 413.2(h): Density Acceptance

TABLE E

Density Limits for Partially Completed Lots

Mixture NMAS	Density Limits
All RPS 9.5 mm, 12.5 mm, 19 mm, and 25 mm Wearing or Binder Course	$\geq$ 92.0% and $\leq$ 98.0%
All Standard 9.5 mm, 12.5 mm, 19 mm, and 25 mm Wearing or Binder Course	$\geq$ 91.0% and $\leq$ 98.0%
All 25 mm and 37.5 mm Base Course	$\geq$ 90.0% and $<$ 100.0%

- **PAYMENT:**
- If density meets Table E Criteria: **100% Pay**
- If density no more than **2%** below min. or no more than **2%** above max: **90% Pay**
- Other cases: Defective work. Remove & Replace unless directed otherwise by the District

Section 413.2(j): Density Acceptance

TABLE F

Density Acceptance

Density Acceptance Level	Acceptance Criteria
Non-movement	Table H
Optimum Rolling Pattern	Table H
Pavement Cores*	Table I
* Only when mixture is accepted by lots	

Section 413.2(j): Density Acceptance

Min. Thickness Requirement if Density Acceptance by Cores for Standard Construction

TABLE G

Mixture Minimum Compacted Depths

Mixture	Minimum Depth
9.5-mm Wearing Course	1 ½” (≈ 40 mm)
12.5-mm Wearing Course	2” (≈ 50 mm)
19-mm Wearing and Binder Course	2 ½” (≈ 60 mm)
25-mm Binder Course	3” (≈ 80 mm)

Section 413.4: Measurement & Payment

- **TABLE H - Mixture Acceptance by Certification**
  - **Asphalt Content**

NMAS	Criteria	Value		PF, %
All sizes	Printed Tickets	Al least 90% is ± 0.2 of JMF		100
		Less than 90% is ± 0.2 of JMF		85
19 mm and smaller	QC Sample Testing	Single, n=1	n≥ 2	--------------
		±0.7%	±0.5%	100
		±0.8% to 1.0%	±0.6%	85
		> ±1.0%	≥ ±0.7%	RR or 50%
25 mm and larger	QC Sample Testing	±0.8%	±0.6%	100
		±0.9% to 1.2%	±0.7%	85
		> ±1.2%	≥ ±0.8%	RR or 50%

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Section 413.4: Measurement & Payment

- **TABLE H - Mixture Acceptance by Certification**
  - **Gradation**

NMAS	Criteria	Value		PF, %
		n=1	n≥ 2	
All sizes	QC Sample Testing for % Passing #200 Sieve	±3.0%	±2.1%	100
		±3.1% to ±4.0%	±2.2% to ±2.7%	85
		> ±4.0%	≥ ±2.8%	RR or 50%
All sizes	QC Sample Testing for % Passing #8 Sieve	±6%	±4%	100
		±7% to ±8%	±5%	85
		> ±8%	≥ ±6%	RR or 50%

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Section 413.4: Measurement & Payment

- **Mixture Acceptance by Lots**

  TABLE I: Upper & Lower Spec Limits for Calculating Percent Within Tolerance

  TABLE J: : Dispute Resolution Retest Cost Table

NECEPT

Summary

- **Discussed PennDOT Spec. 408**
- **Reviewed changes in Asphalt Specifications.**
- **Major additions within the last 5 years:**
  - **Pervious Pavements (420)**
  - **Ultra-Thin Bonded Wearing Course (489)**
  - **6.3 mm Thin Lift (412)**
  - **SP Mixes with PWL-LTS (413)**
  - **SP Mixes for Base Course (313)**

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Summary

- **Major Changes within the Last 5 years:**
  - Addition of VMA Criterion for 4.75-mm mixes
  - Use of Antistrip Additives in asphalt mixes
  - Allowing WMA in SMA
  - Revised Tack Coat Spec
  - Revised Emulsion for Microsurfacing (Section 283)
  - Seasonal Limitations for Paving
  - Requirements for Extended Season Paving
  - Revised compacted depth for 12.5-mm mixes
  - Change of Density Limits for Partially Completed Lots

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PennState

Thank You!

pennsylvania
DEPARTMENT OF TRANSPORTATION

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PENNSTATE

Plant Technician Certification Program

Segregation in Asphalt Concrete

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Objectives

- What Is Segregation?
- How Does It Happen?
- How Can It Be Prevented?
- What Action Needs To Be Taken?
- How Does Segregation Affect Pavement?

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What Is Segregation?

Webster defines *Segregation* as: “to separate from the main mass and collect together in a new body.”

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Applied to Asphalt Mixture:

Segregation is the separation of the course and fine aggregate in the mix, collecting and distributing these fractions so that the Mix Asphalt is no longer uniformly textured.

Can Mix Design Cause Segregation?

- Dense grades mixes are less prone to segregation compared to gap-graded mixes.
- Gap-graded mixes are unforgiving, and errors in plant production or loading are hard to fix during the placement.
- The use of higher binder content and fibers in gap-graded SMA mixes reduces the segregation potential.

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What Is the Effect of Segregation on Pavement?

- Premature Distress
  - Raveling
  - Frost Damage
  - Potholes

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Why Do Premature Failures Occur Due To Segregation?

- **Weaker Aggregate Structure and Gradation**
- **Weaker Mix**
- **Higher Voids**

NOTE:

A large portion of material presented in the next section are developed based on the information from the following source:

Technical Paper T-117, Segregation Causes and Cures
By J. Don Brock, James G. May and Greg Renegar, 1997

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Sources of Segregation

- Stockpiling
- Plant Operation
  - Cold Feed Bins
  - Hot Bins on Batch Plant
  - Drum Mixer
  - Surge & Storage Bins
- Truck Loading

Plant Technicians Responsibility

- Truck Unloading
- Paver
  - Hopper
  - Slat Conveyer
  - Hopper gates
  - Auger
  - Screed

Field Technicians Responsibility

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How Does It Happen?

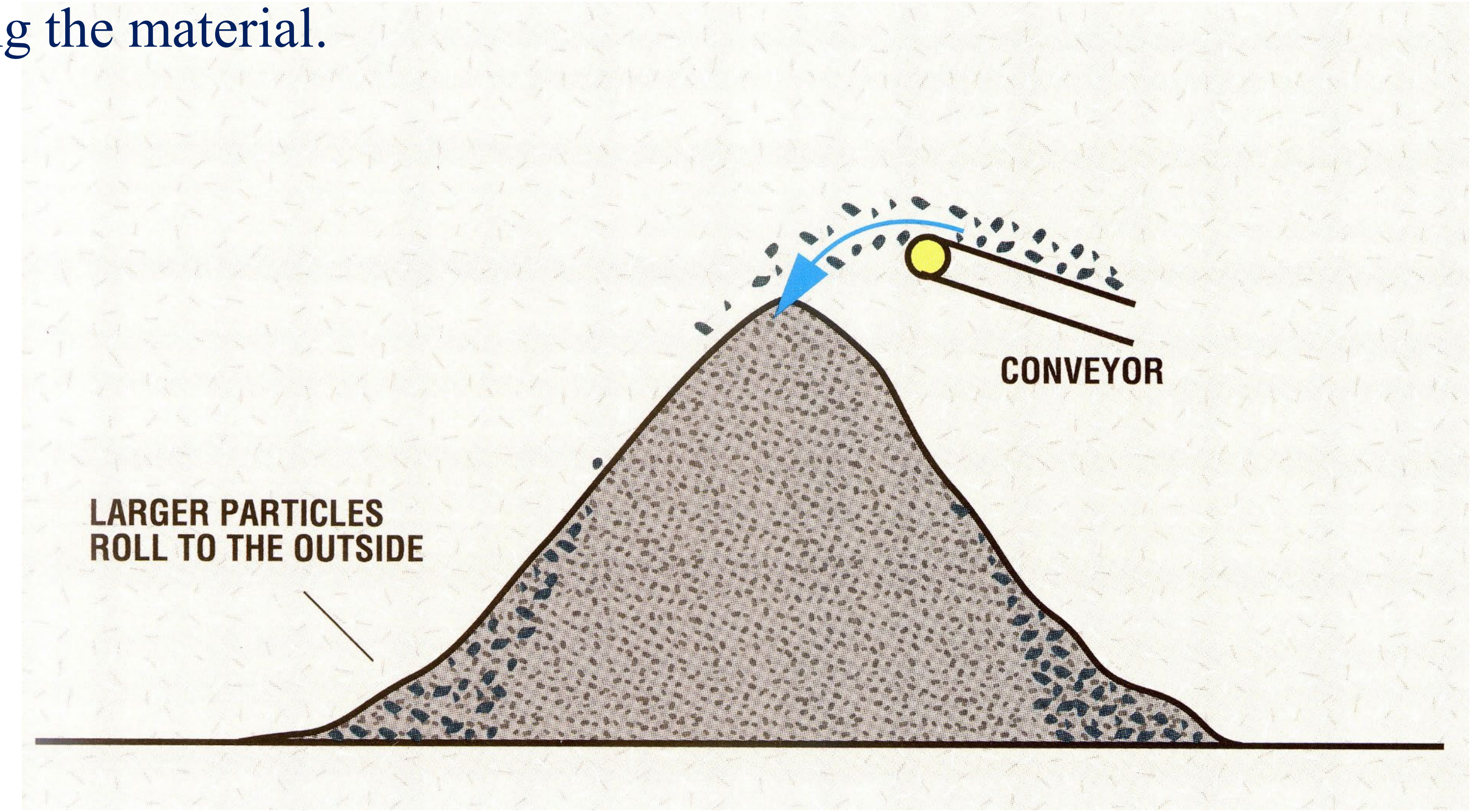
Stockpiling

- Overlapping Aggregate Sizes (**Contamination**)
- Large Stockpiles (**More Segregation Potenti**al)

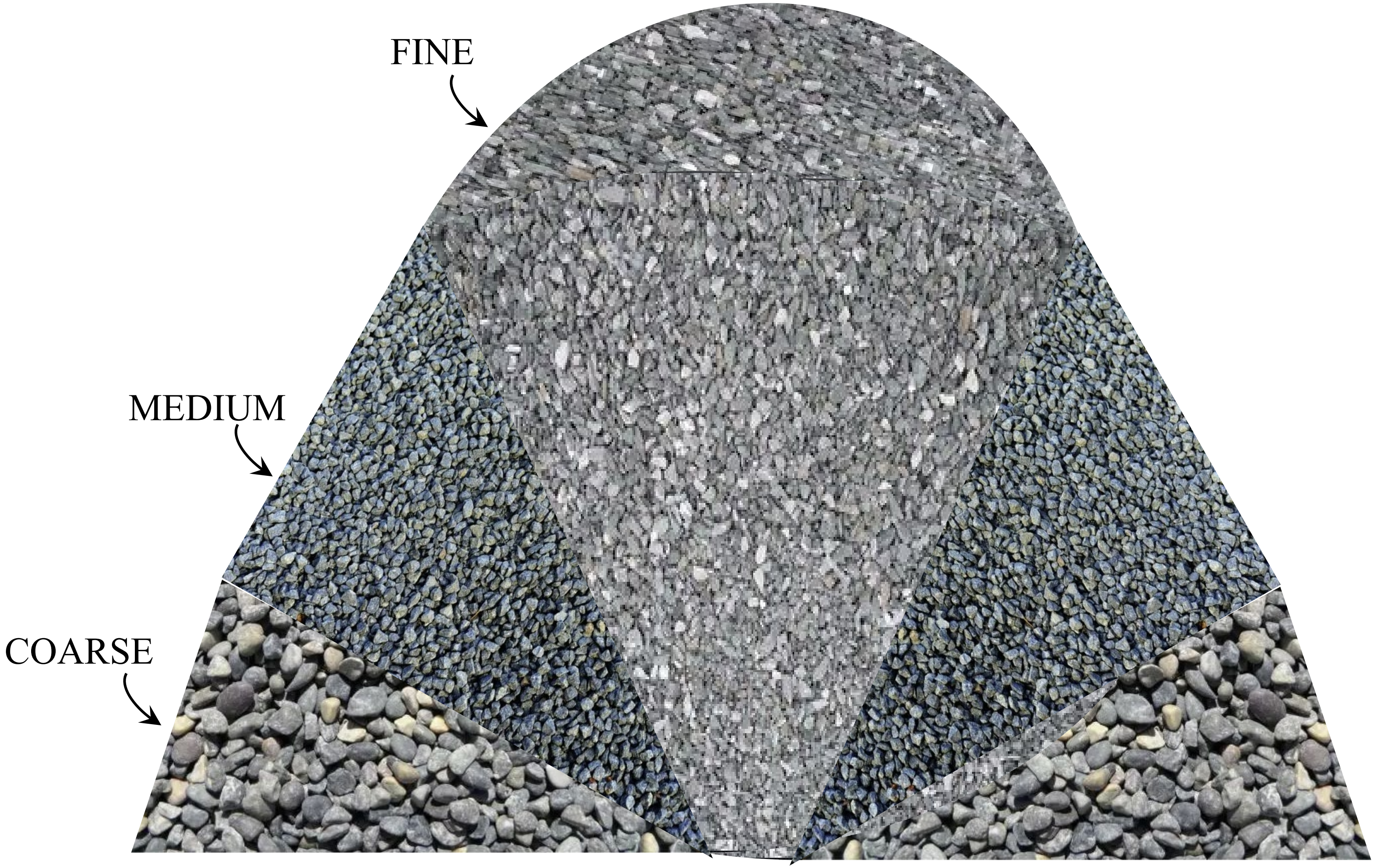
How Does It Happen?

In Stockpiling

Larger particles have the tendency to roll to the outside of the pile thereby segregating the material.



Stockpile Size Separation



How Does It Happen?

- Stockpiling-Dumping Over the Edge!

- **Avoid dumping over the edge.**
- **High potential for segregation due to increased drop height**

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How Is It Prevented?

Stockpiling

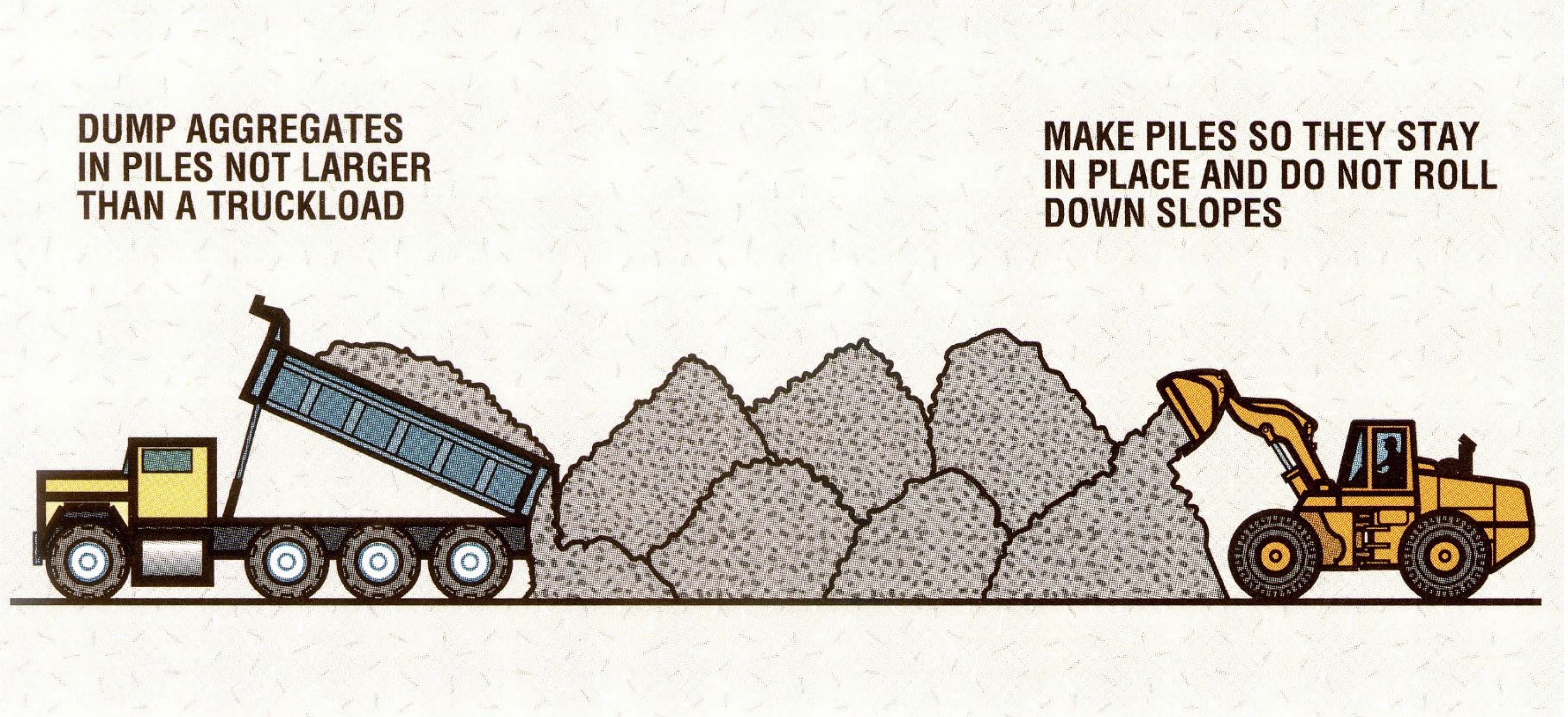
- Different-sized Material
- Separate piles
- Build Horizontal Layers
- Build Sloped Layers

How Is It Prevented?

Stockpiling

Limit Stockpile Height & Separate Sizes

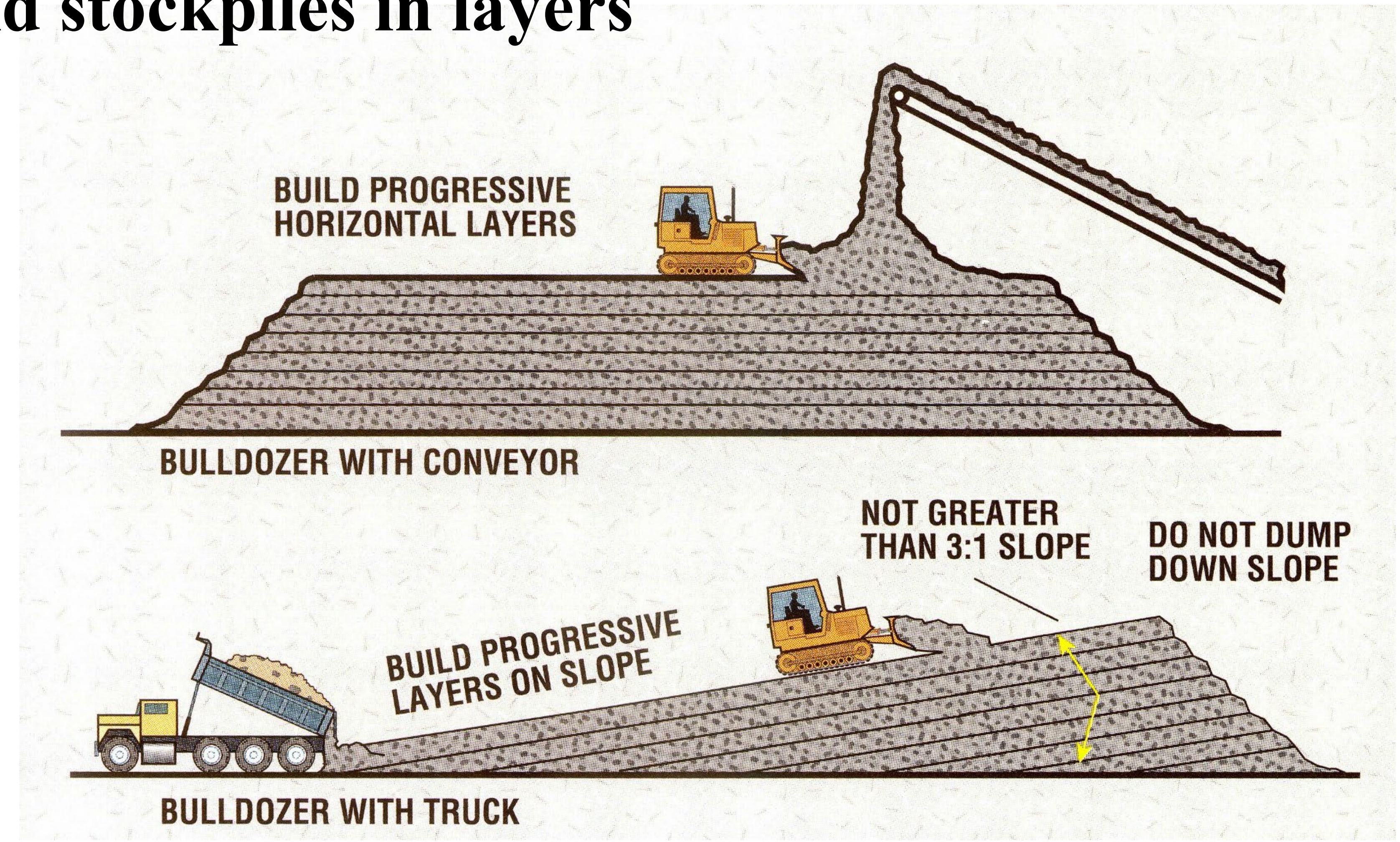
Generally, different-sized materials are stockpiled separately for feeding to an asphalt plant. To minimize segregation in forming a stockpile use numerous small piles or………….



How Is It Prevented?

Stockpiling

Build stockpiles in layers



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How Is It Prevented?

Working the Stockpile

A good front-end operator can take a segregated pile and by working the pile minimize the problem. By the same token, he can take a good pile and mess it up.

Keep the bucket up and don't dig up to prevent contamination)

Every time the loader bucket touches the stockpile, more fine material is produced (as a general rule, 1 percent -#4 sieve)

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How Is It Prevented?

In Loadout from Stockpile

- Mix the material in stockpile
- Consider three or more vertical cuts around the pile.
- Take loads from each cut
- Use bucket low without touching the ground
- **Push** the bucket into the stockpile and pull upwards (remember coarse material is on the outside and fine material inside)

Safety around Stockpiles!

Stockpiles may inhibit visibility around corners!

Dump truck going over the edge???

- **Maybe use a berm as visual reference point for operator**
- **Stockpile pad must be clean and sturdy**
- **Make dump area slightly graded for better control (gives better drainage too!)**

https://www.worksafenb.ca/hazard-alerts/en/safe-driving-techniques-around-stockpiles.html

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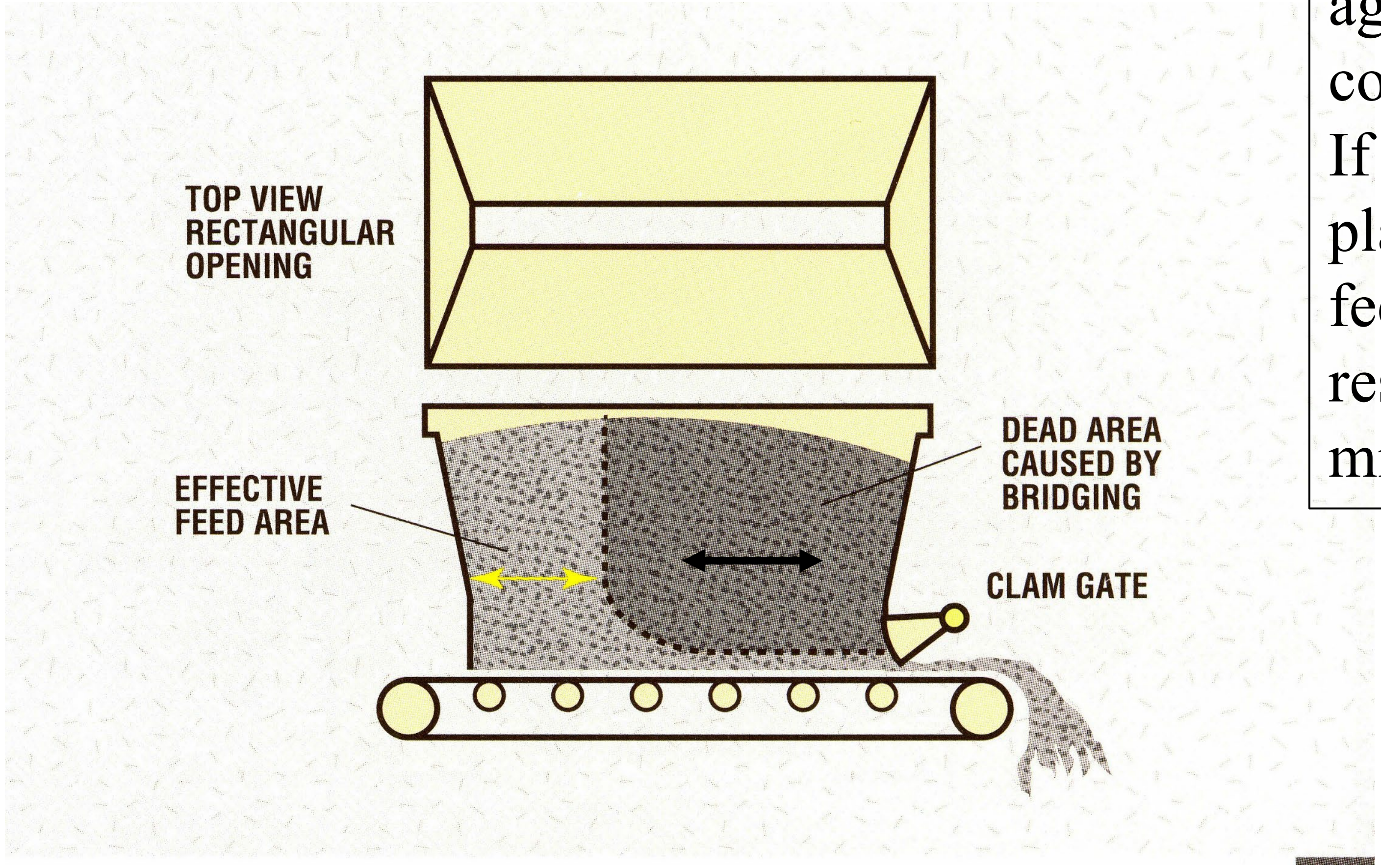
How Does It Happen?

In Feeding Cold Feed Bins

- Bridging



Segregation in cold feed bins is usually not a problem unless the aggregate material consists of several sizes. If material bridging takes place non-uniform feeding takes place, resulting in a segregated mix.

How Is It Prevented?

In Feeding Cold Feed Bins

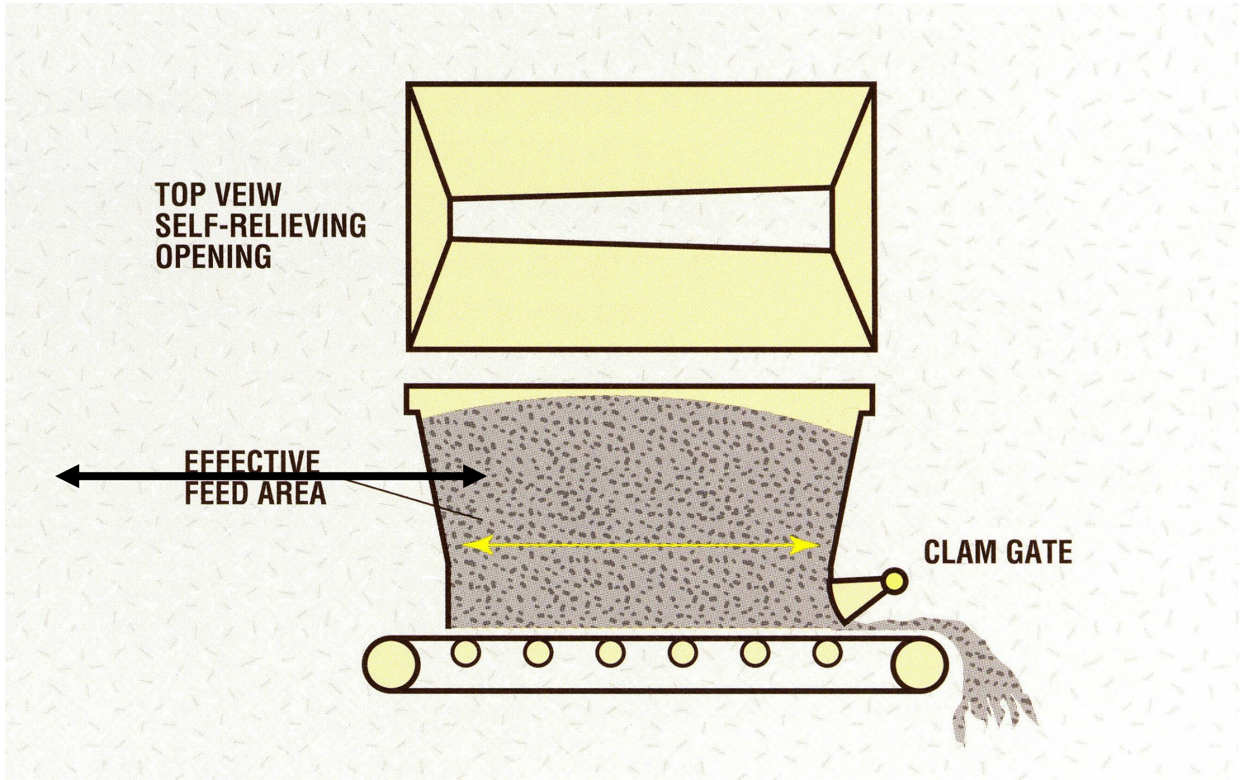
- Reconfigure Opening

  Make bin opening variable size

  Make bin sides at different angles

  Use compressed air to separate the fines from the bin wall

Also, by utilizing a self-relieving bottom, uniform feeding will occur all along the opening of the cold feed bin, eliminating bridging as a source of segregation.

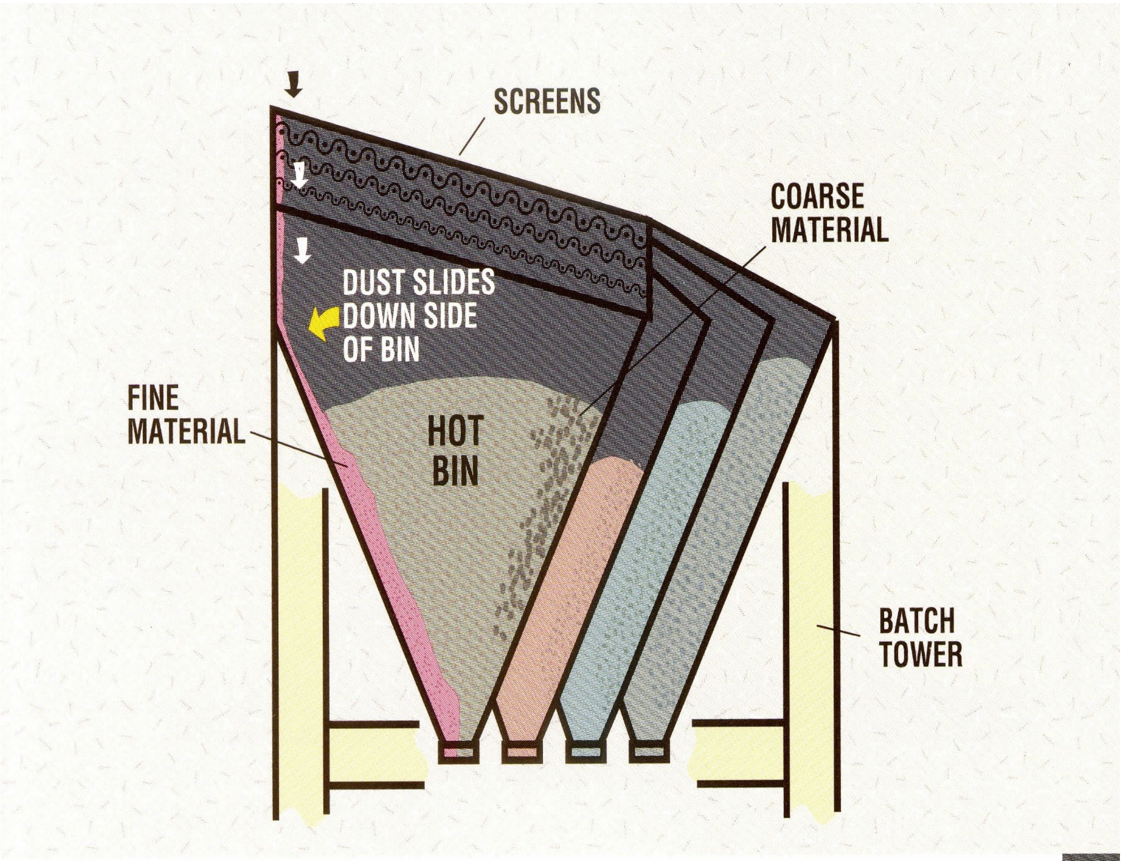


How Does It Happen?

In Feeding Hot Bins on a Batch Plant

- Range of Materials
- Size of Bin
- Shape of Bin
- No. 1 Bin

Segregation often occurs in the No.1 hot bin due to the size and shape of the large bin and the wide size range of materials in that bin. The ultra-fine dust may lay on the sloping bin wall and then break loose in large slugs, producing an ultra-fine mix that is segregated and uncoated.

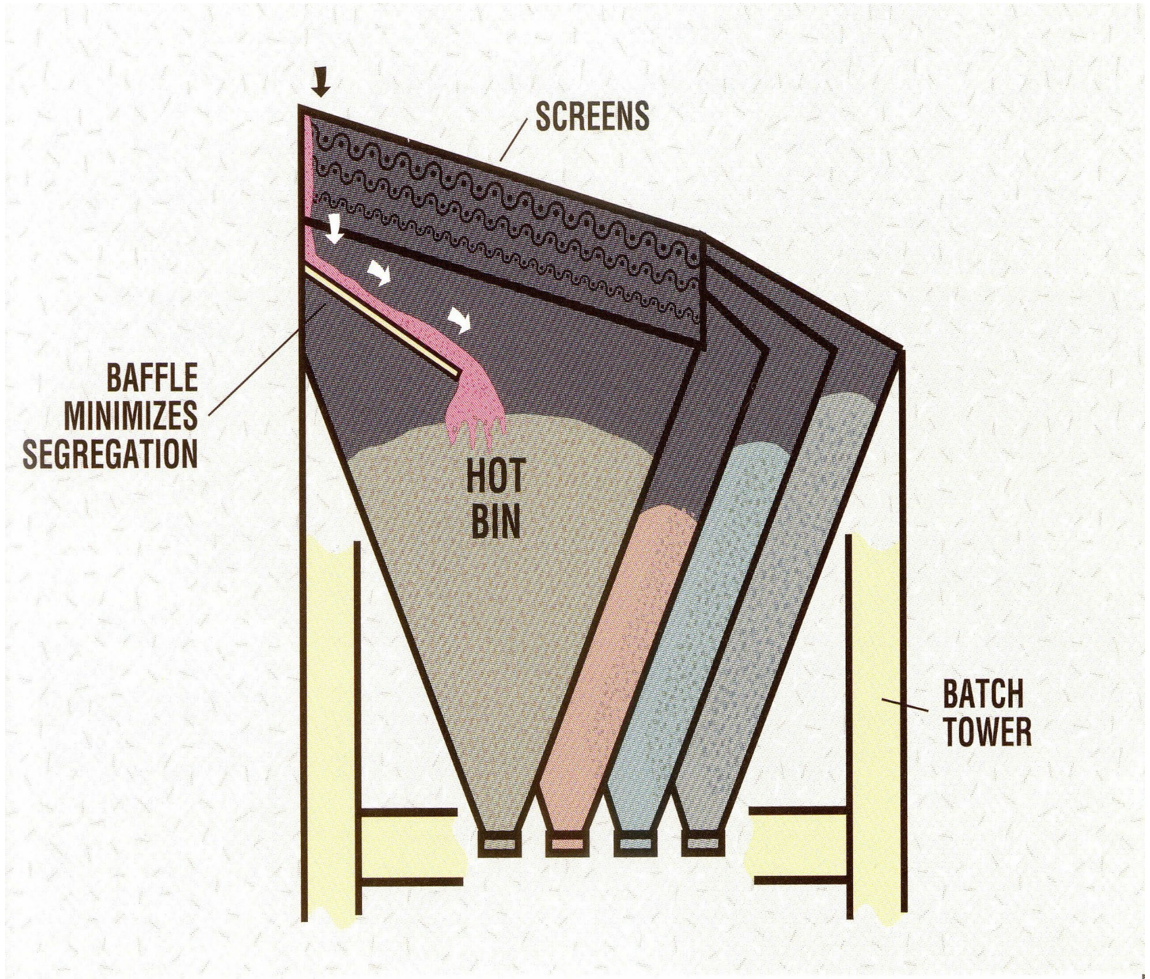


How Is It Prevented?

In Feeding Hot Bins on a Batch Plant

- Install Baffle in the hot bin carrying the finest material

The metal plate (baffle) welded part-way across the number one hot bin helps prevent segregation by directing fine material toward the center

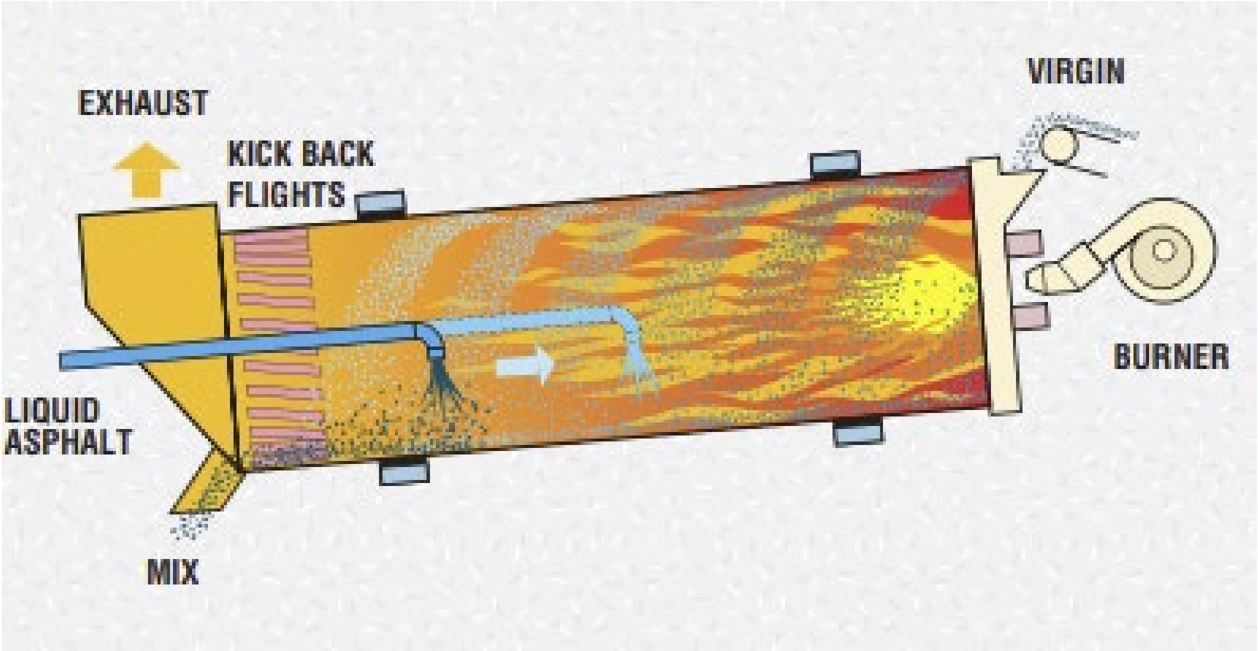


How Does It Happen?

In a Drum Mixer

Mixture speed: Large Aggregates move faster than Fine Aggregate during initial start up and plant shut-down.

When gap graded mixes are processed in drum mixers, it becomes more difficult to achieve a thorough coating with a uniform thickness. The uncoated or thinly coated coarse materials are more likely to segregate.

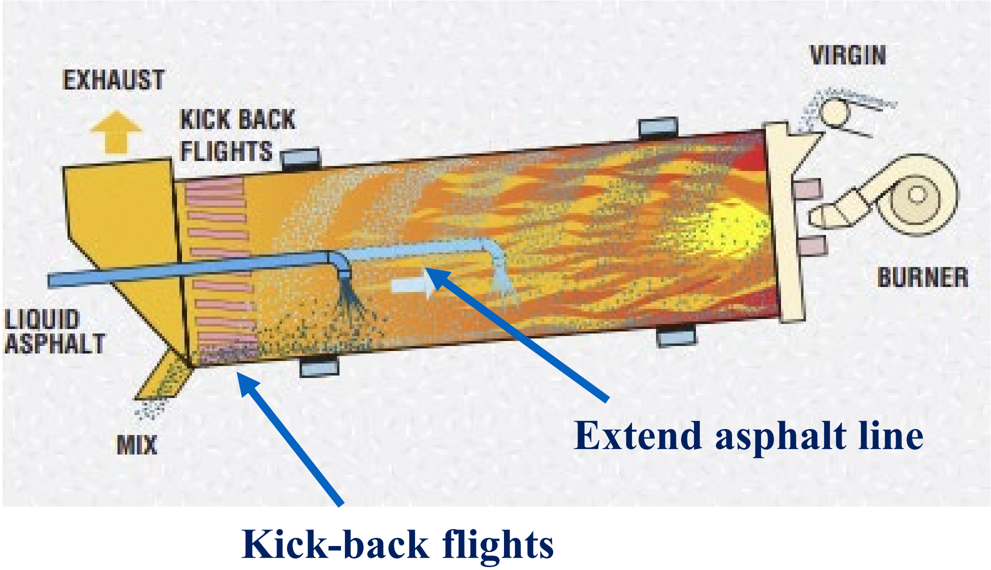


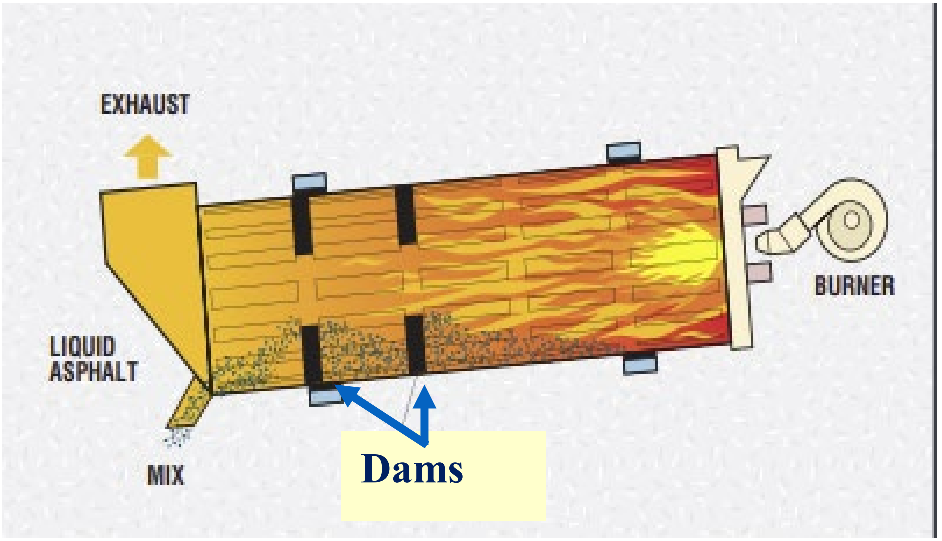
How Is It Prevented?

Adjusting the start/stop time intervals between the cold feed bins.

Increase Mixing Time

- Kick-back flights
- Extend asphalt line
- Install a dam (donut)





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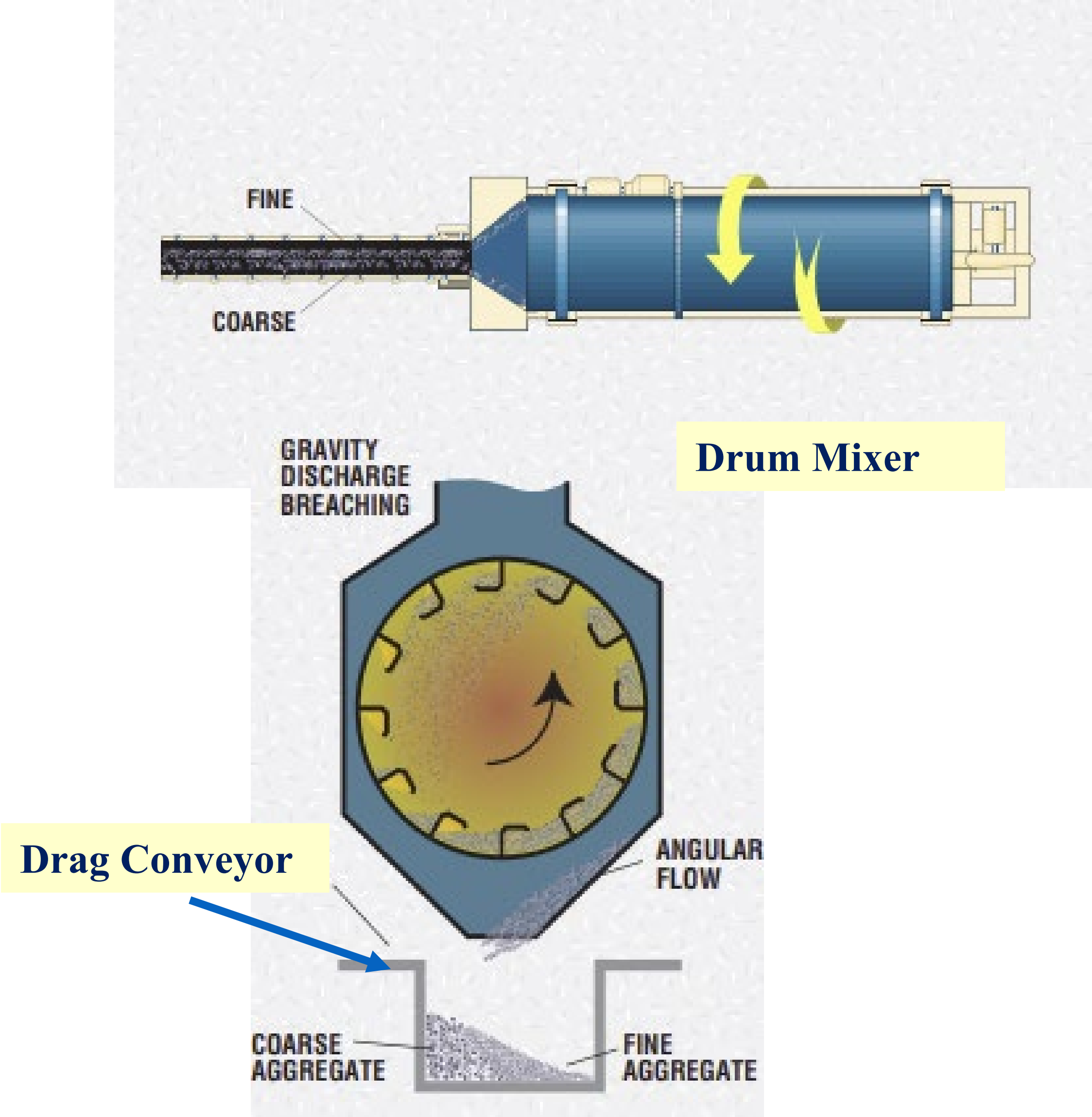
How Does It Happen?

In a Drum Mixer

Coarse Material discharges to one side and fine Material to the other side

Mix discharged from drums by gravity feed is more sensitive than mix discharged from drums with a high lift where the material is required to make a 90-degree turn prior to discharge. The segregated material drops directly on a drag conveyor and continues to segregate right on through the plant.



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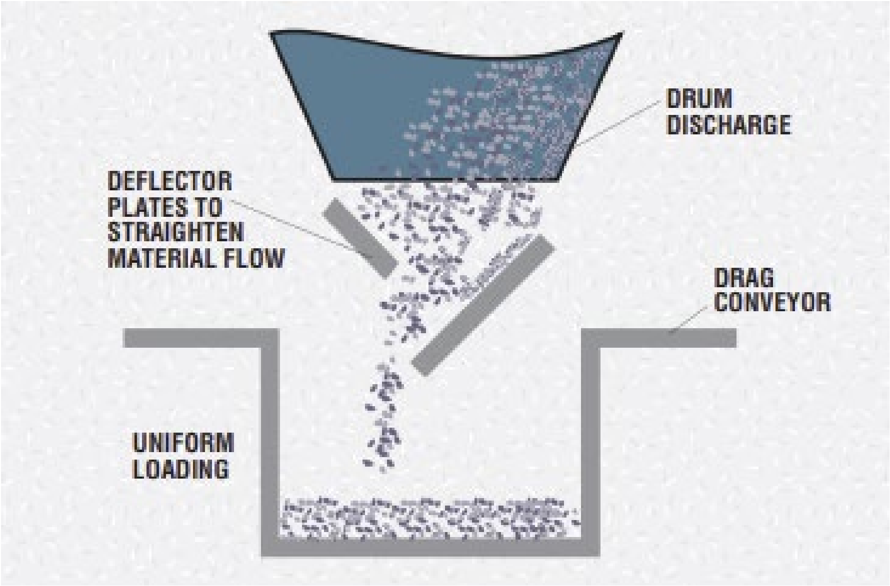
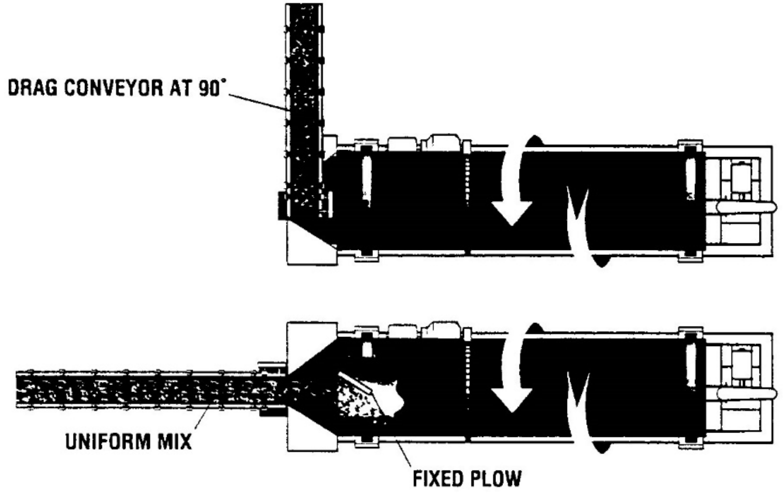
How Is It Prevented?

- Deflector Plates
- Discharge at 90-degree angle
- Install a Plow





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How Is It Prevented?

See previous slide:

The problem can be improved by restricting the discharge chute from the drum to a smaller opening, forcing the mix into the center of the drag conveyor. Adding deflector plates or straightening vanes is also an effective way to ensure the drag conveyor is properly loaded. Another solution is to install a plow or single discharge point in the drum forcing the mix to come out at one point. However, it is difficult to design and install an effective plow on most from drum mixer. When possible, it is best to set the drag conveyor at a 90-degree angle to the drum discharge to create a right-angle change in material flow. This setting reduces or eliminates drum discharge segregation.

How Does It Happen?

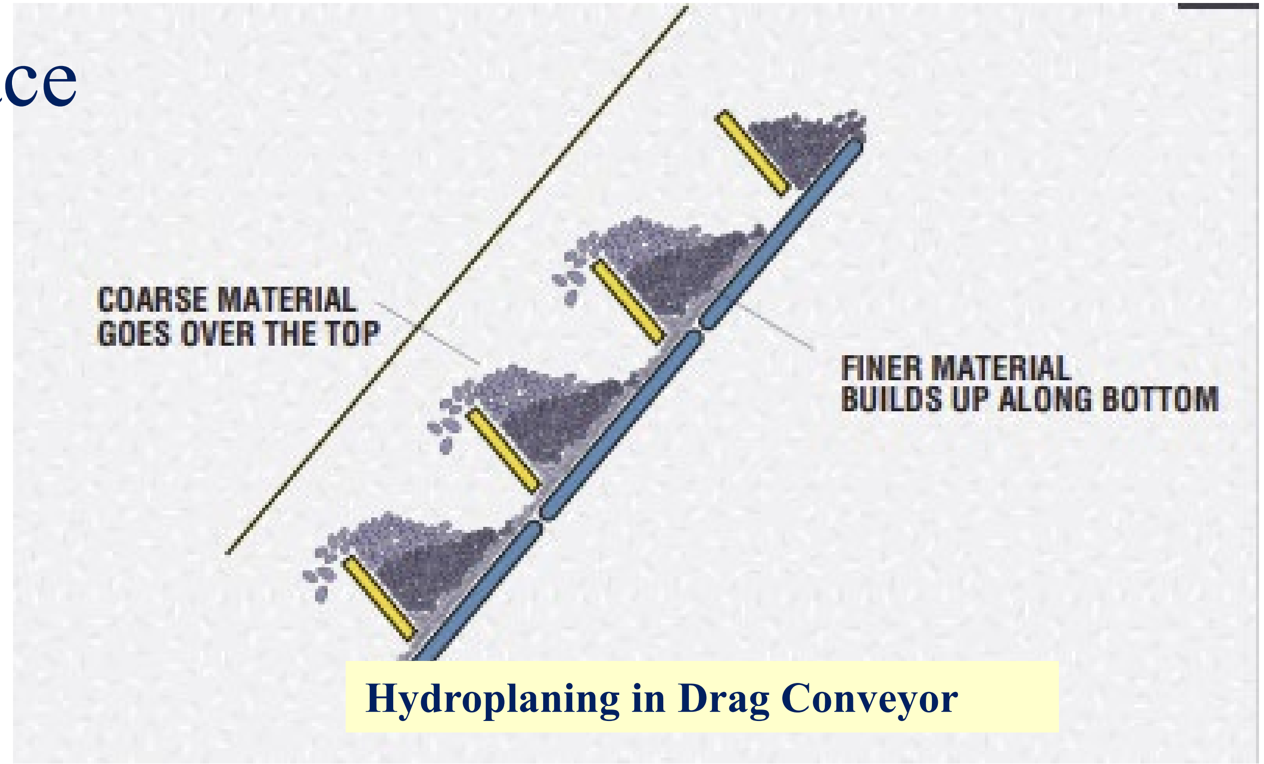
Filling Surge and Storage Bins

- Drag Conveyor
- Rotating Chute
- Bin Loading Batchers

How Does It Happen?

Drag Conveyors

- Hydroplaning (material buildup at bottom of the conveyor) – startup issue (cold)
- High Friction Drag Surface
- Partially Full



Hydroplaning in Drag Conveyor

How Does it Happen?

See previous slide:

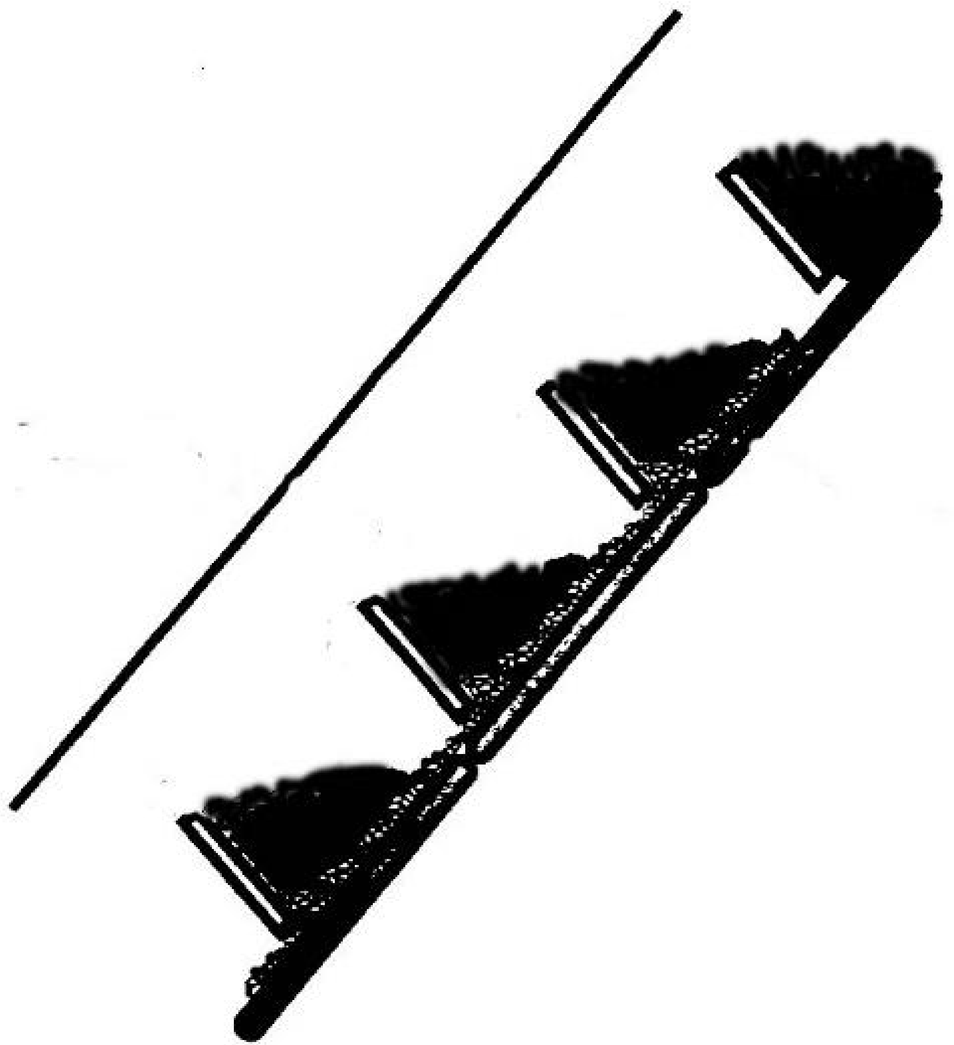
Segregation will usually not occur in a drag conveyor unless it is "hydroplaning". Hydroplaning occurs as a result of material build up in the bottom of the drag conveyor. Cold conveyors that do not have floating hold-downs are prone to build-up on the bottom liners. The build-up creates a high friction drag surface that results in material spilling backwards over the drag flights, even at very low production rates. This condition is easily observed. Material falls backward down the drag conveyor instead of moving uniformly in one mass with full material from flight-to-flight.

How Is It Prevented?

Drag Conveyors

Equipped with

- Floating hold downs
- Heated bottoms
- Full slats



How Is It Prevented?

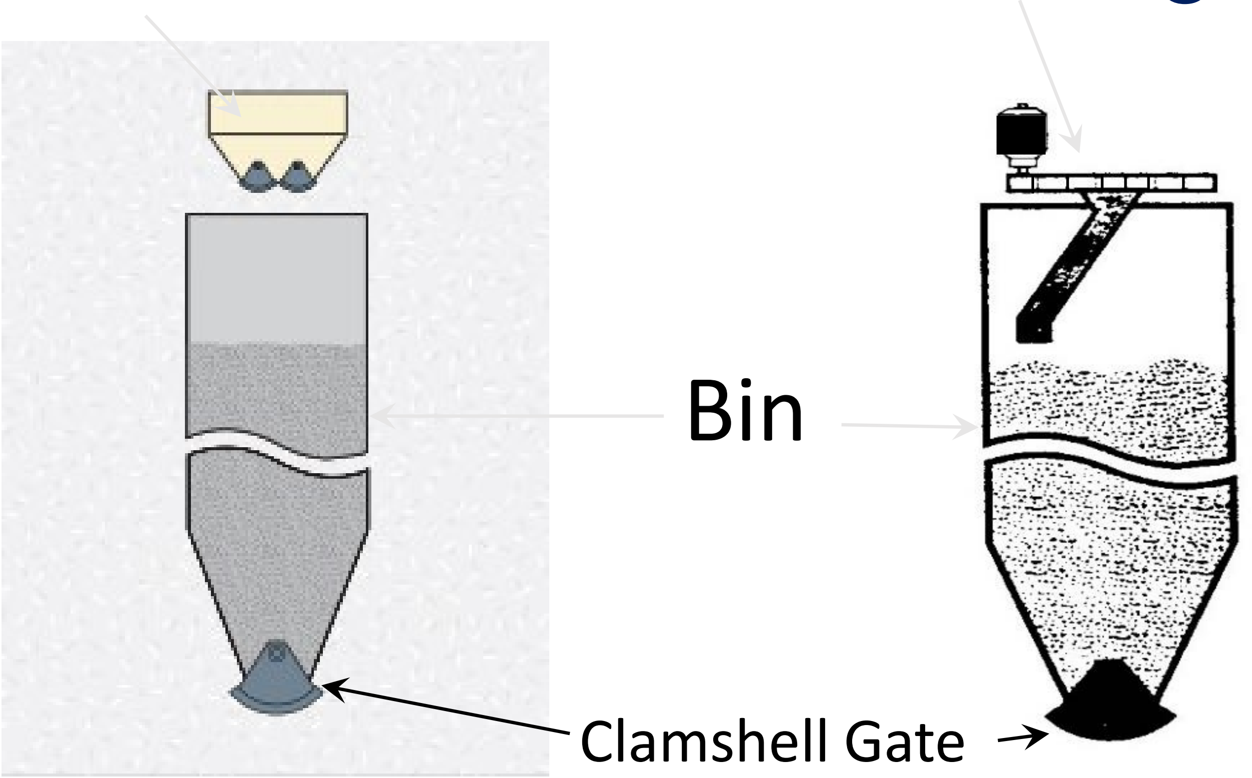
See previous slide:

Drag conveyors should be equipped with floating hold downs and heated bottoms for cold start-ups. Segregation is minimized when the drag conveyor is as full as possible. When the slats are only partially filled, the large aggregate is apt to roll to each side within the drag conveyor. It is better to run at higher production rates to keep the drag conveyor full. When producing a segregation prone mix at production rates higher than the rate used by paving operations, store the extra mix.

How Does It Happen?

In Loading Storage or Surge Bins

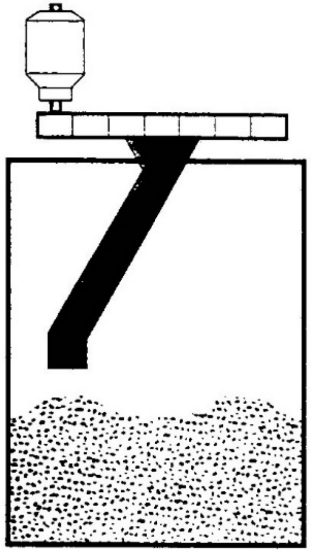
- Batcher
- Rotating Chute

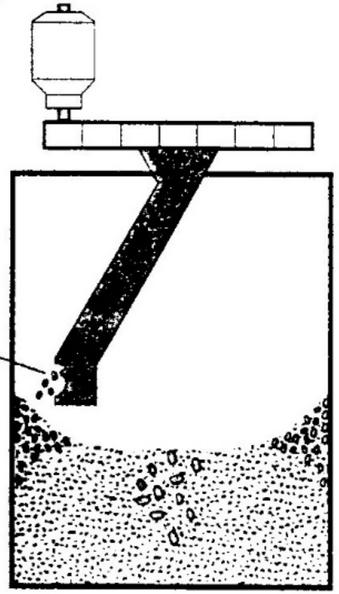


How Is It Prevented?

Rotating Chute

- Must Rotate
- Not worn



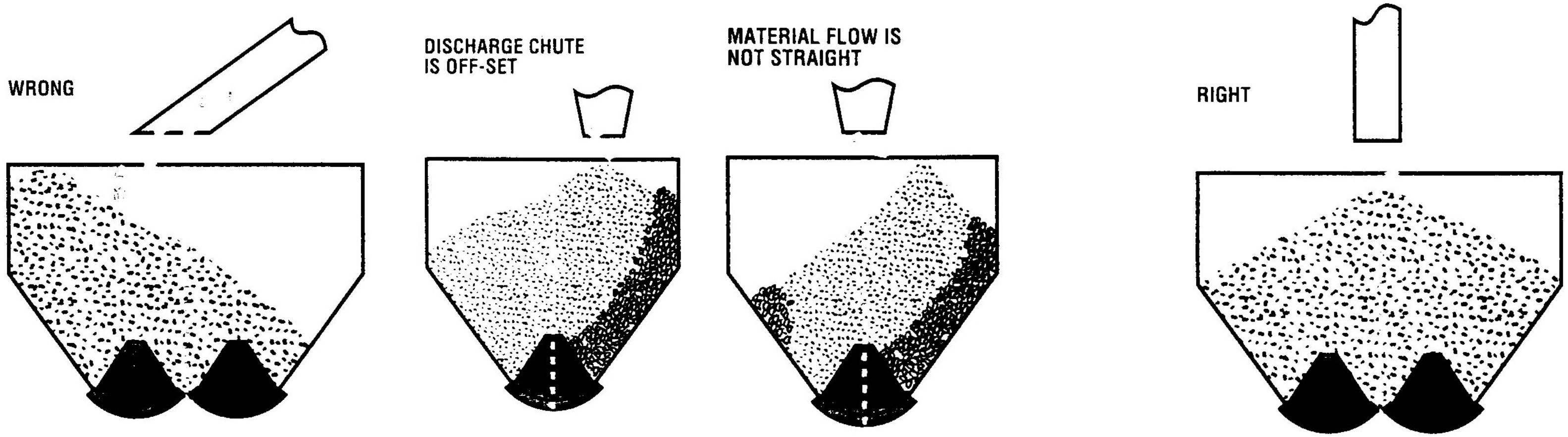


It is essential that the rotating chute does actually rotate and that the material dropping from the chute turns directly downward.
When the chute gets older and the end wears out, considerable segregation can occur.

How Is It Prevented?

Batcher: **Load the**

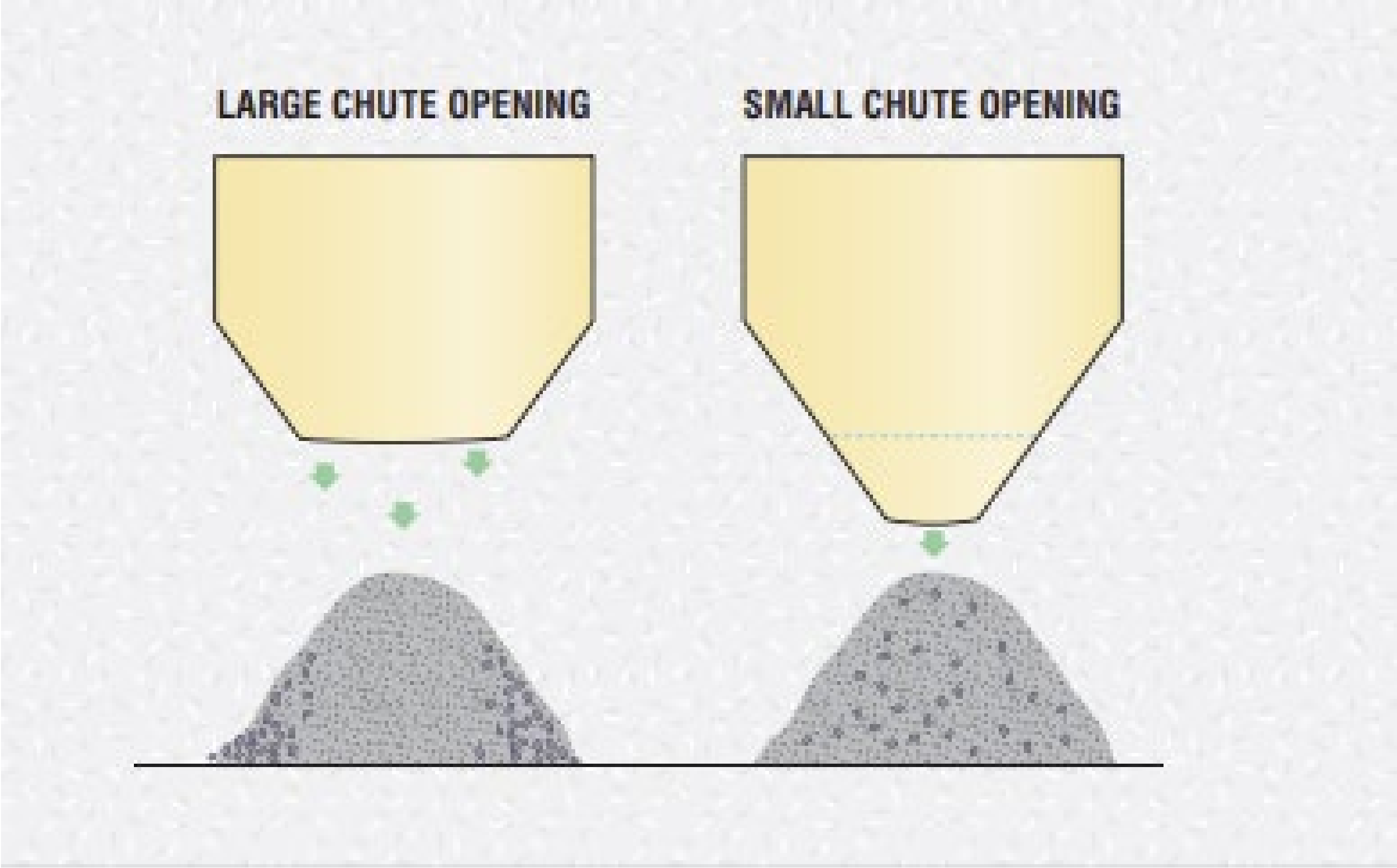
- Loaded in Center
- Filled to Capacity before each drop



The batcher should be filled to its maximum capacity (at least 5000 lbs.) and a relatively large diameter gate opening to insure rapid discharge into the storage bin. The batcher must be loaded directly in the center and the material should have no horizontal trajectory.

How Is It Prevented?

Batcher: A smaller chute opening minimizes segregation



The Rules for Correct Batcher Operation

Batcher Rules

1. Batch size should be at least 5000 lbs.
2. Batcher should be loaded in the center.
3. Material should flow straight down into the batcher.
4. Batcher gate timers should be adjusted so that gates shut with 6-8 inches of material left in batcher. Do not allow any free flow through the batcher.
5. Batcher should be maintained so that the mix drops out rapidly as a slug.
6. Do not keep material level consistently near the top.

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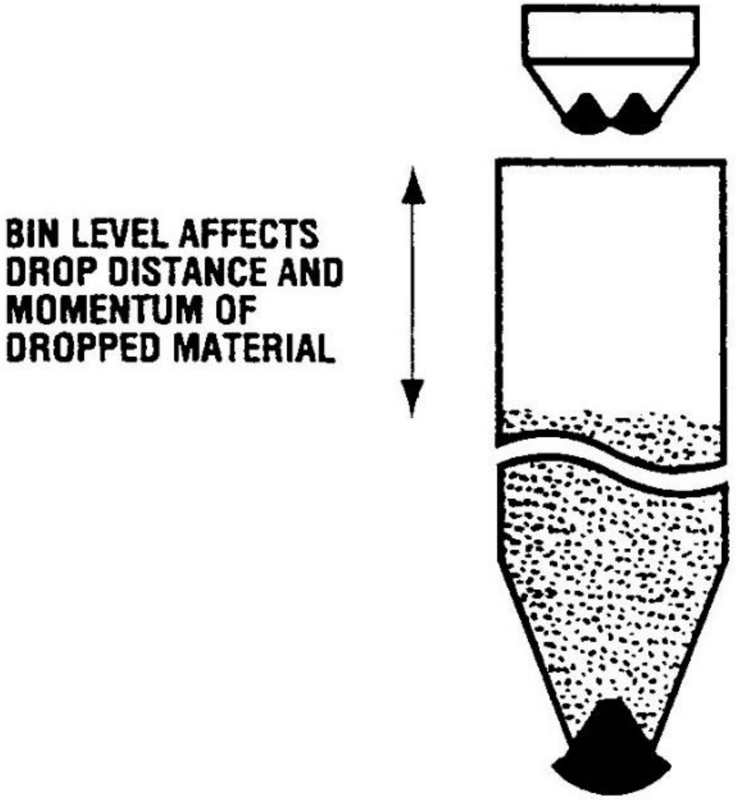
How Does It Happen?

In Loading from a Surge or Storage Bins

Bins: the most sensitive areas for segregation in asphalt plant

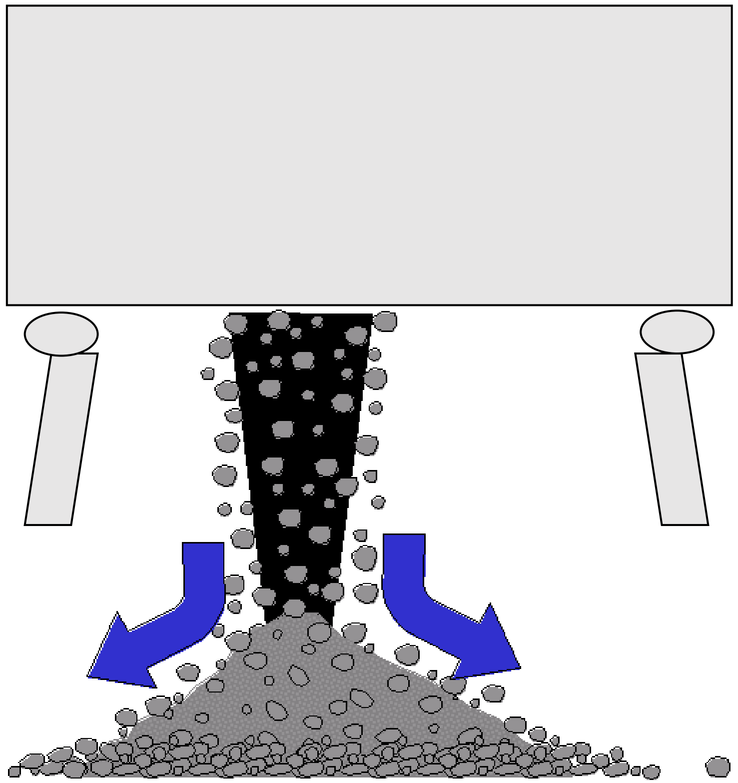


With gap-graded material, material should not be allowed to drop below the cone.

How Is It Prevented?

Rapid Discharge

Rapid discharge from the silo gate. In cold weather, bins should be insulated, at least on the cone.



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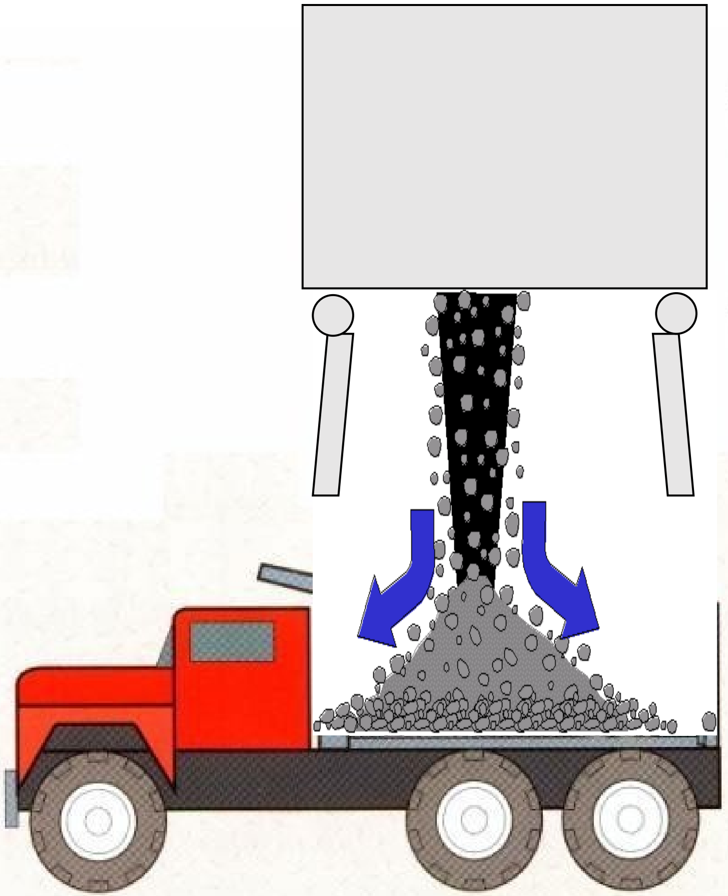
How Does It Happen?

In Loading the Truck

- Dribbling the material

Segregation can be caused by not loading the truck in mass, but rather loading it by trickling or dribbling the material into the truck. This will cause the larger aggregate to separate and fall into the truck first.

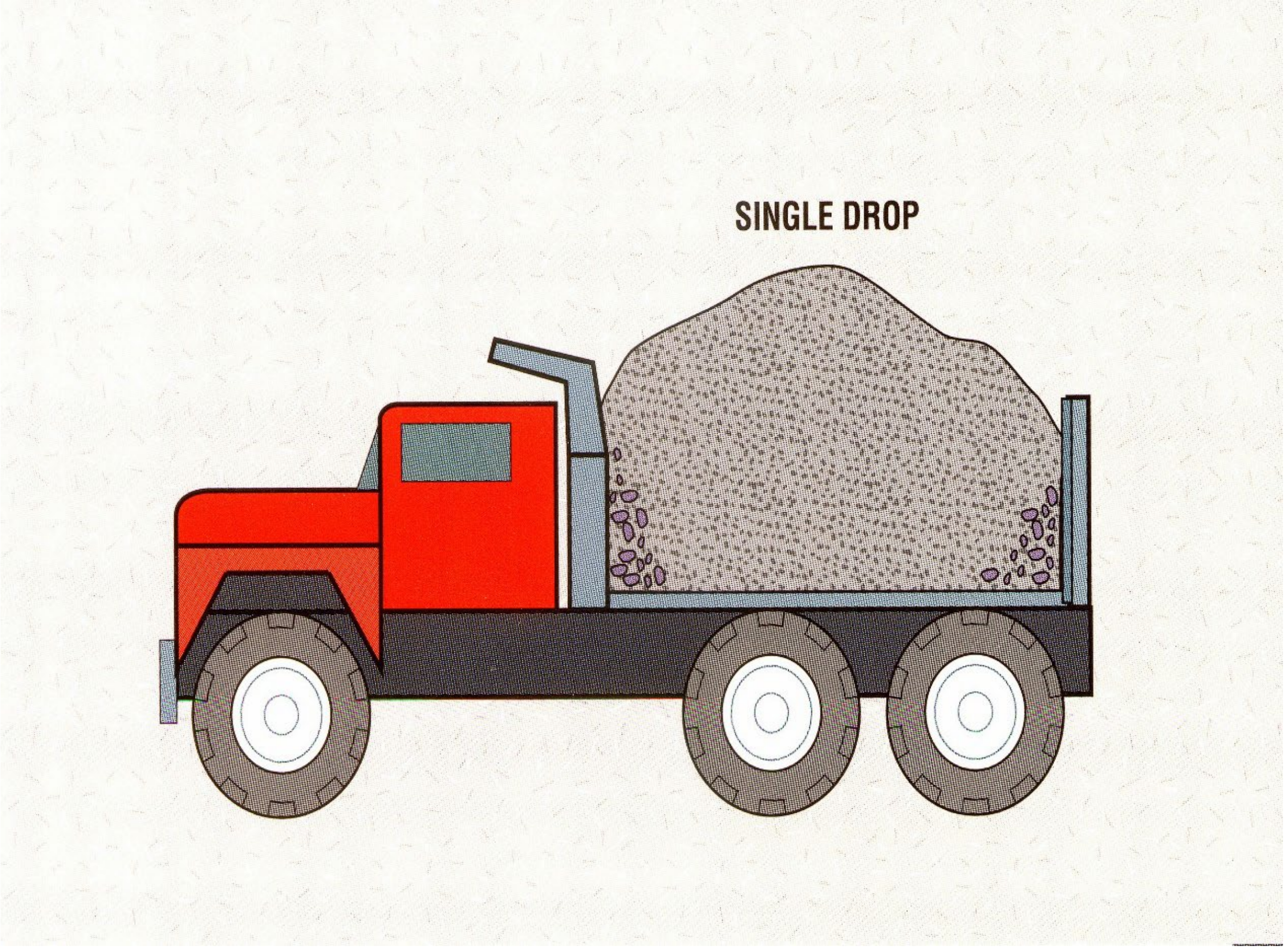


How Does It Happen?

In Loading the Truck

- Single Drop

Single drop will cause the larger stones to roll to the front of the truck, to the rear, and to the side, resulting in the coarse material being the first and last material to be discharged from the truck bed.



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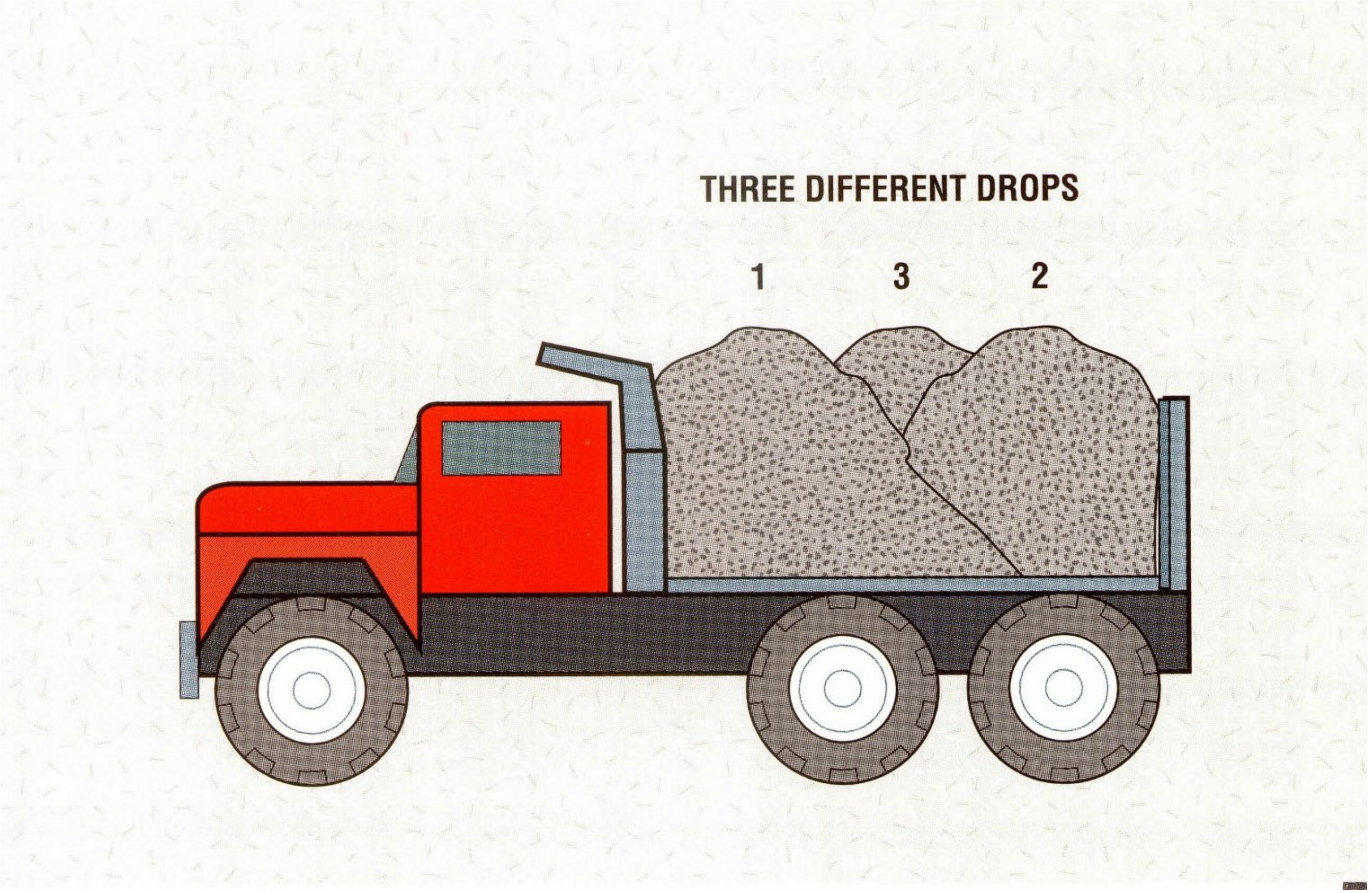
How Is It Prevented?

In Loading the Truck

- Three Drops
  - first drop: very near the front,
  - second drop: very close to the tail gate, and
  - third drop: in the center



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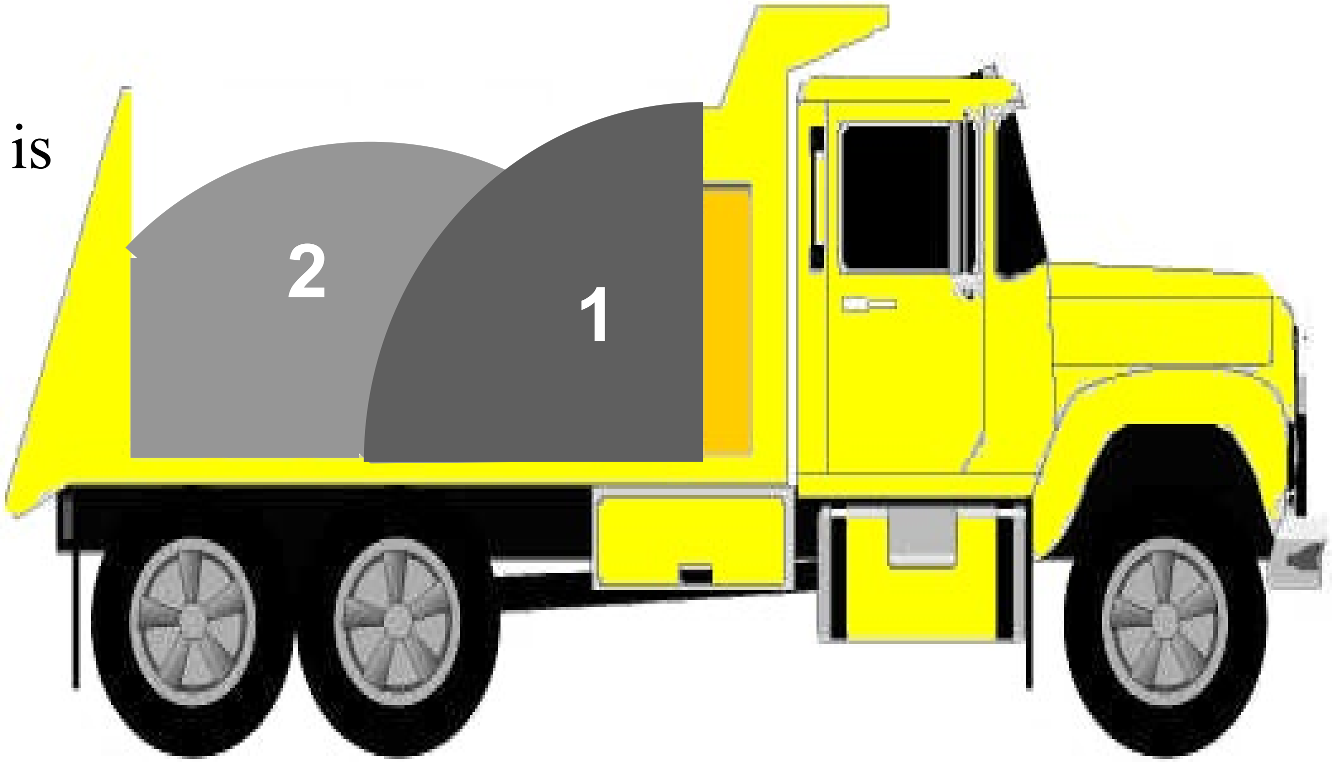
How Is It Prevented?

In Loading the Truck

- Two Drops

Two drops could be used when the truck is small, and capacity is limited.



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Segregation
Trouble Shooting

- **What is Wrong?**

Segregation
Source And Cause

- **Nothing!**
- **This is one beautiful mat.**

So, we discussed

- What Is Segregation?
- How Does It Happen?
- How Can It Be Prevented?
- What Action Needs To Be Taken?
- How Does Segregation Affect Pavement?

Thank You!

Performance Tests for Asphalt Mixes

Asphalt Plant Technician Certification

Update & Refresher Course 2022

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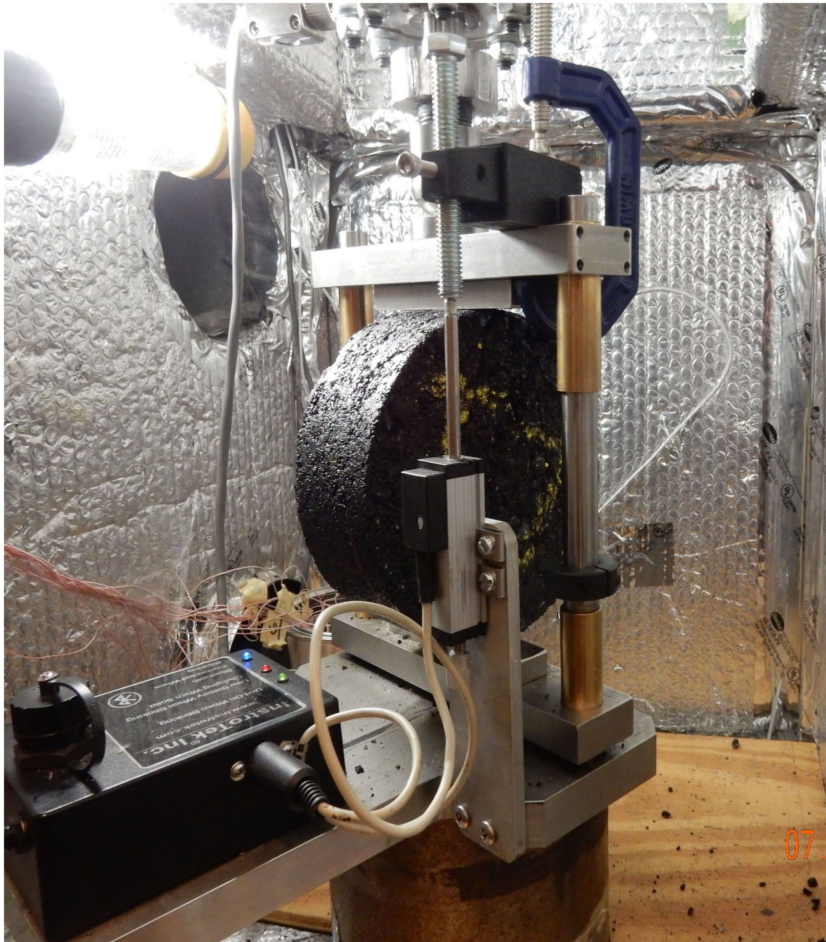

Discussion Topics

- **Background**
- **Testing Modes**
- **A Review of Performance Tests**
- **Results & Observations**

What is Performance Test for Asphalt?

Performance Test or
Performance Based Test

A Quantitative Mechanical **Test**
to Measure **Performance** of the Mix
as Related to Field Performance

Testing is integral to our QC Plans
but not all tests are performance tests.

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Have you done a stress test lately?

Performance Test…

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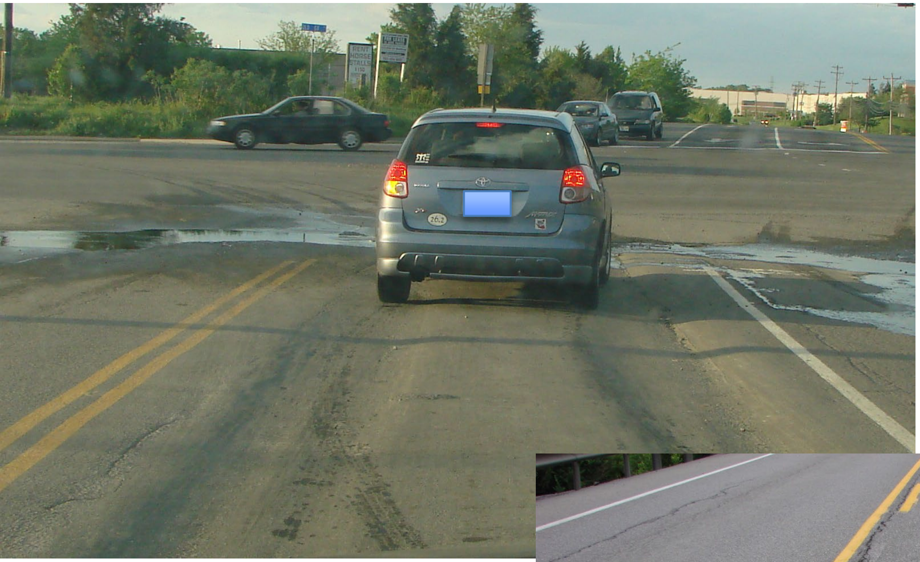
Asphalt Concrete LABORATORY PERFORMANCE TESTS

Is Your Mix Good and Healthy?

- Permanent Deformation (Rutting) ✓
- Moisture Induced Damage ?
- Low Temperature Cracking ?
- Fatigue Cracking ?

Field Performance (Pavement Distresses)



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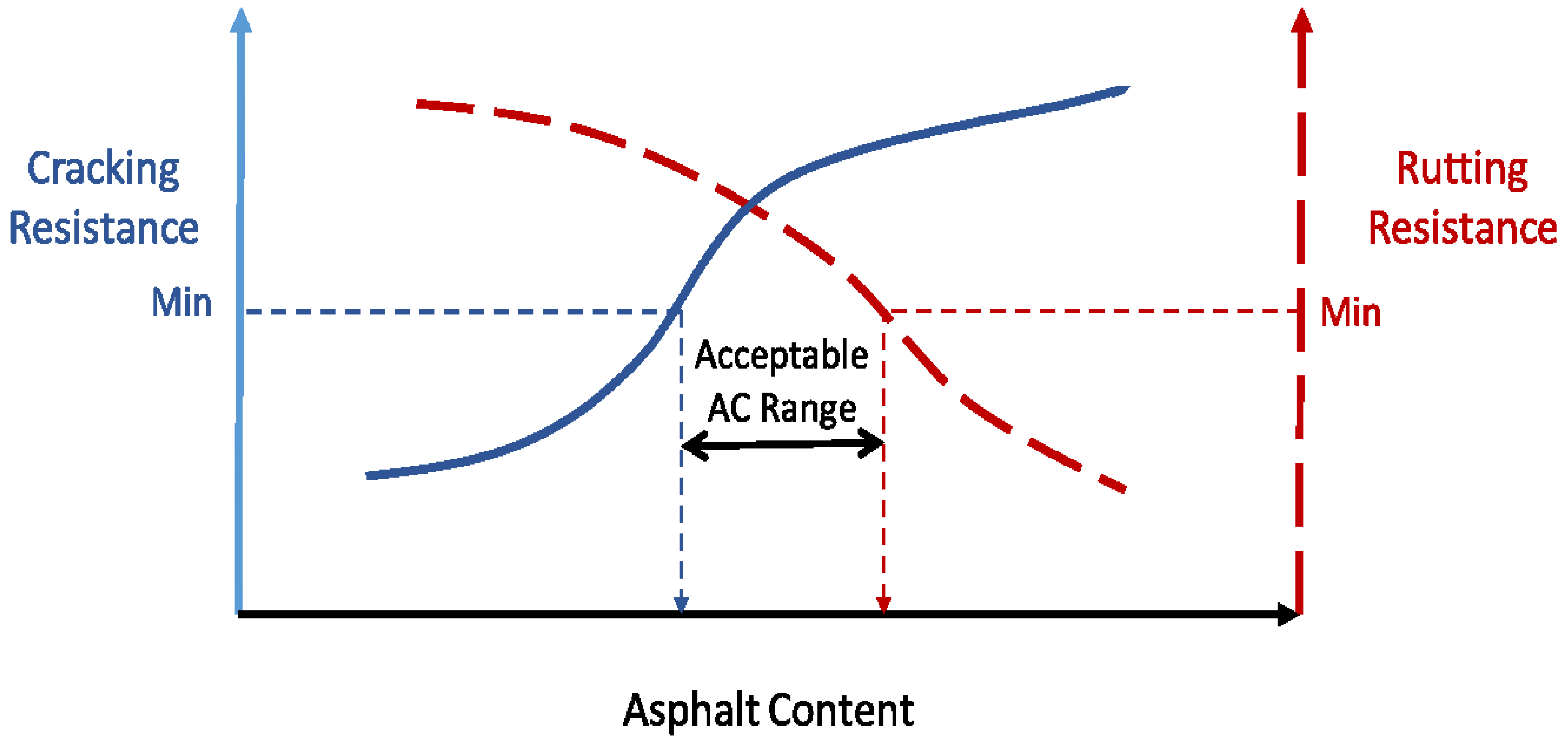
Design/Place A Mix that Does Not

RUT **CRACK**

Balanced Mix Design
The Goldilocks Principle

Balanced Asphalt Mix Design



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LABORATORY PERFORMANCE TESTS
Modes of Testing

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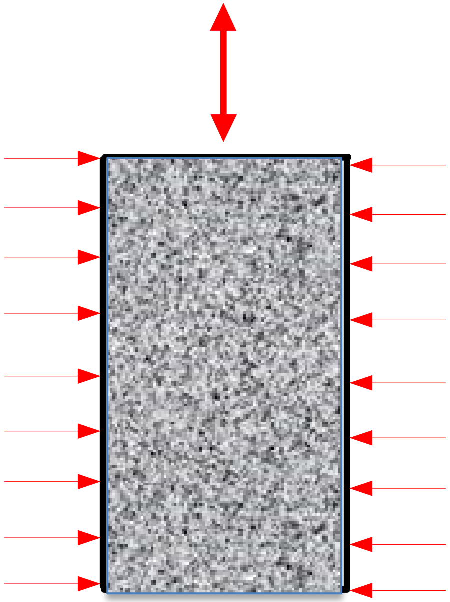
Loading Modes

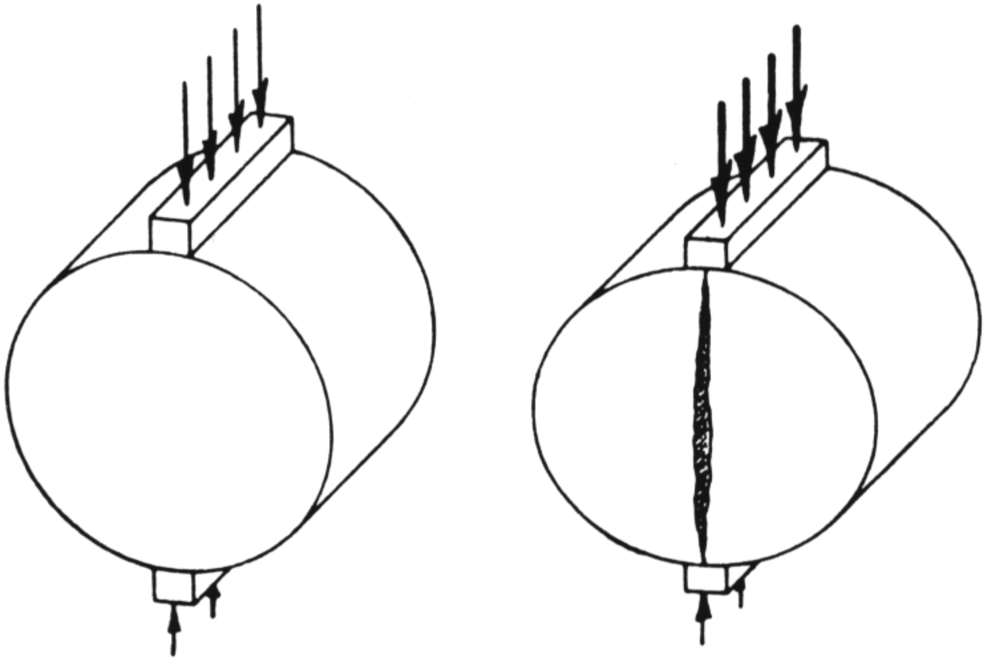
- Uniaxial Compression
- Uniaxial Direct Tension
- Indirect Tension
- Triaxial Compression
- Shear
- Flexure

Laboratory Tests on Asphalt Concrete

Triaxial Test

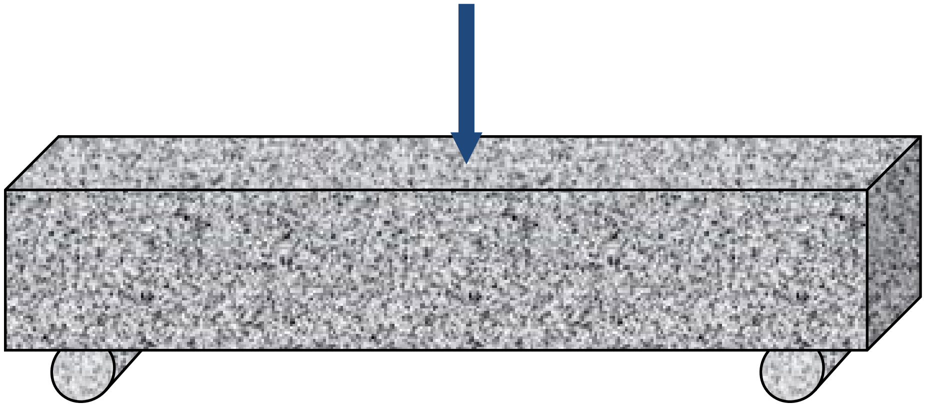


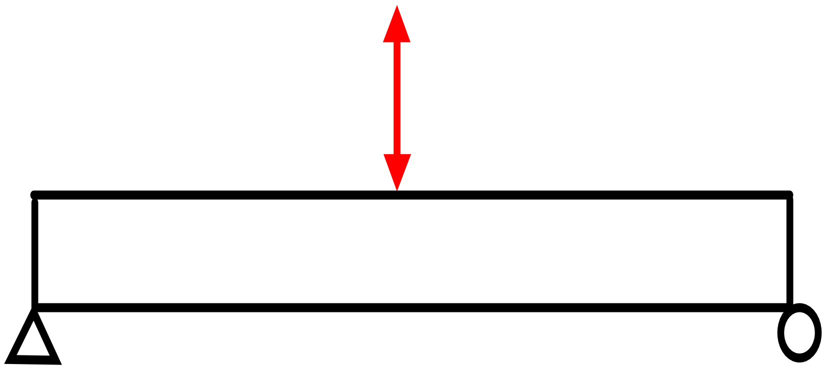
Indirect Tensile Test



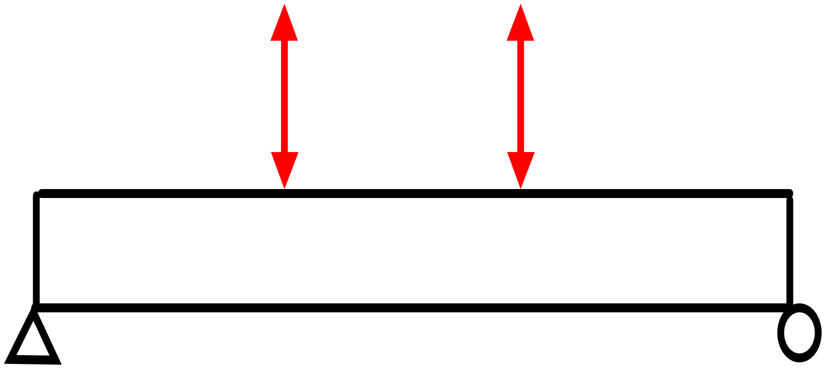
Laboratory Tests on Asphalt Concrete

Flexural Beam Test





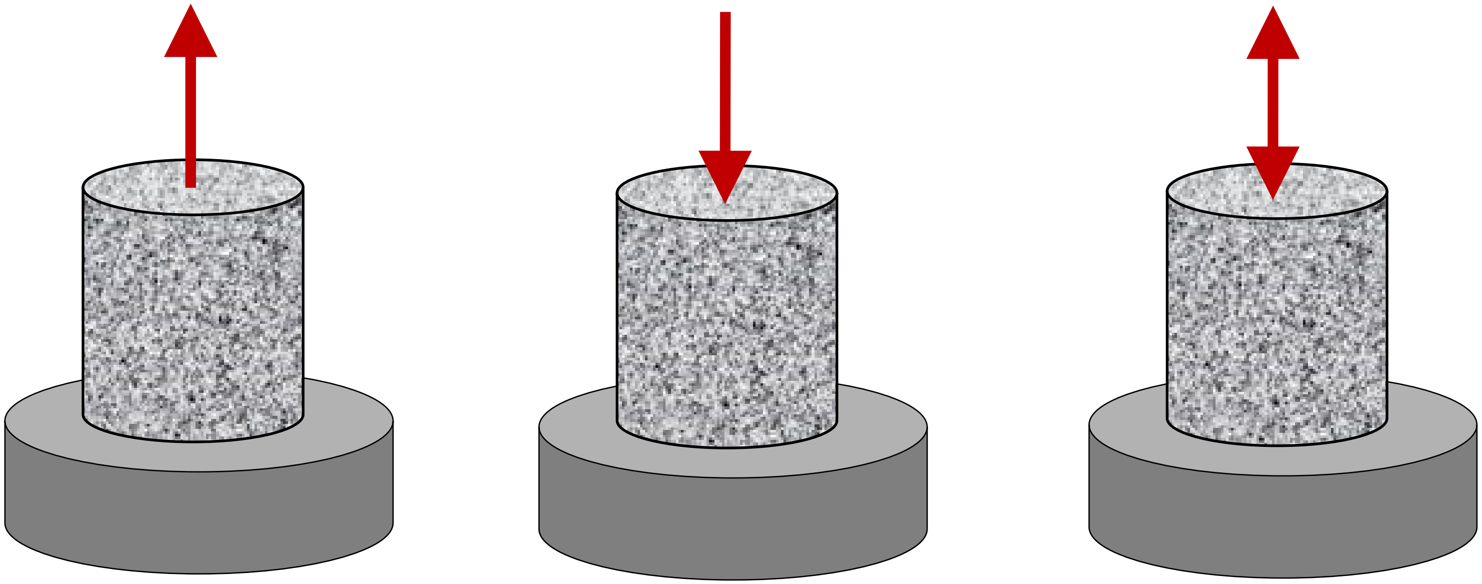
3-Point Bending Test



4-Point Bending Test

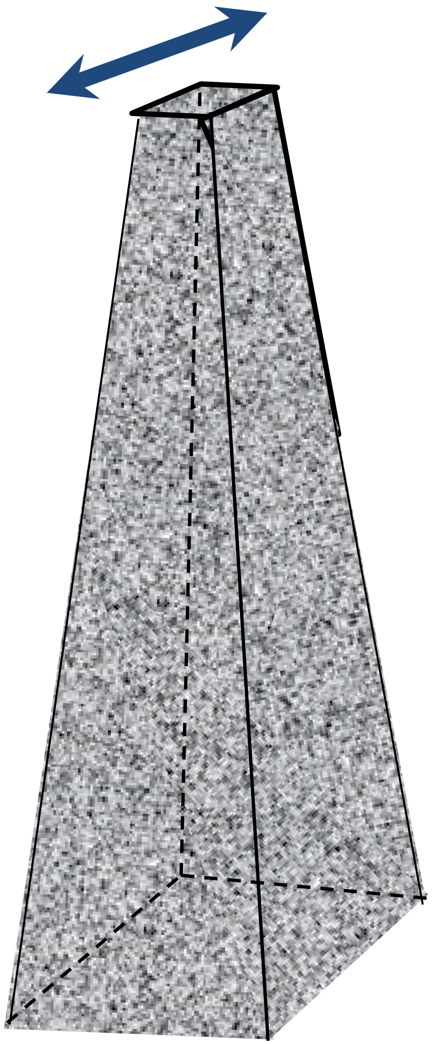
Laboratory Tests on Asphalt Concrete

- Uniaxial Tension
- Uniaxial Compression
- Cyclic Uniaxial Tension/Compression



Laboratory Tests on Asphalt Concrete

European Standard Test



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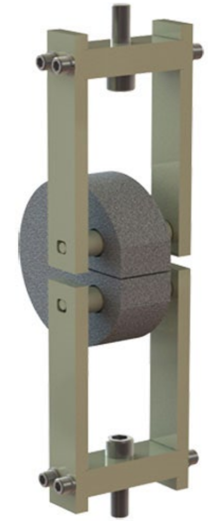
Lab Scale Tests

Monotonic Tests

- Indirect Tensile
- Semi-Circular Beam
- Disk-Shaped Compact Tension



Cyclic Tests

- Four Point Bending Beam
- Indirect Tensile
- Uniaxial Push-Pull
- Texas Overlay

Picture Curtesy: IPC Global, Umass, Penn State

How Old is Performance Testing of Asphalt Mixtures?

Very Old,
Almost 100 years.

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Preliminary Roads (No Performance Test)

John McAdam introduced compacted stone surface in 1815.

A Macadam Road
1850s, California

First Asphalt Roads (No Performance Test)

- First Modern Asphalt Road, 1858, Paris
- First Compacted Asphalt Pavement, 1869, London
- First Asphalt Roadway in US, 1870, Newark, NJ

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Rational Approach to Designing Asphalt

Charles Hubbard and Frederick Field (mid-1920s)
Hubbard Field Method of Design

- 2 inches Specimens compacted with a hand rammer.
- 6-inch specimens compacted with two different rammers. (Modified)

- First 30 “heavy blows” with the 2-inch rammer followed by 30 blows with a 5.75-inch rammer. Do both sides

- The specimen placed in a 10,000-pound load compression machine
- allowed to cool in a cold-water bath under compression

- Hubbard Field stability: Specimen squeezed through a ring slightly smaller than the specimen

- Design based on Air Void and Stability

Rational Approach to Designing Asphalt

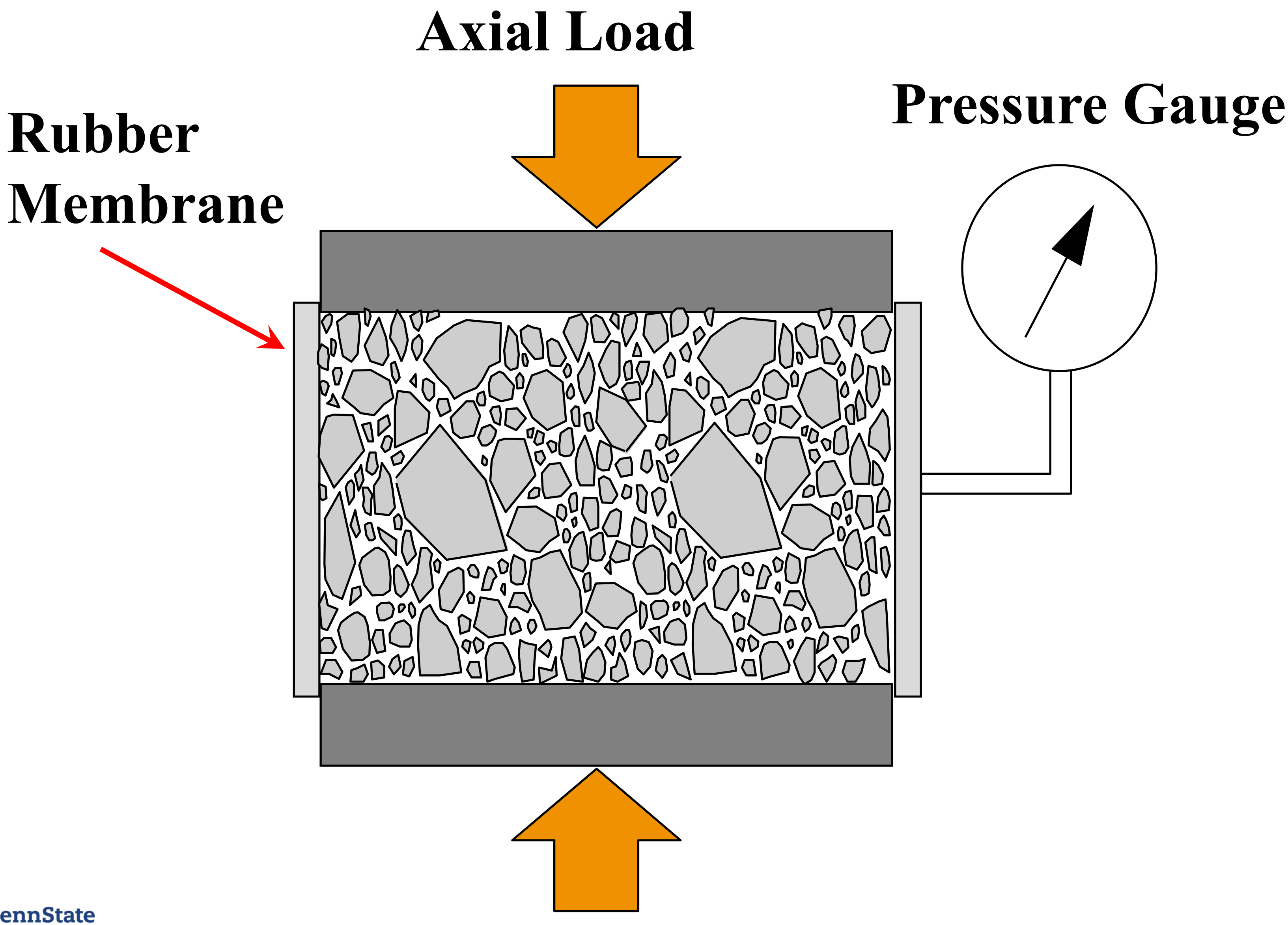
Introduced by Francis Hveem of California DOT in mid 1920's

Hveem Mix Design (includes Performance Test)

Kneading Compactor

Hveem Stabilometer

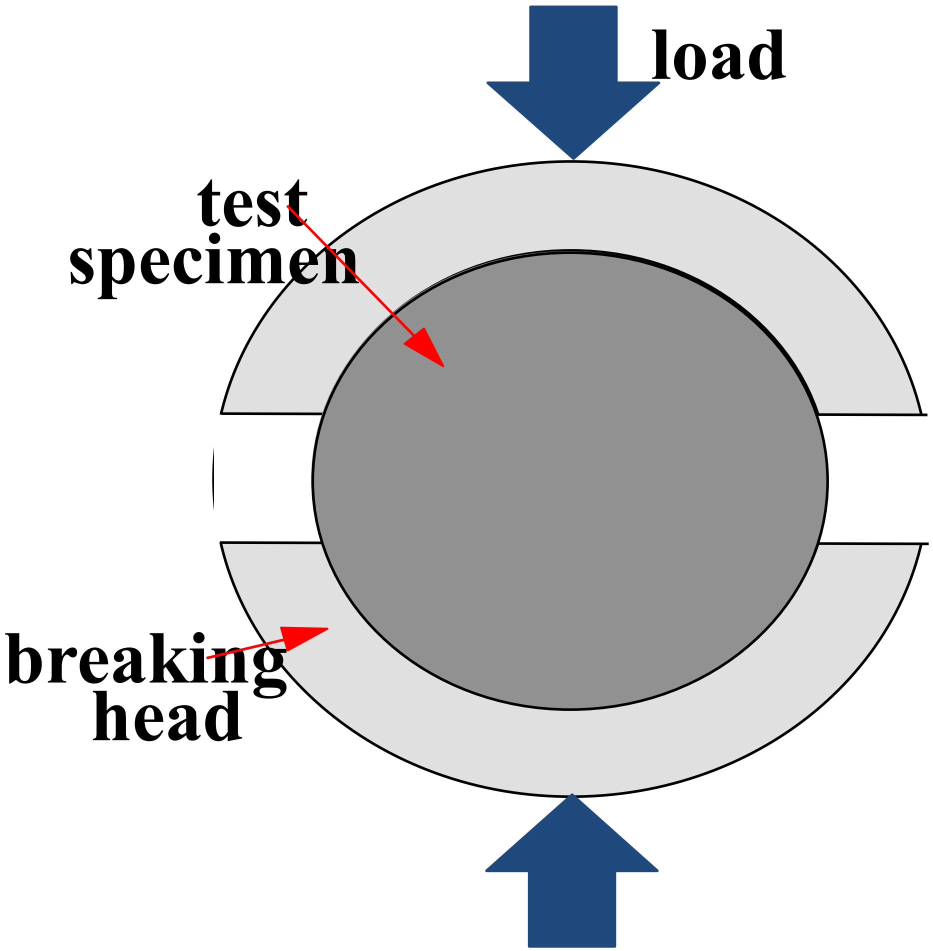
Hveem Test Using Stabilometer

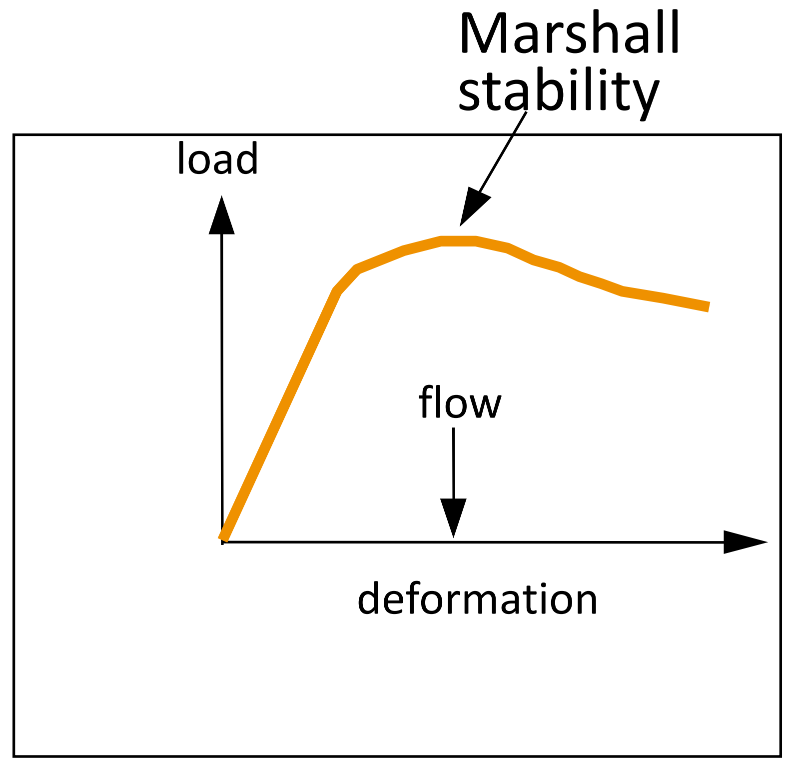


Marshall Mix Design (includes Performance Test)

Developed by Bruce Marshall for the Mississippi Highway Department in the late 1930's.

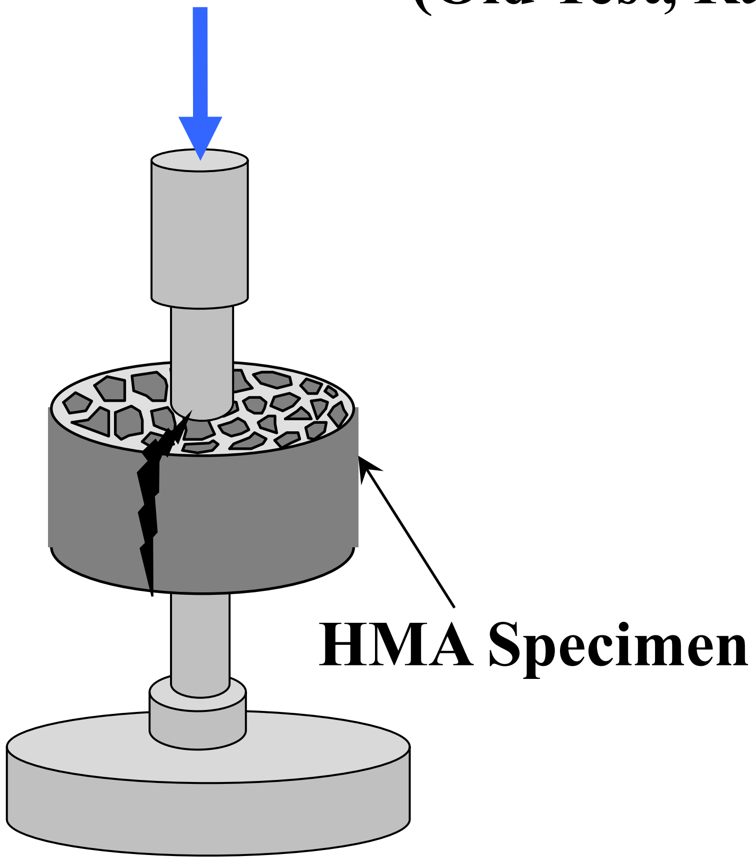
Marshall Stability and Flow





Asphalt Concrete Strength Test

Double Punch Test (Developed by Jimenez, 1974)
(Old Test, Rarely Used)



Derform. Rate: 25 mm/min

Punch Diameter:
D: 10, 16, 24 mm

Test Temp.: 25° C

Specimen Size:
H: 50, 101, 203 mm
D: 50, 101, 152 mm

FIELD PERFORMANCE TESTS
(Test Tracks & Accelerated Loading Facilities)

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Heavy Vehicle Simulator (HVS) US Corp of Engineers

Penn State Test Track

NCAT Test Track

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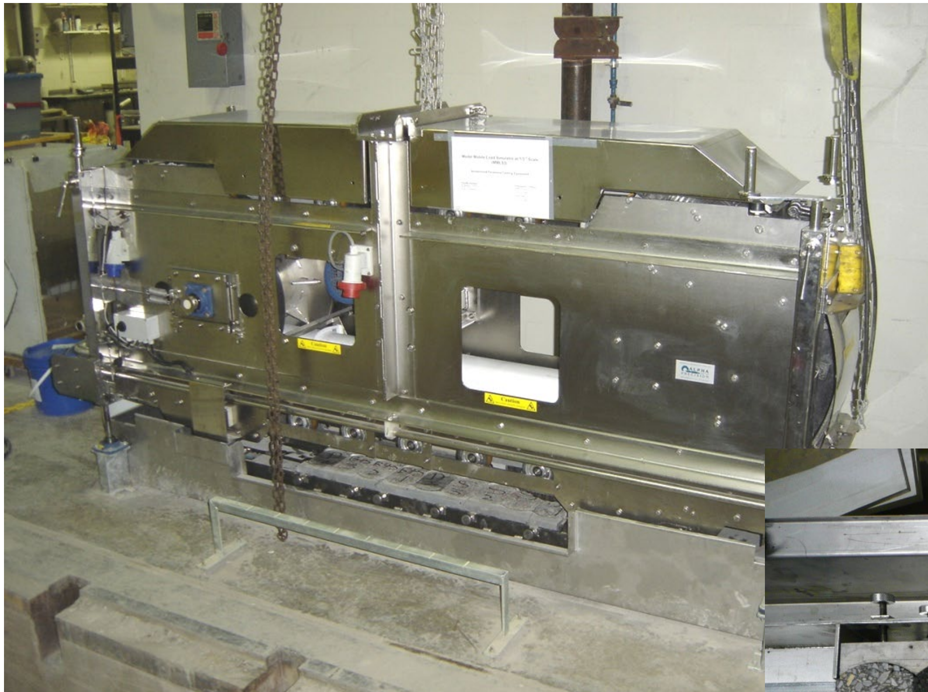
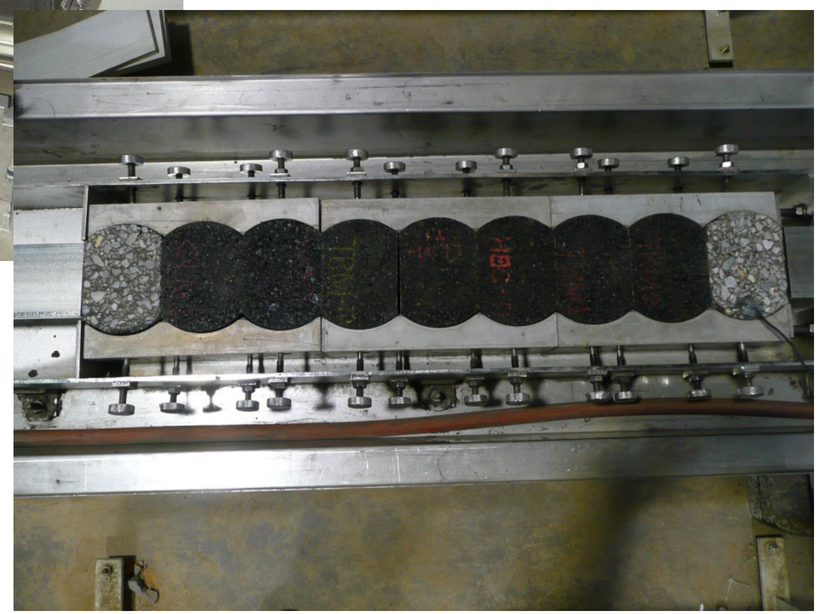
Accelerated Pavement Testing



3rd Scale Model Mobile Load Simulator (MMLS3)

Specimen Set-UP & Assembly



Accelerated Pavement Testing

Model Scale Accelerated Tests

- Third Scale Model Mobil Load Simulator (MMLS3)

Model Mobile Load Simulator (3rd Scale)

Accelerated Loading

Up to 100 psi pressure

Up to 600 lbs load

7200 passes per hour

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Examples of Performance Tests for Rutting/Moisture Damage

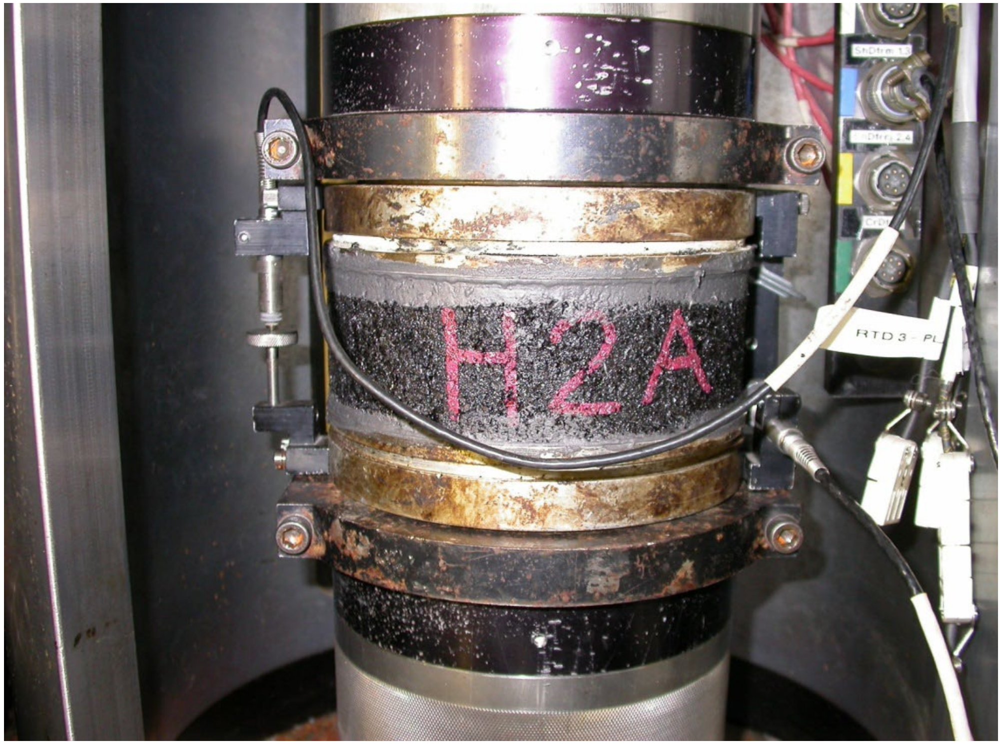
(Measurement of Engineering Properties)

Asphalt Concrete
Dynamic Modulus/Flow Test
(Rutting)

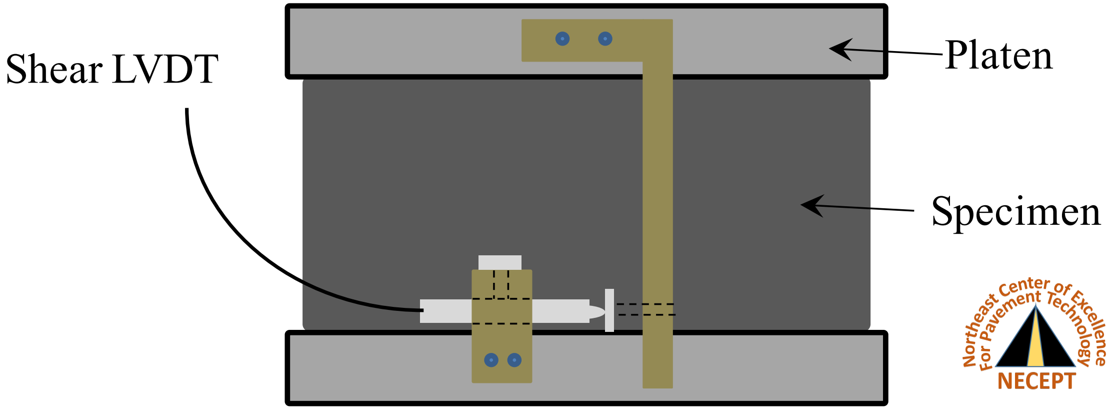
Specimens for DM and Flow Tests

Coring (left) and sawing (right) of a gyratory compacted specimen

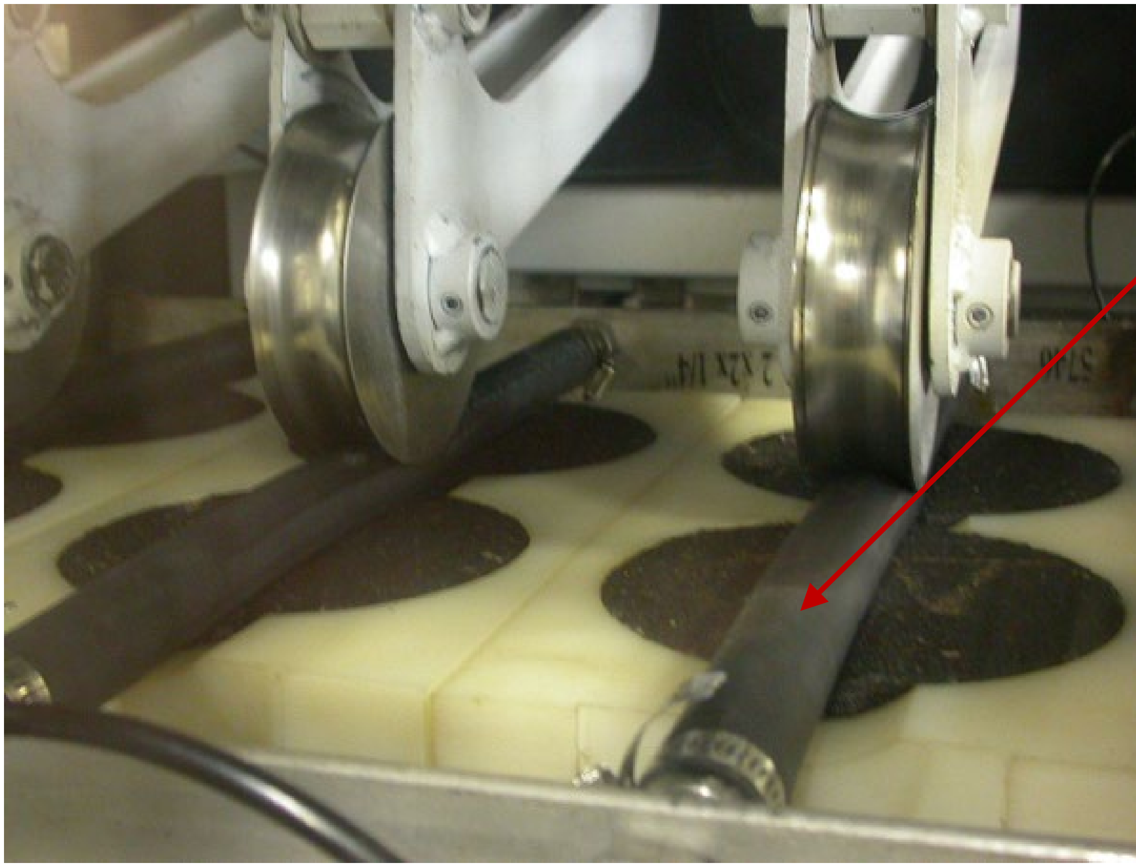
Shear Test
Rutting Test



Specimen glued at top & bottom



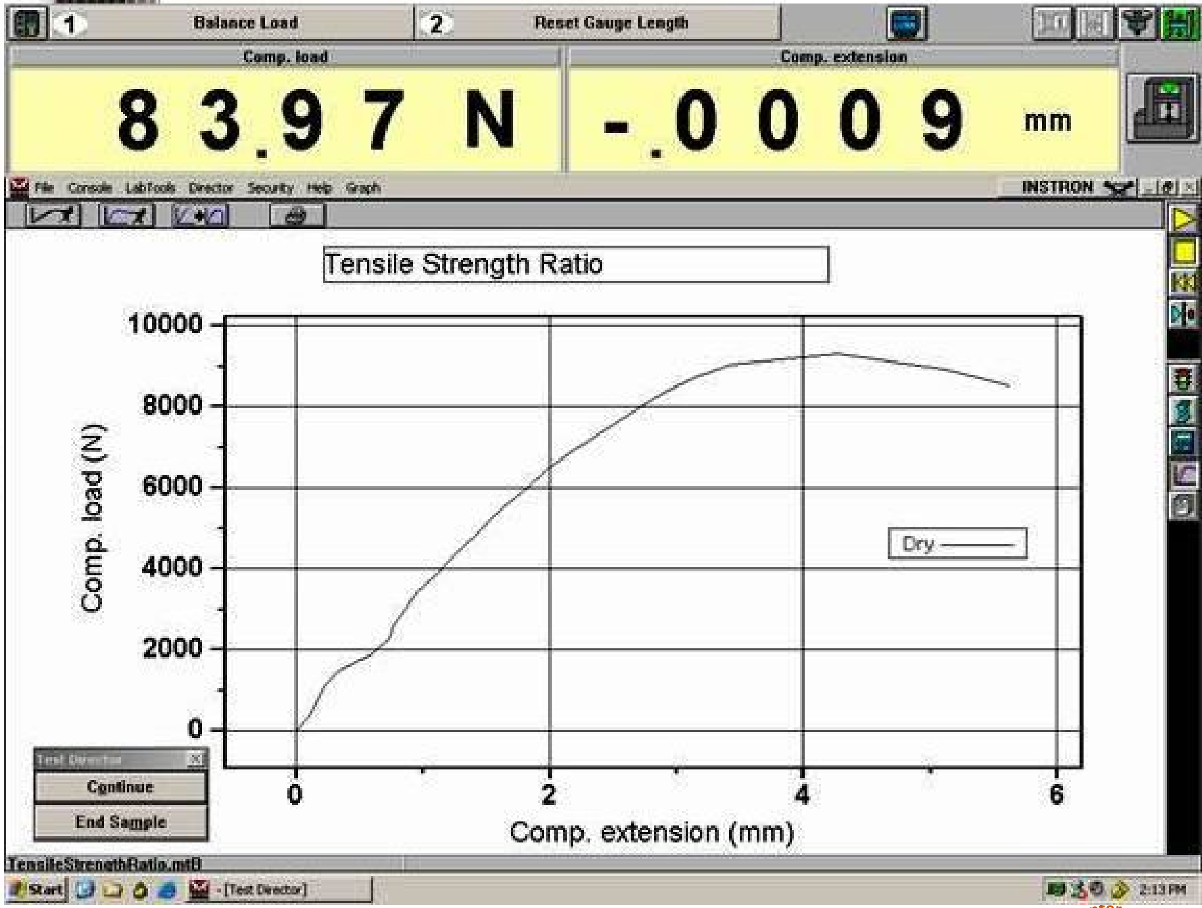
Asphalt Concrete Rutting Test



Pressurized Hose

Asphalt Pavement Analyzer APA)

Indirect Tensile Test (Moisture Damage)



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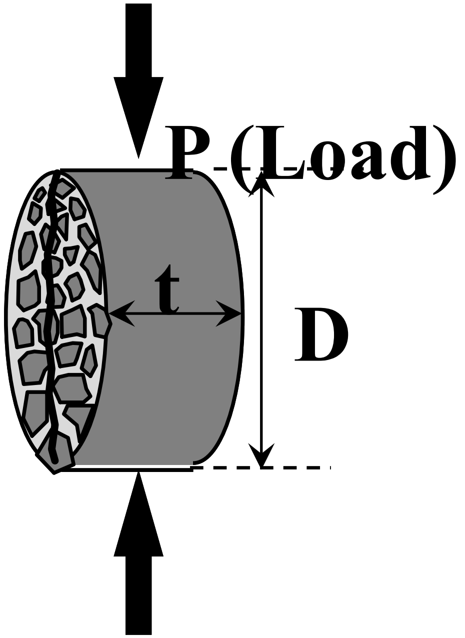
Resilient Modulus, ASTM D7369 Repeated Haversine Loading

$$\mu = \frac{3.588 + 0.2699\dfrac{\Delta V}{\Delta H}}{0.0627 - \dfrac{\Delta V}{\Delta H}}$$

ΔV = recoverable vertical deformation
ΔH= recoverable horizontal deformation
μ = Poisson's ratio



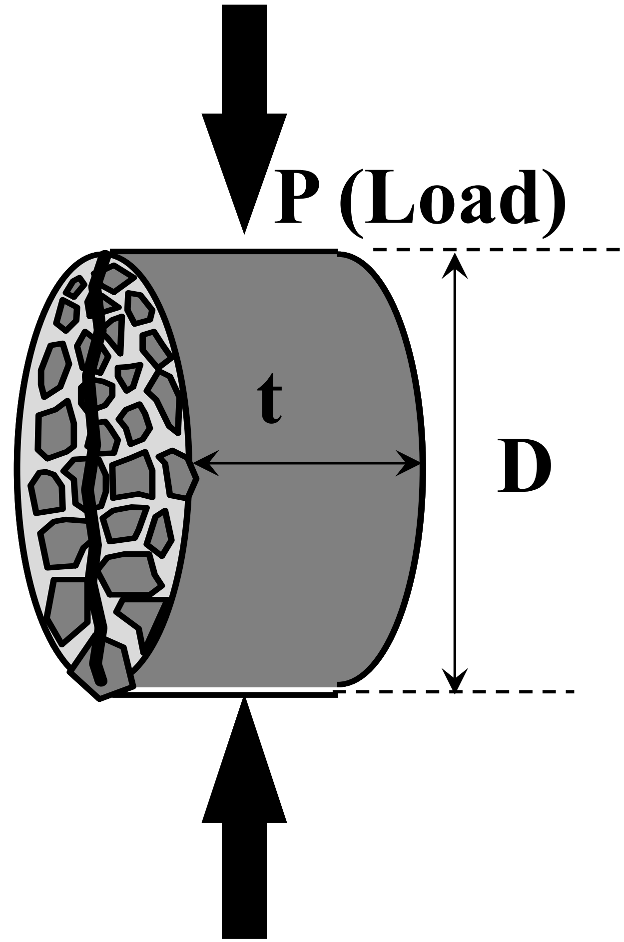
P = load
t = thickness
M_r = Resilient Modulus

$$M_r = \frac{P}{(\Delta H) x t}(0.2699 + \mu)$$

Asphalt Concrete
Creep & Strength Test at Low Temperature

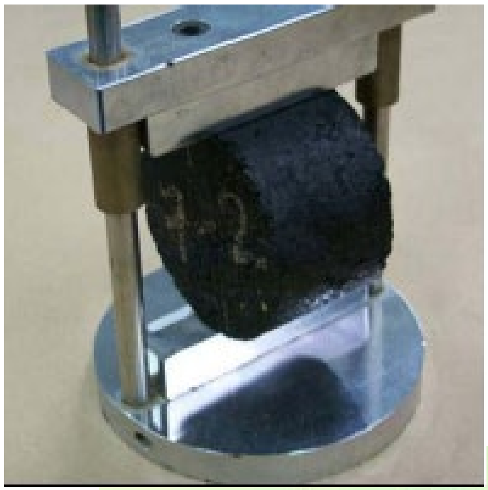
(for example, as input for Pavement ME)

Indirect Tensile Test



Moisture Damage Test

Modified Lottman Test (AASHTO T 283)



Uses Indirect Tensile Test

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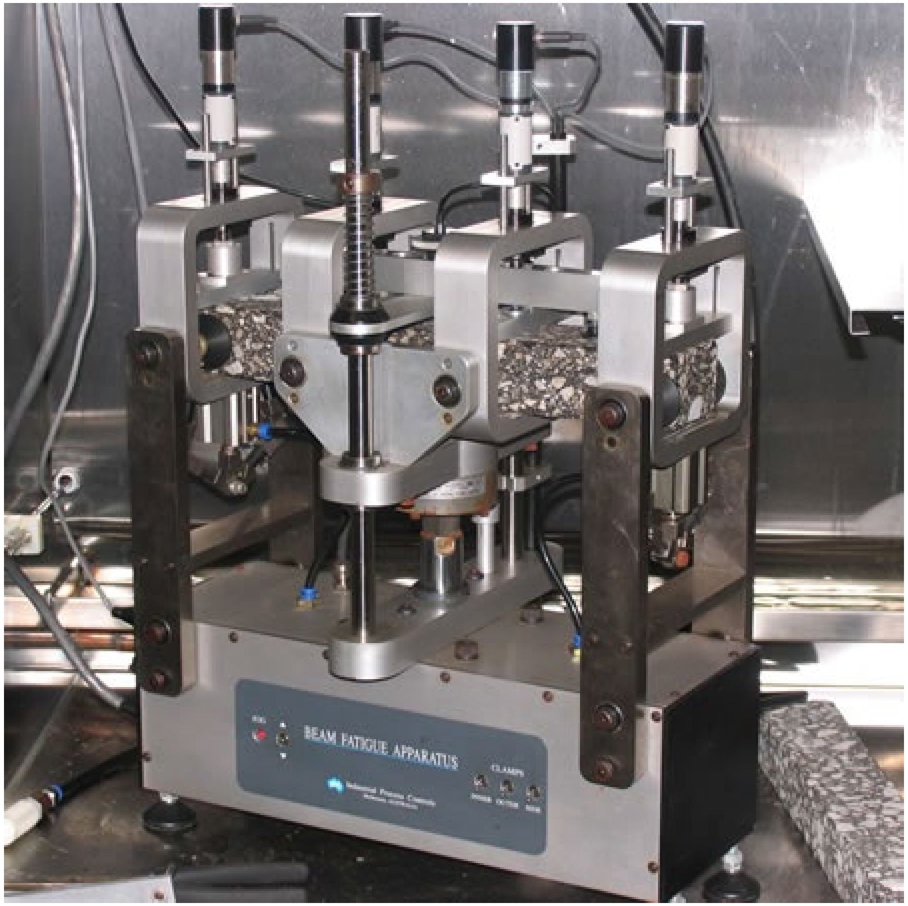
Asphalt Concrete Strength & Fatigue Test

4-Point Bending Test

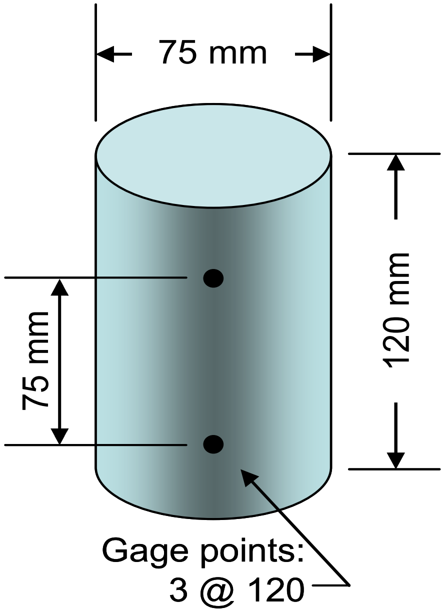
Repeated Loading Used



Test Conducted either Load Controlled or Deformation Controlled

Tension/Compression (Fatigue)

NOTE: Specimen is glued at the ends with double-component epoxy



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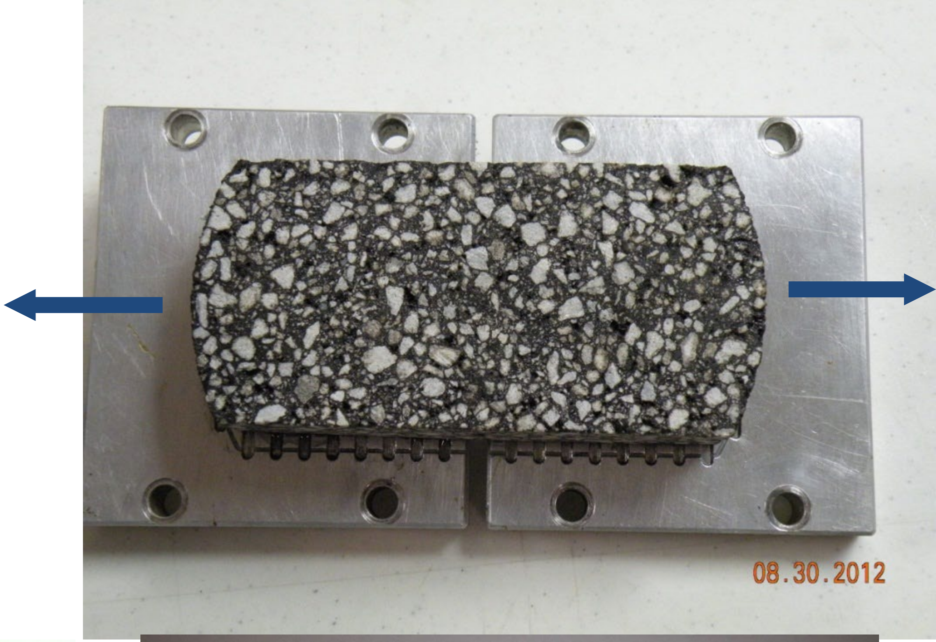
Lab Scale Tests (Cyclic Fatigue Tests)

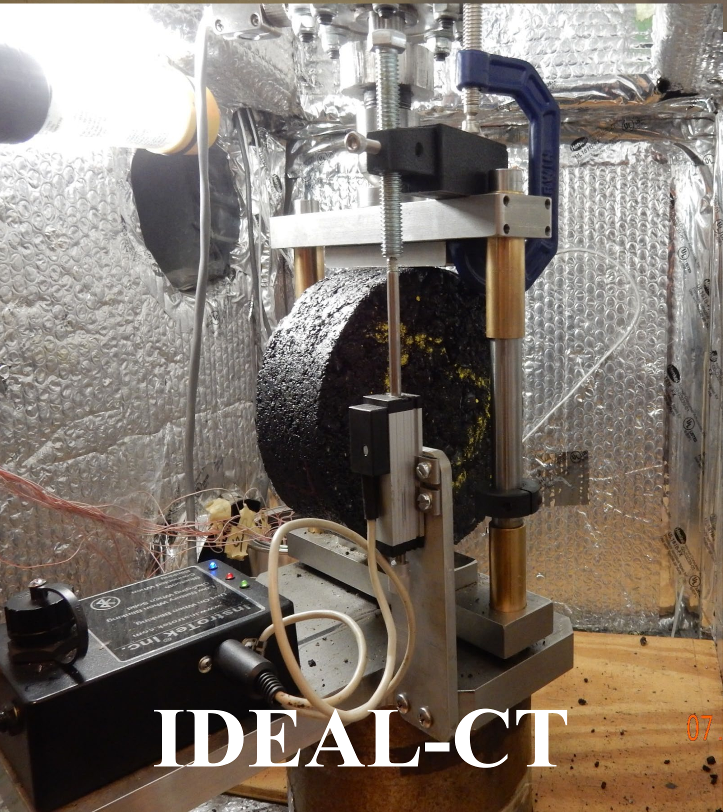
Texas Overlay Tester



PA Initiative on Performance Tests

- **Move to Performance Testing**
- **Initiated by Asphalt Quality Improvement Committee, PAPA, and PennDOT**
- **Industry Interested in Accelerating Move to Performance Testing**

PA Looking into Performance Tests



Performance Tests for Rutting/Moisture Damage

(Torture Tests)

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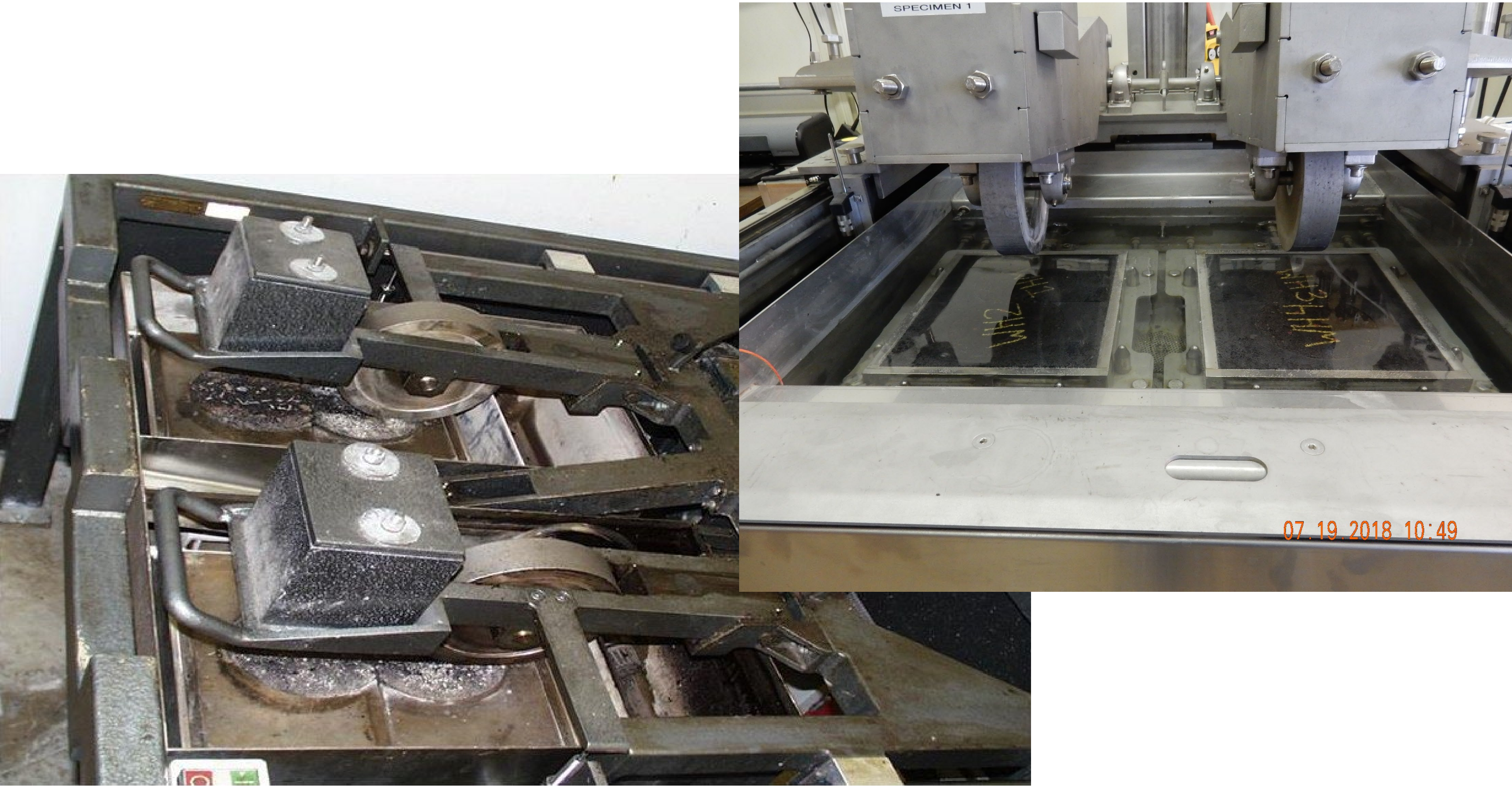
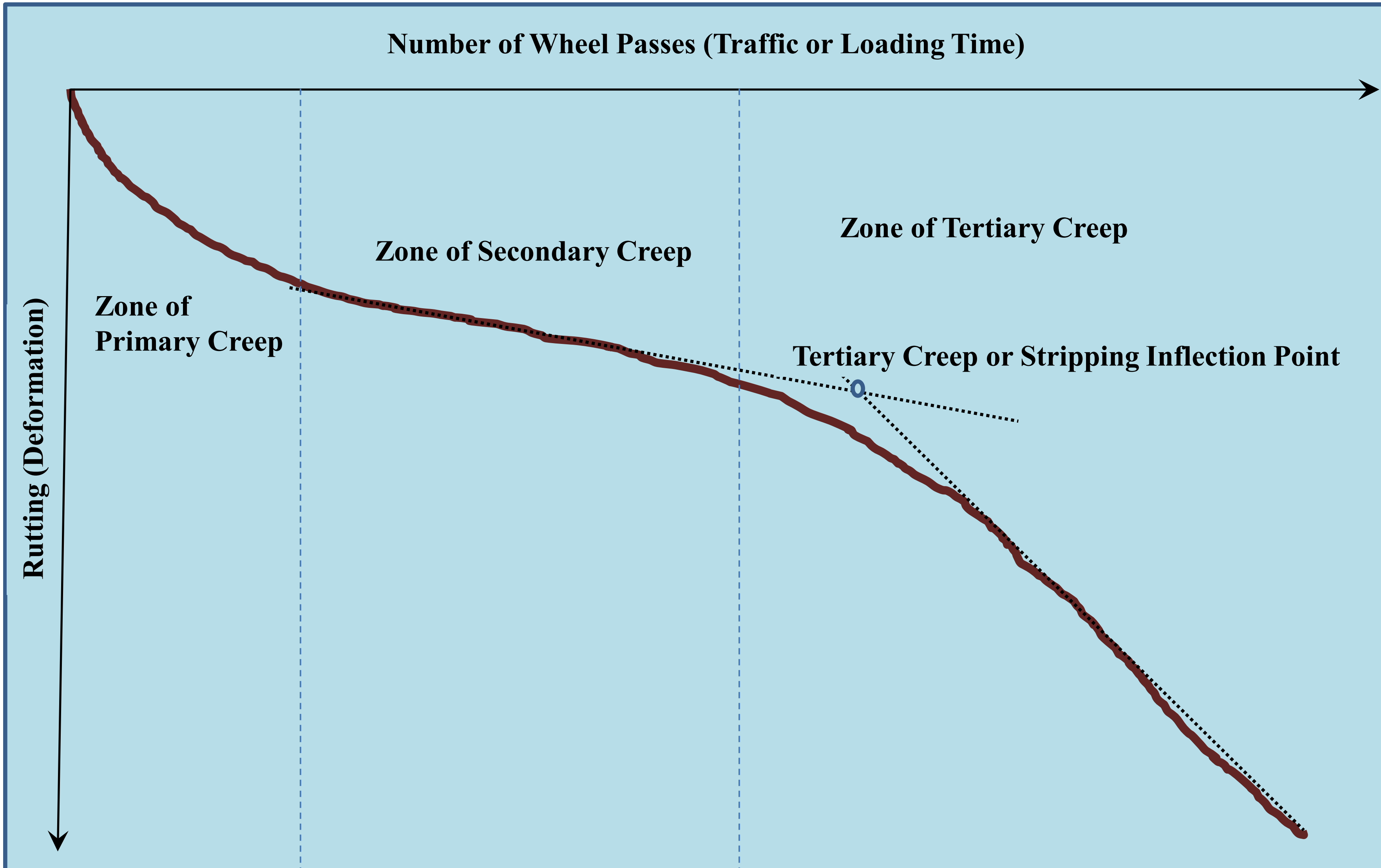
Asphalt Concrete
Strength/Moisture Resistance Test



Hamburg Wheel Tacking Device (HWTD)

Rutting/Moisture Damage Test



Binder Stiffness Effect

Hamburg Wheel Tracking

PG 64-22
6,200 passes
> 12.5 mm

PG 70-22
13,300 passes
> 12.5 mm

PG 76-22
20,000 passes
7.2 mm

TxDOT Research

Use Right Additive

TxDOT Research

PG 76-22,
Limestone,
2% Lime,
18,900 passes,
> 12.5 mm

PG 76-22,
Gravel,
1% Lime,
20,000 passes,
> 2.9 mm

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NECEPT

Use Right Additive

TxDOT Research

PG 76-22,
Limestone,
2% Lime
18,900 passes
> 12.5 mm

PG 76-22,
Limestone,
0.5% HP
20,000 passes
= 5.8 mm

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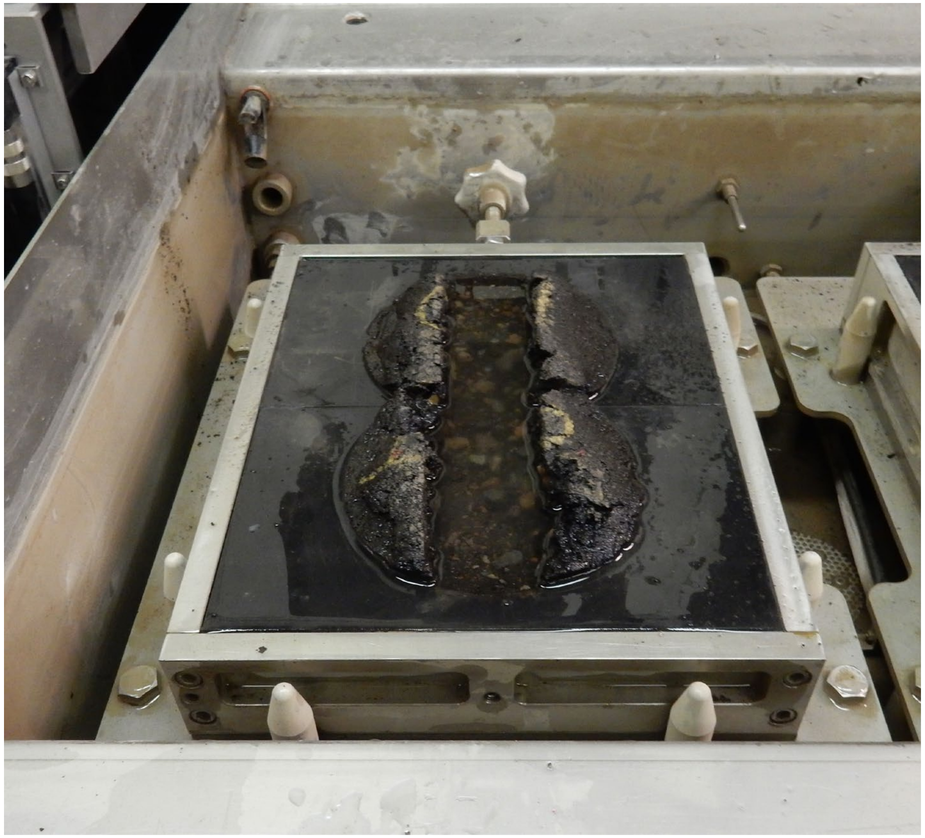
HWT - Submerged

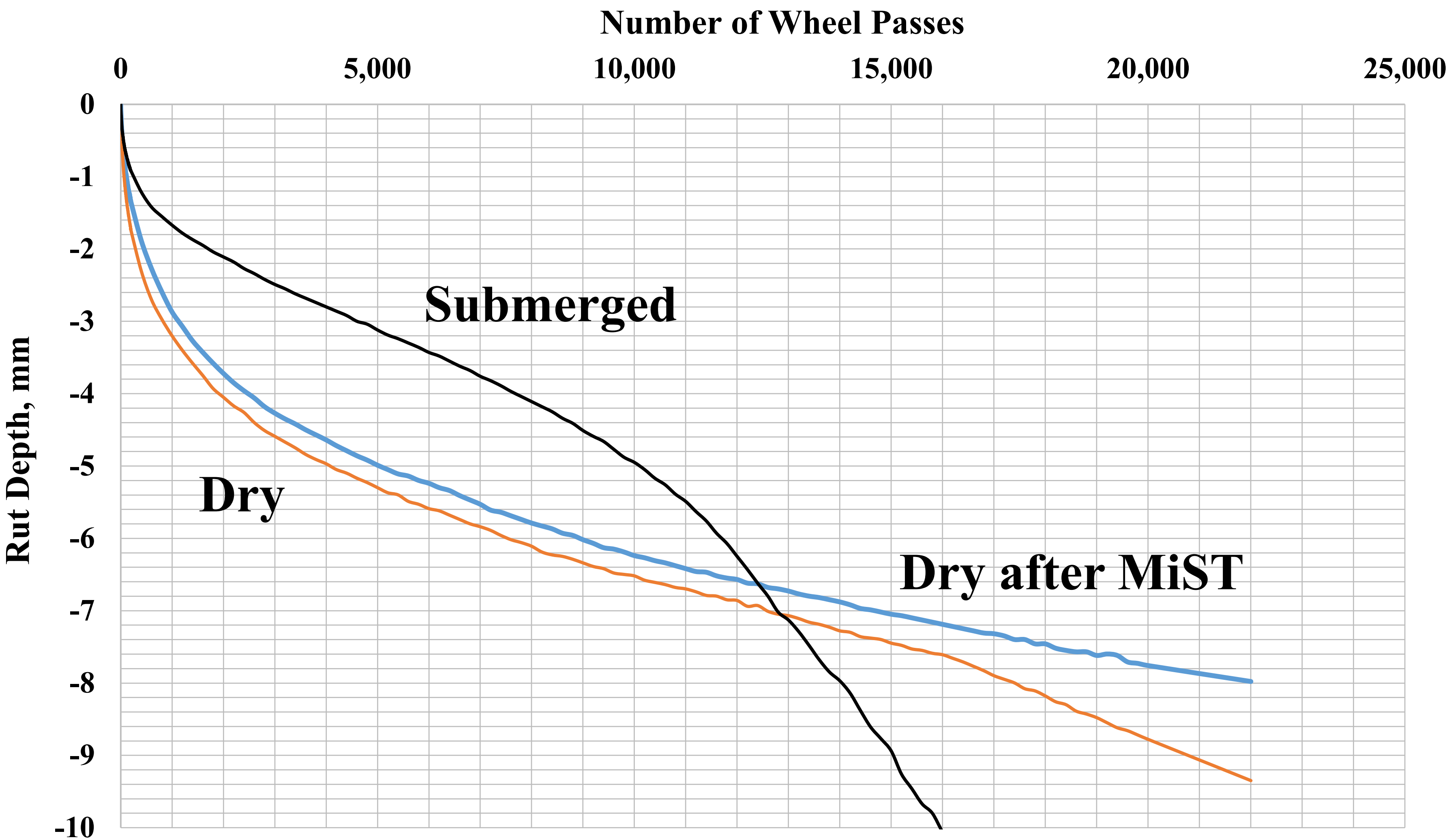
SP 9.5 mm - Local Limestone Aggregate

PG 58-28, Tested under water



PG 58-28, Tested dry

HWT Results



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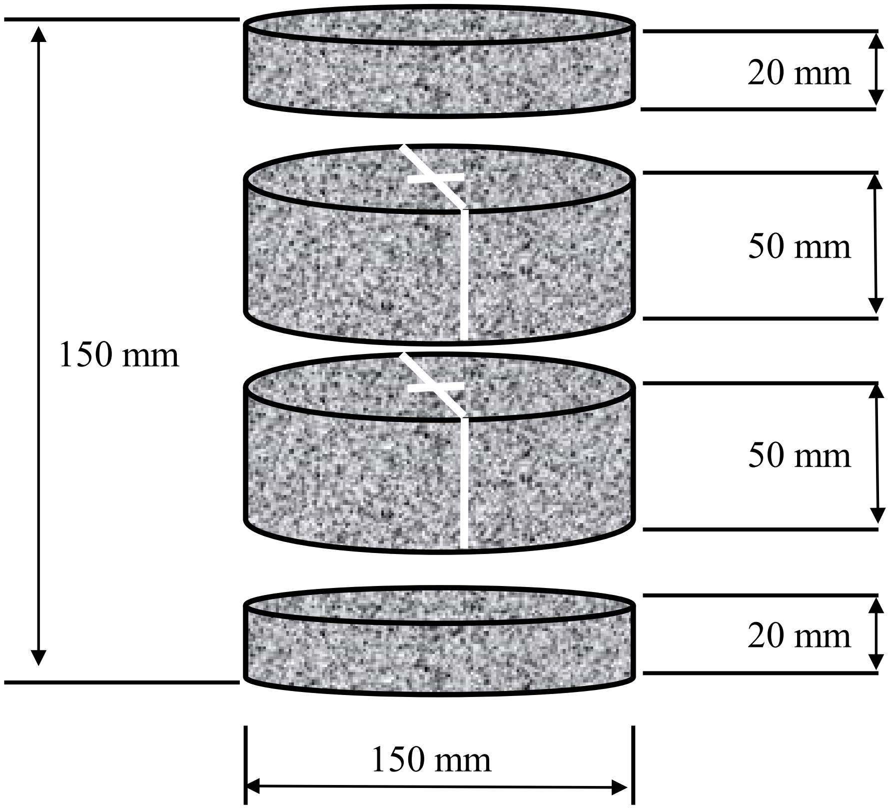
Lab Scale Tests
(Monotonic Fatigue Tests)

Semi-Circular Bend Test



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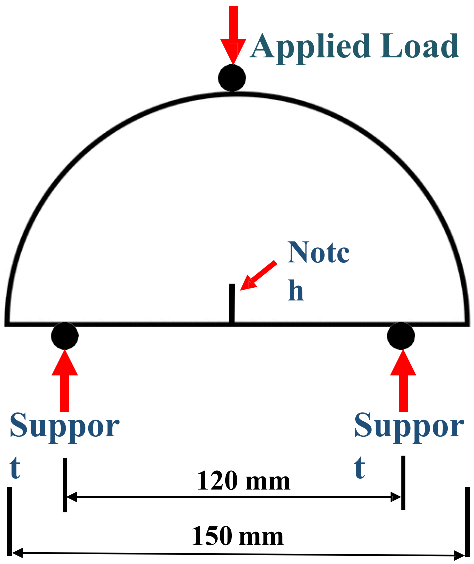
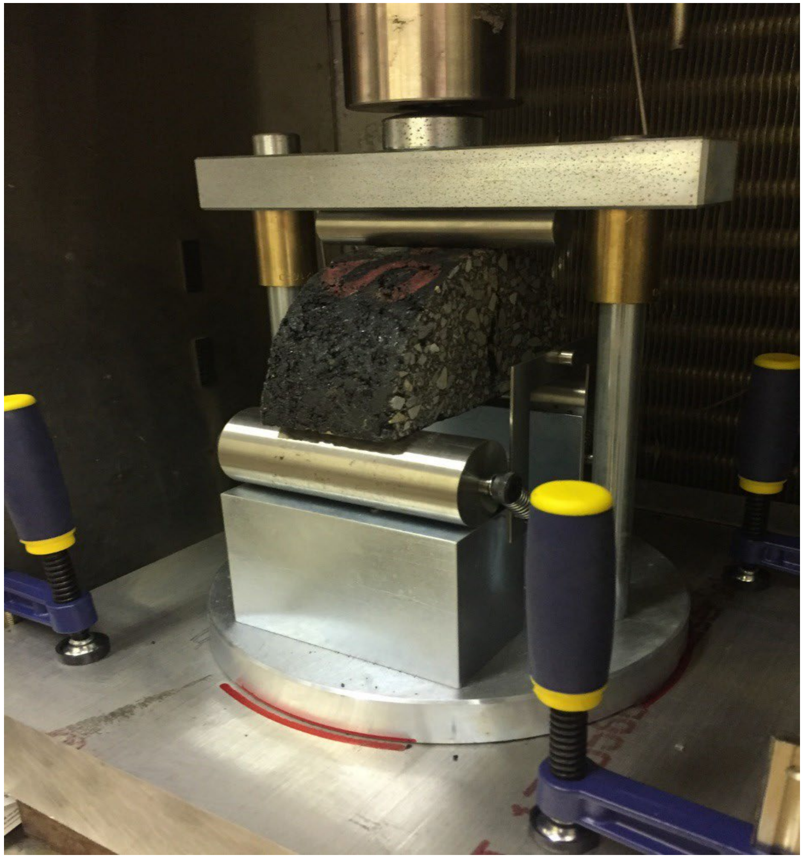
SCB Test Setup



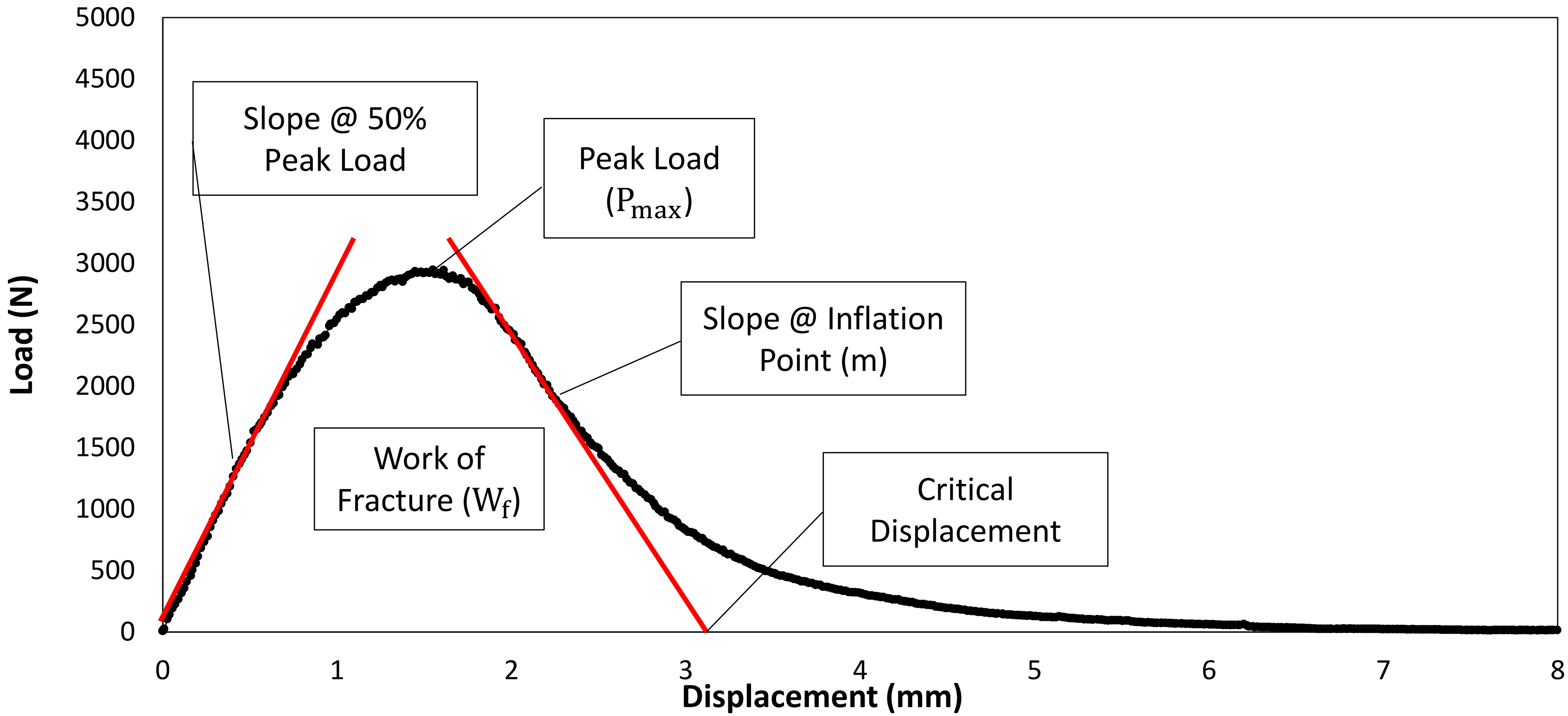


Specimen Thickness: 50
mm Notch Depth: 15 mm
Notch Width: 1.5 mm

Specimens After Cutting
Ready for Testing

Specimens Before (L) / After (R)
Testing

Parameters Used For Evaluation



Fracture Energy

$$G_f = \frac{W_f}{B \cdot L}$$

B: Specimen Thickness

L: Ligament Length

Flexibility Index

$$FI = A \times \frac{G_f}{abs(m)}$$

A: Constant

Stiffness Index

Slope @ 50% Peak Load in Pre-Peak Curve

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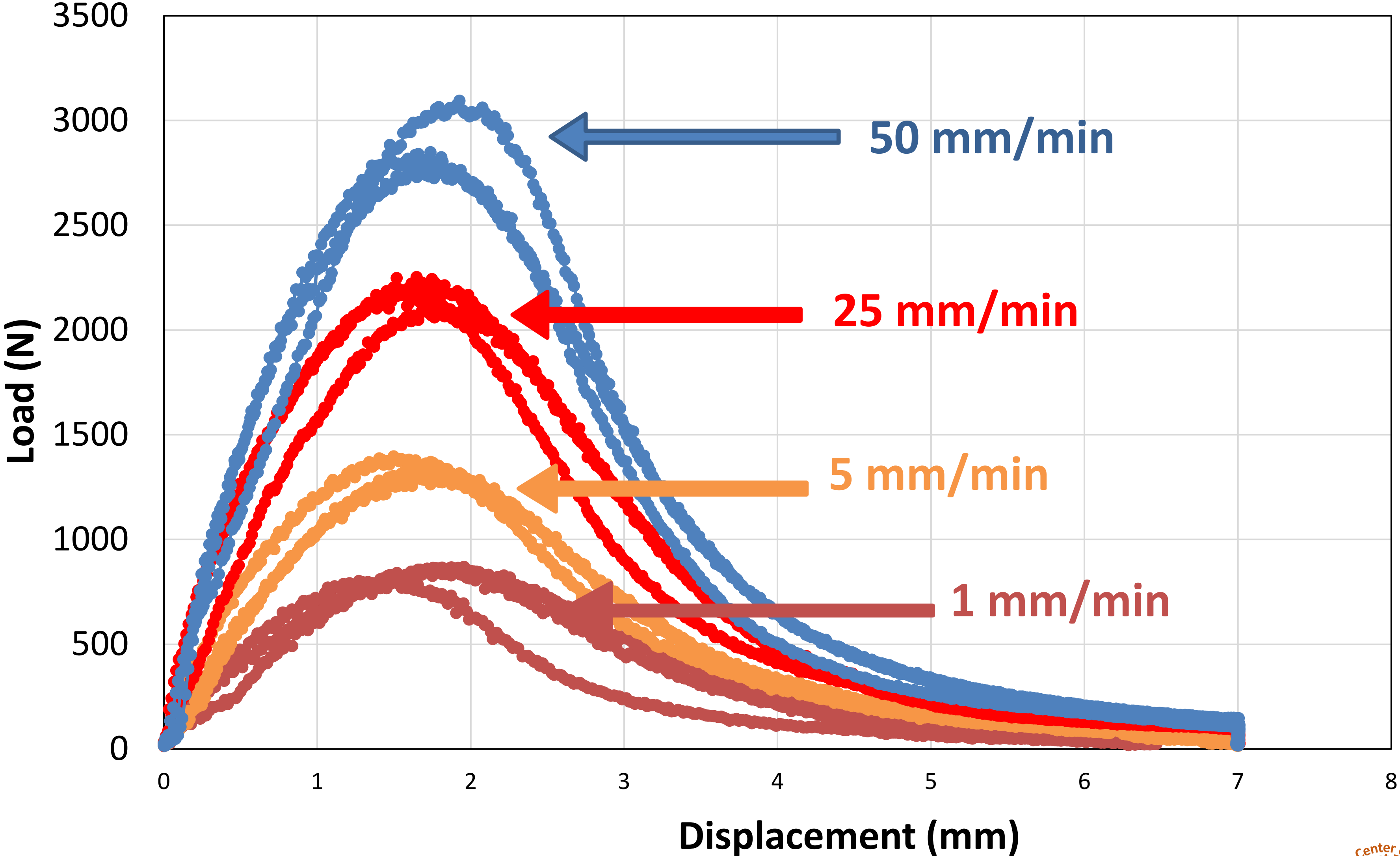
Typical Load vs Displacement Curves
3 Replicates, PG 58-28, 25°C



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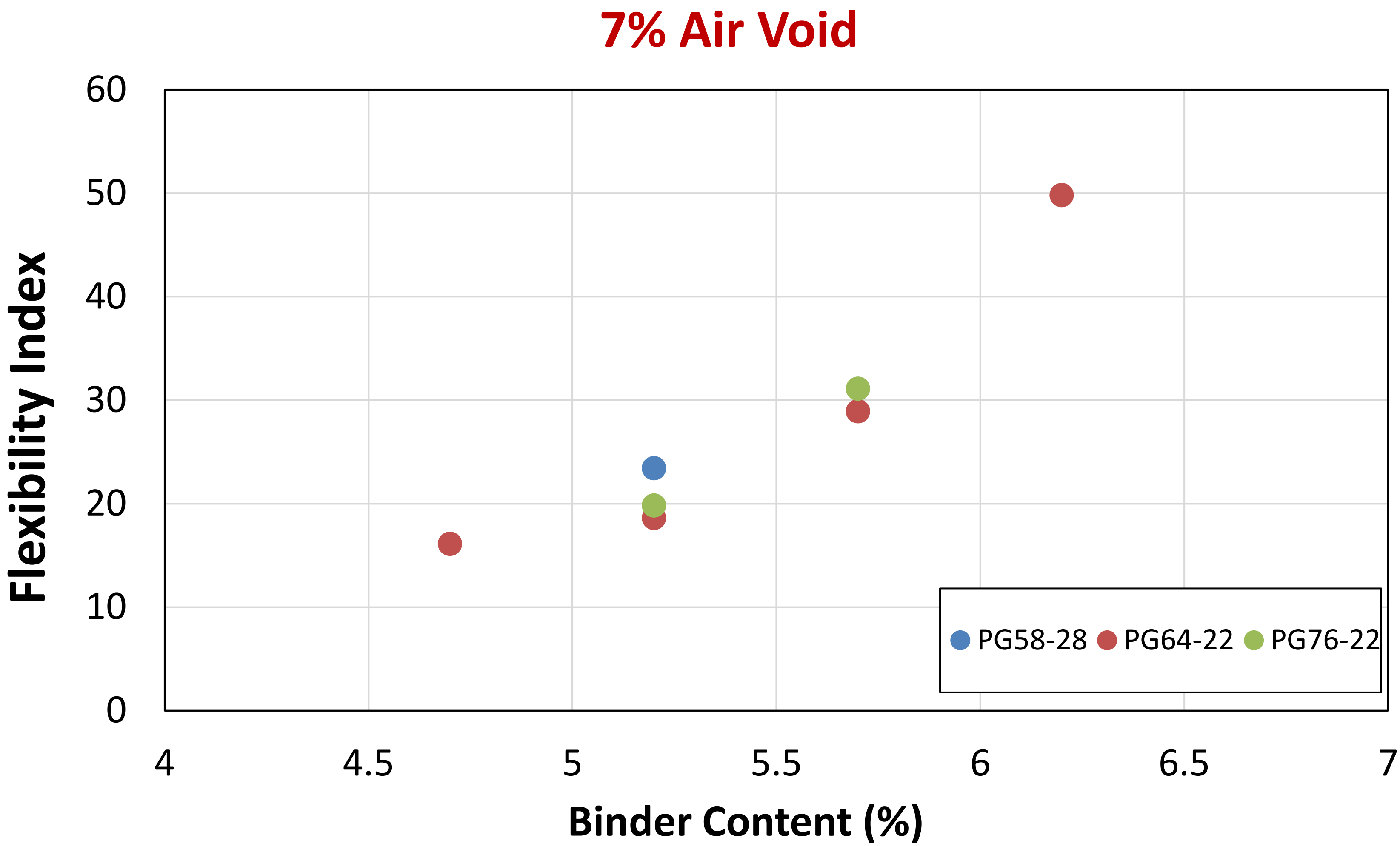
Effect of Binder Content



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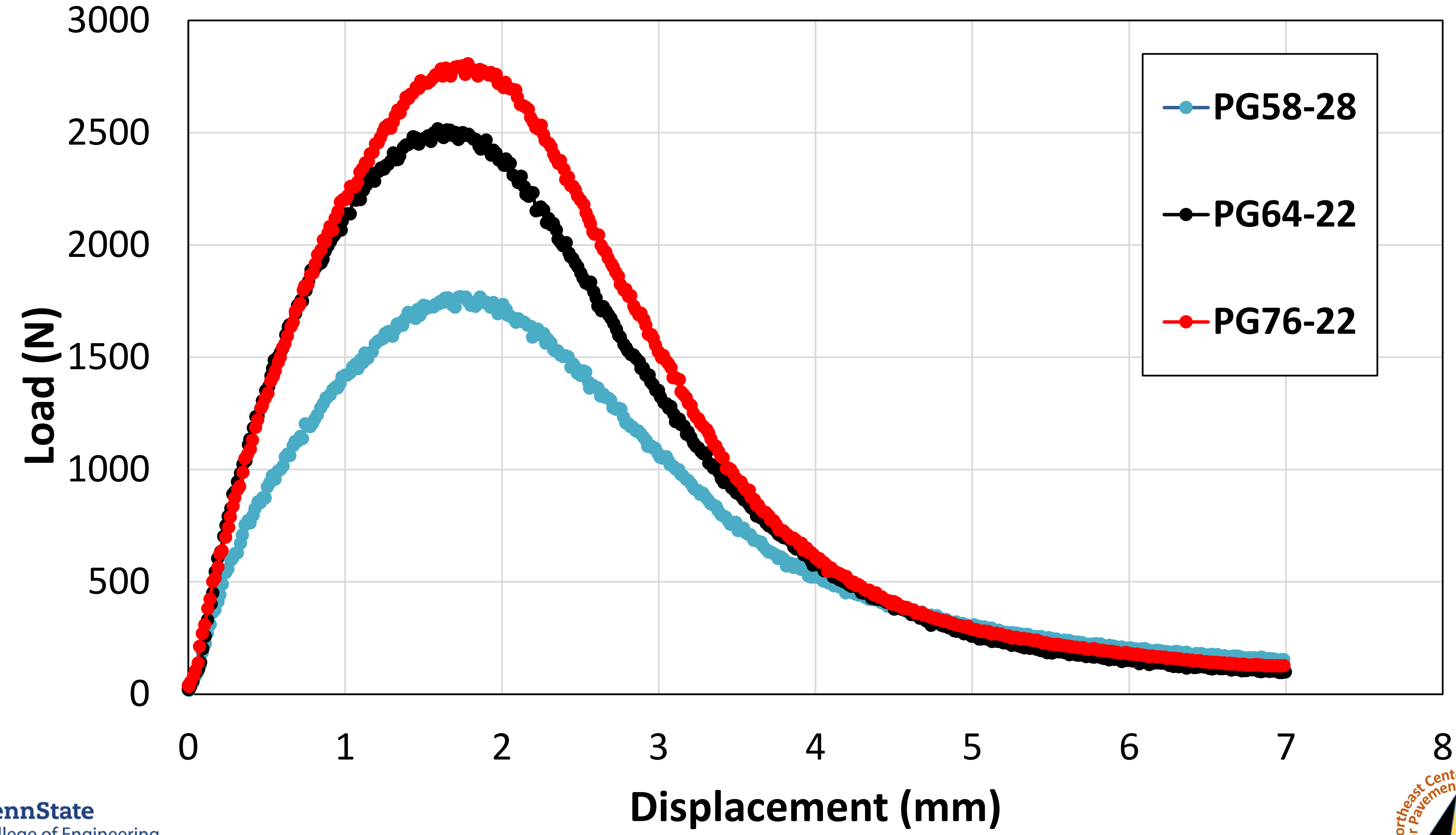
Effect of Binder Grade (Stiffness)

STOA, 7% AV, 5.2% BC



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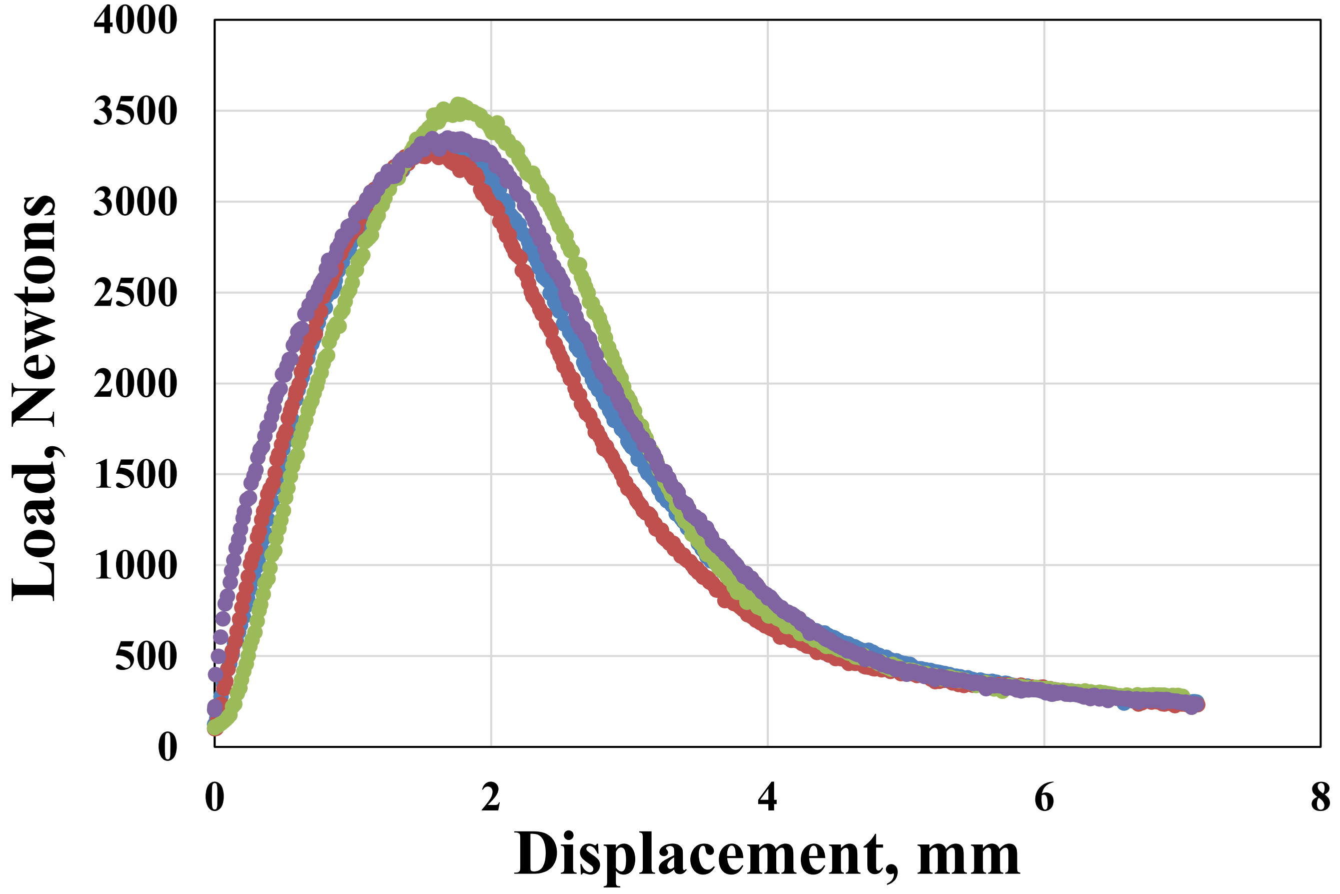
A Typical High Quality Test Result



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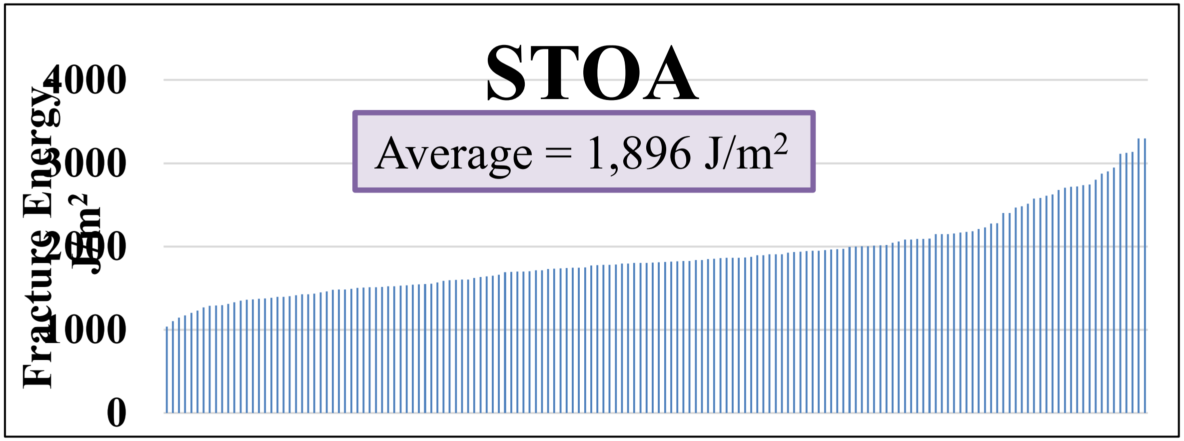
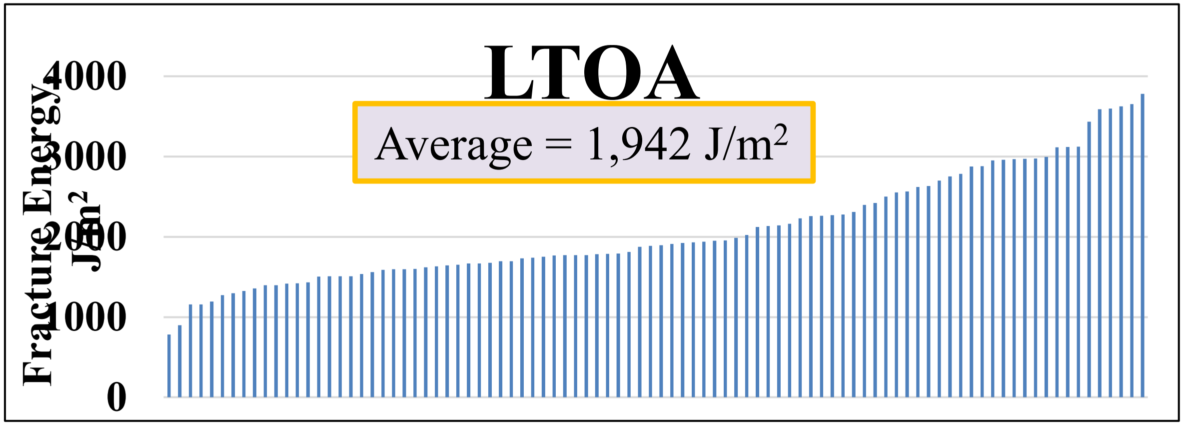
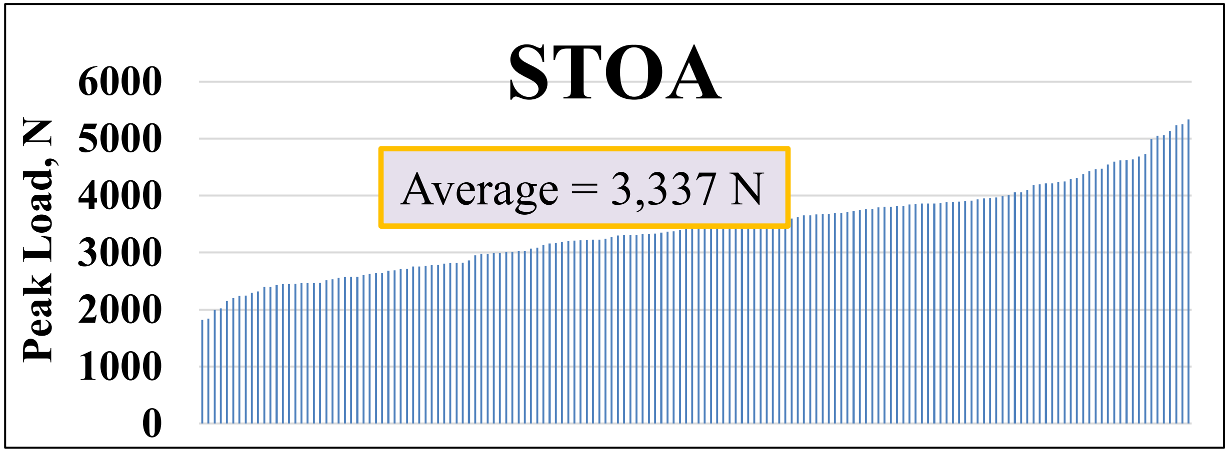
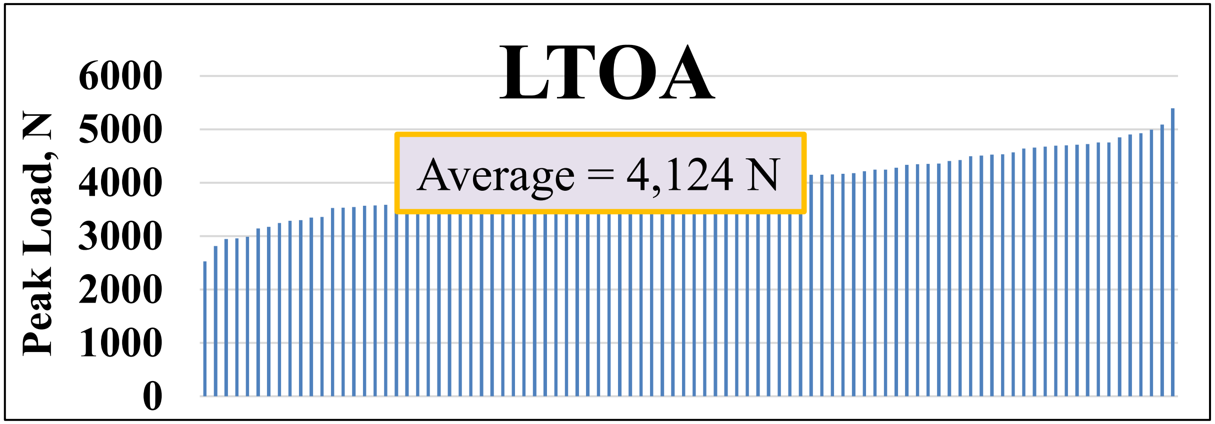
Data Range: Fracture Energy



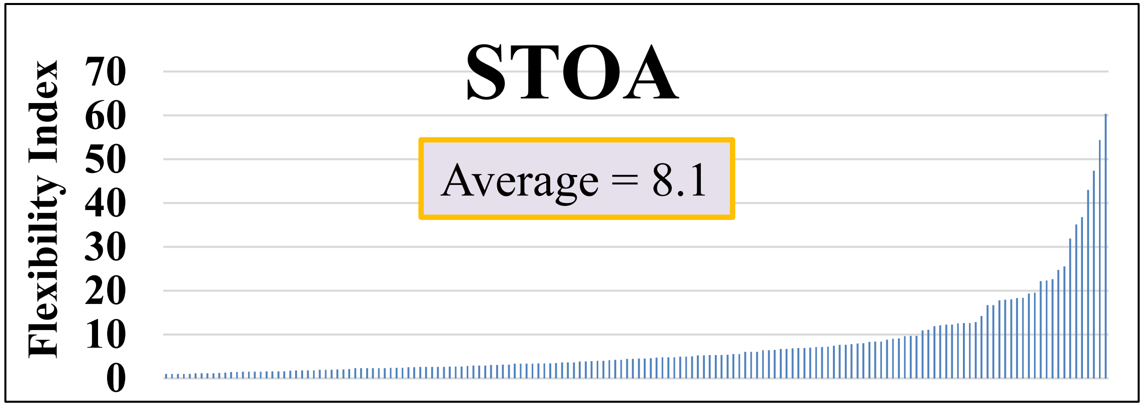


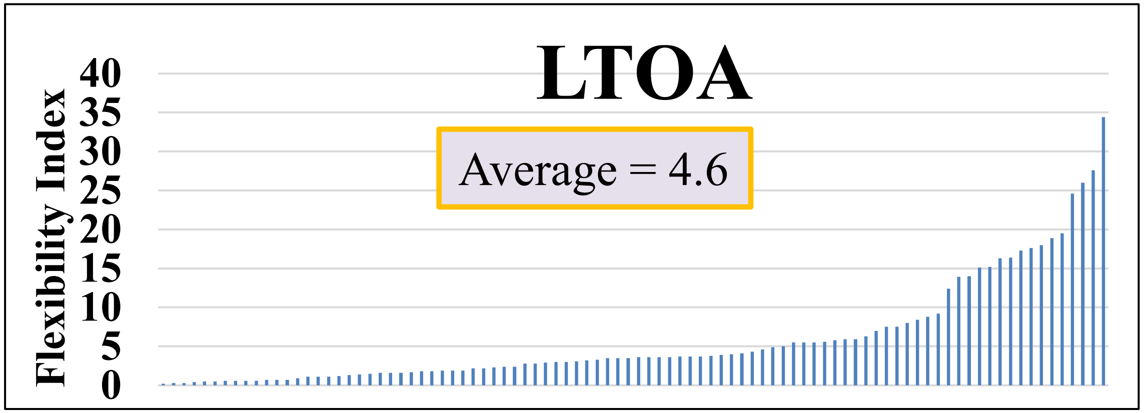
Data Range: Peak Load





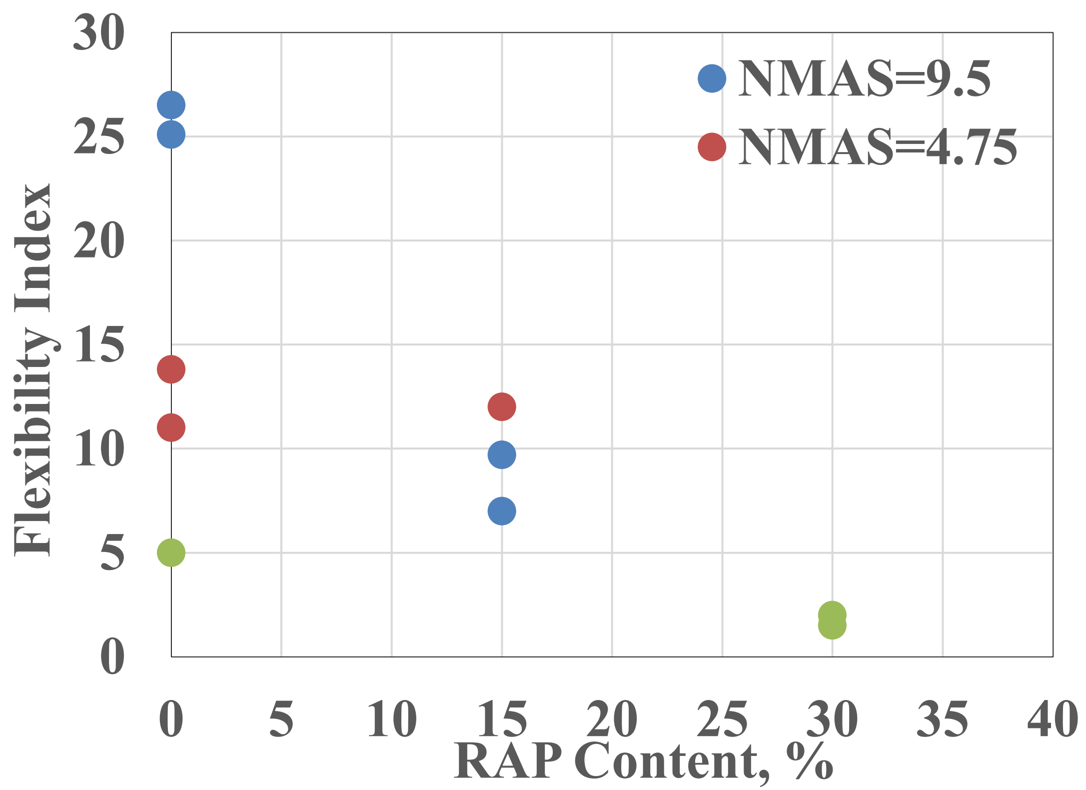
Data Range: Flexibility Index





RAP Content Effect

All Specimens were STOA



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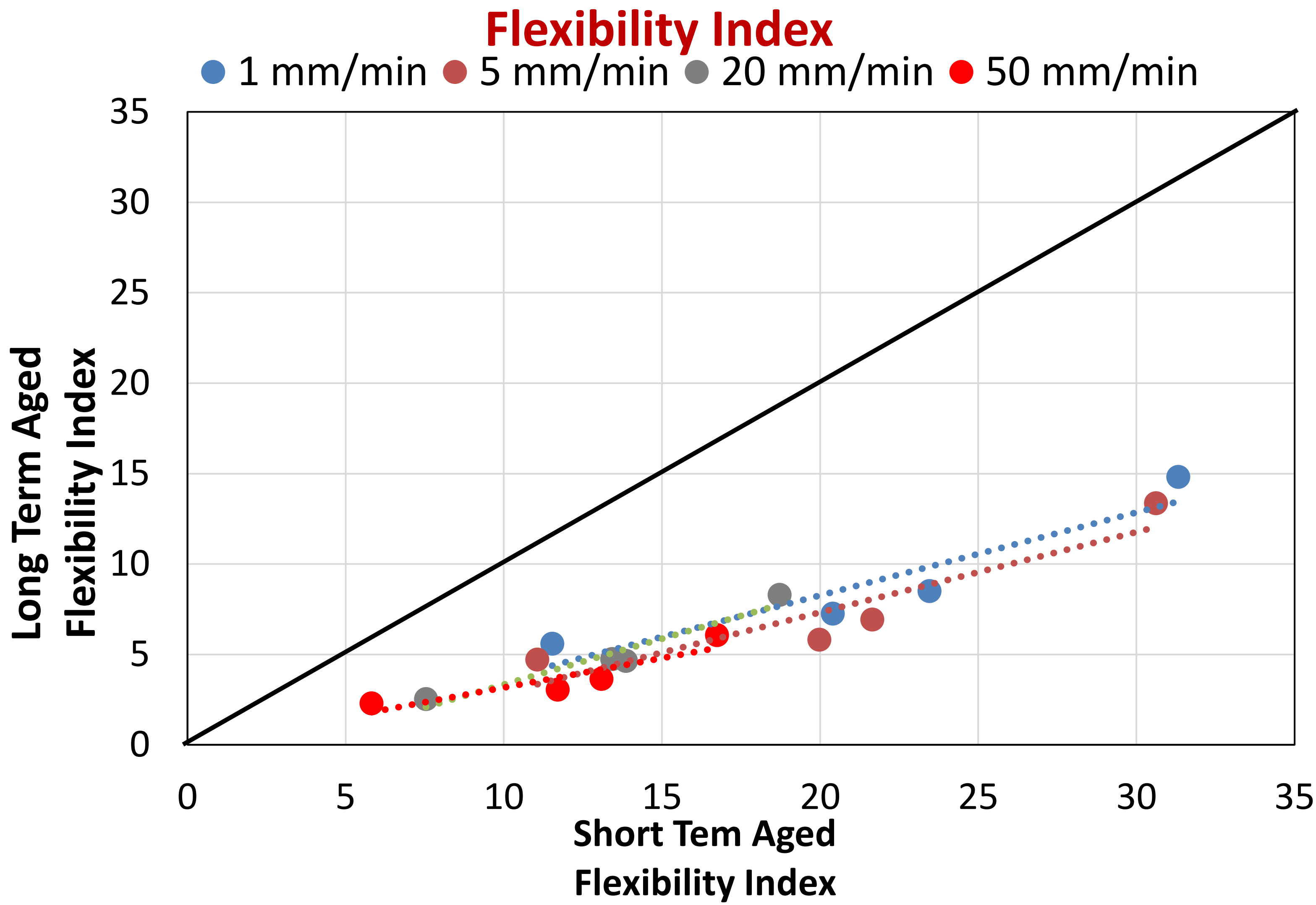
FI of Aged Mixes



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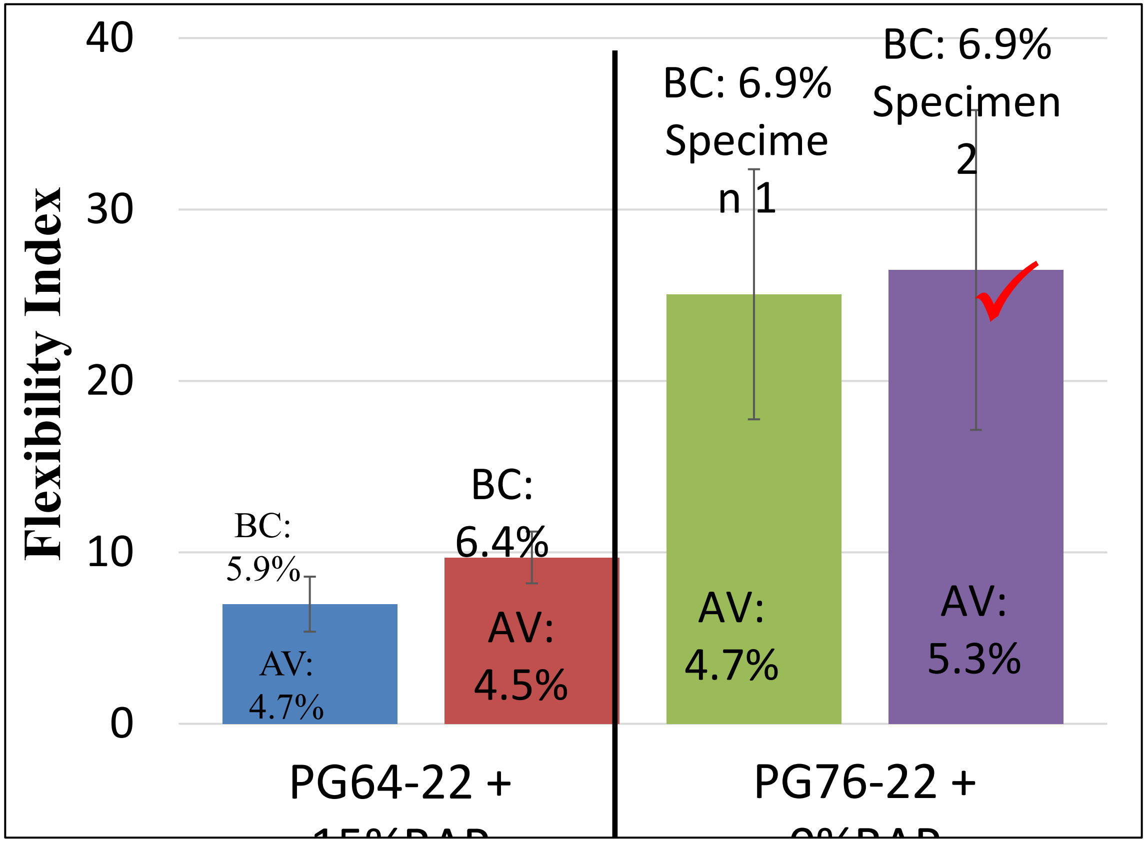
SMA vs Conventional Mix



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General Observations

1. Higher AC Content → higher F.I.
2. Higher RAP content lower F.I.
3. Longer aging → lower F.I.
4. Plant mix has higher F.I. than lab mix
5. Higher voids → higher F.I.
6. SMA mix delivers higher F.I.
7. Finer mix with high BC → higher F.I.

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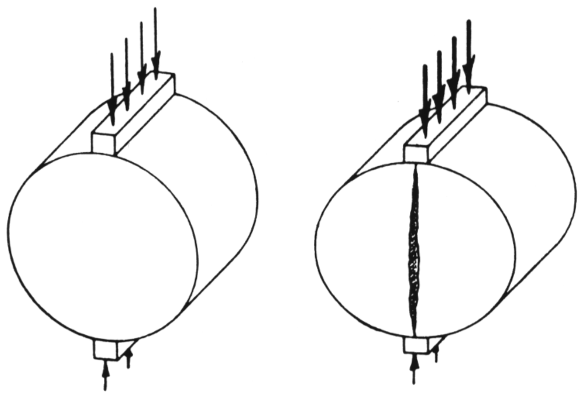
IDEAL Cracking Test for Asphalt Concrete

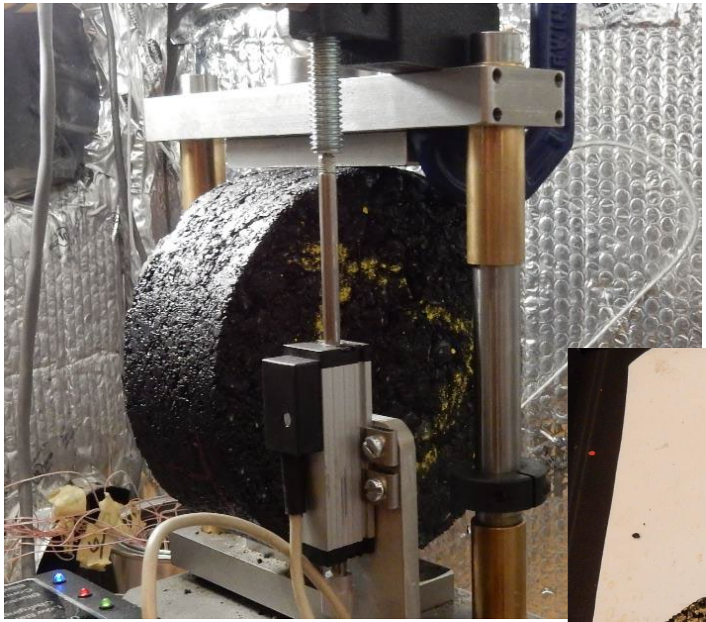


In**d**irect T**e**nsile **A**spha**l**t
Cracking **T**est

IDEAL-CT

Proposed by Research at Texas Transportation Institute (TTI)

Breaking Specimens



Test Temperature: 25◦C
Displacement Rate: 50 mm/min

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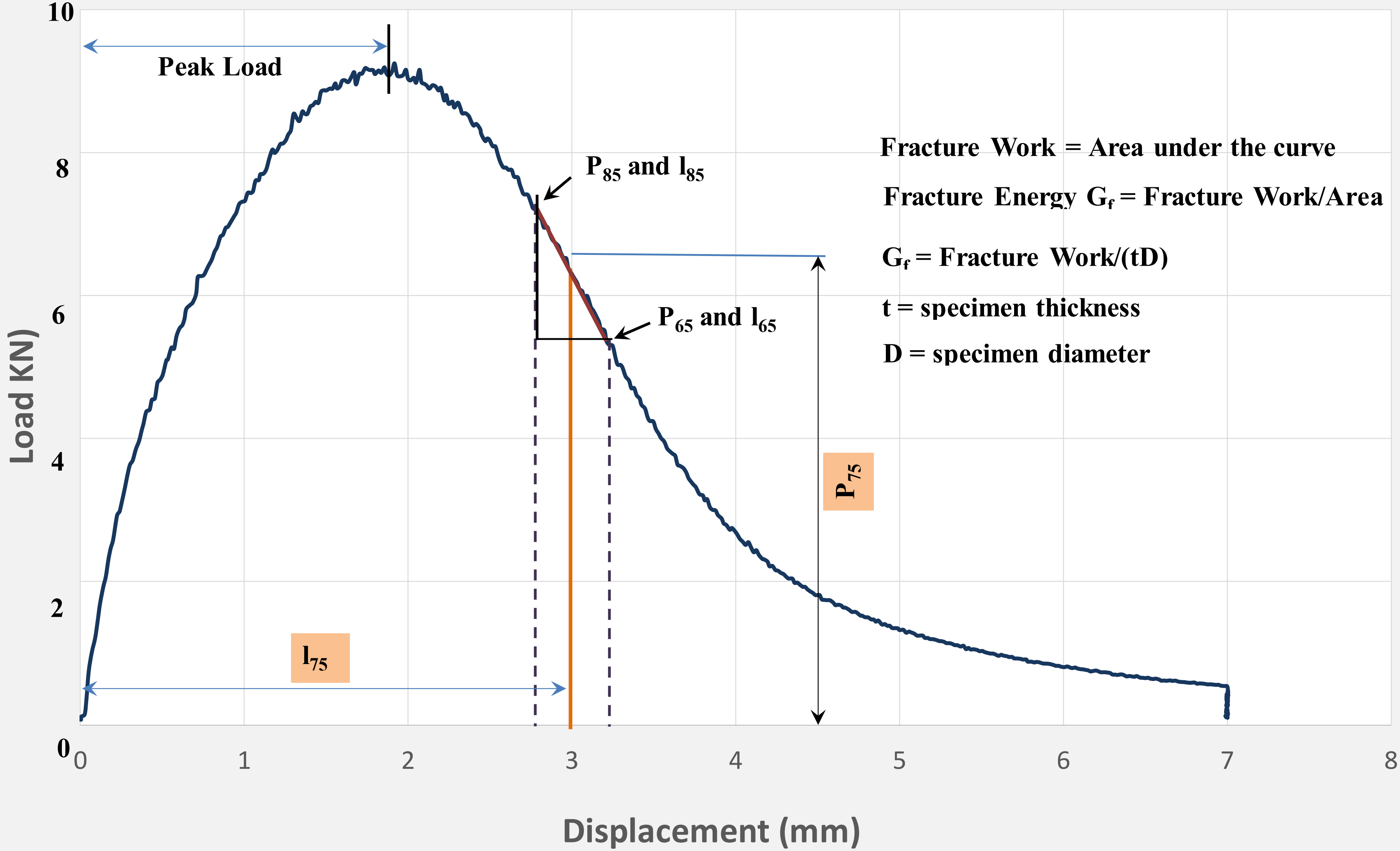
The Brazilian Test
(The Split Test or Indirect Tensile Test)

- Tensile Strength of Concrete (Carneiro, **1943**)
- Tensile Strength of Stabilized Materials (Hudson, Kennedy, **1967**)
- Tensile Strength of Asphalt (Kennedy et al., **1969**)
- Tensile Strength of Rocks (ISRM, **1978**)

IDEAL – Test Results



Fracture Work = Area under the curve

Fracture Energy G_f = Fracture Work/Area

G_f = Fracture Work/(tD)

t = specimen thickness

D = specimen diameter

IDEAL – Test Results

Criteria established based on CT_{Index}

$$CT_{Index} = \frac{G_f}{\frac{P}{l}} \times \left(\frac{l_{75}}{D}\right)$$

$$\frac{P}{l} = |m_{75}| = \frac{P_{85} - P_{65}}{l_{85} - l_{65}}$$

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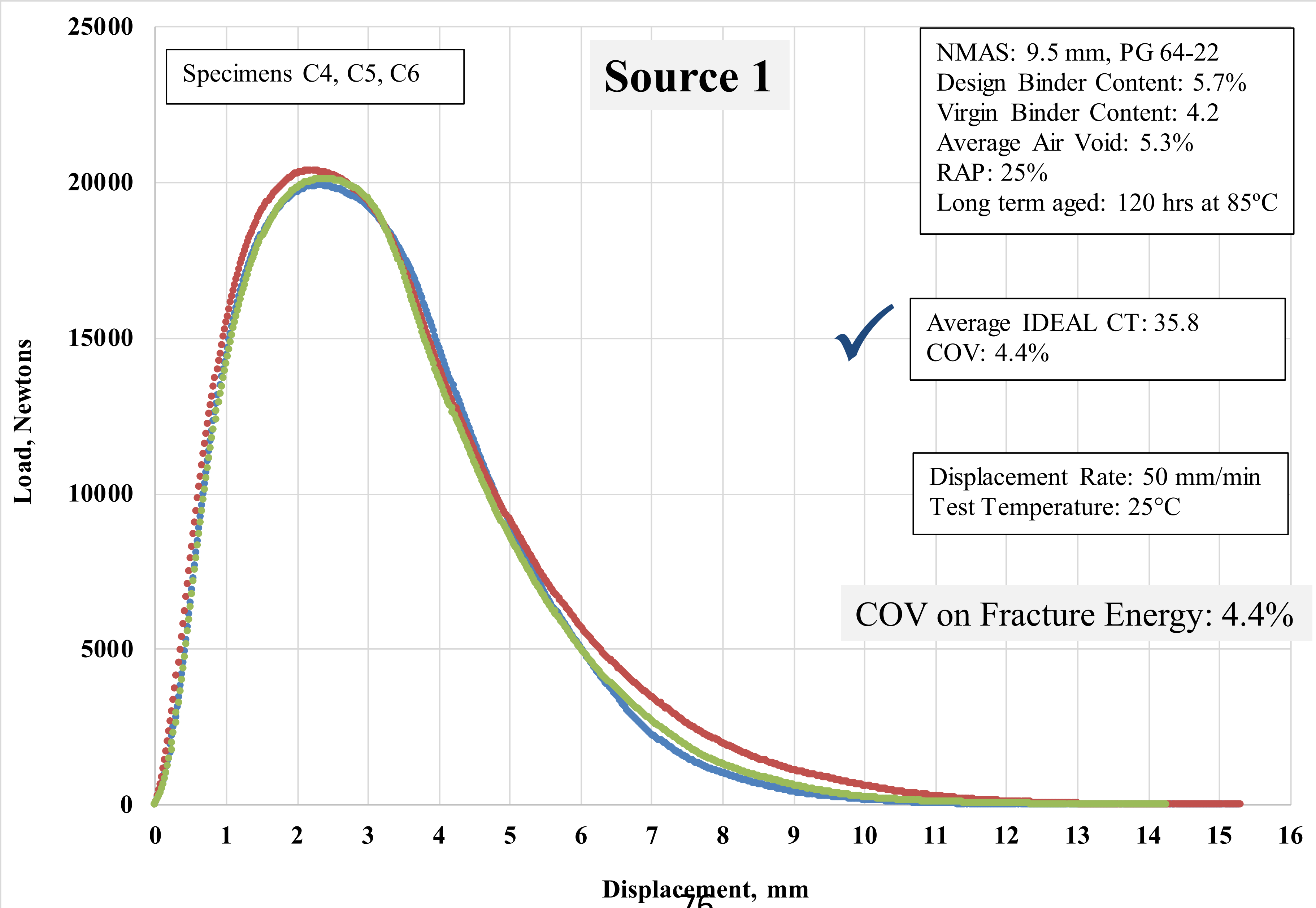
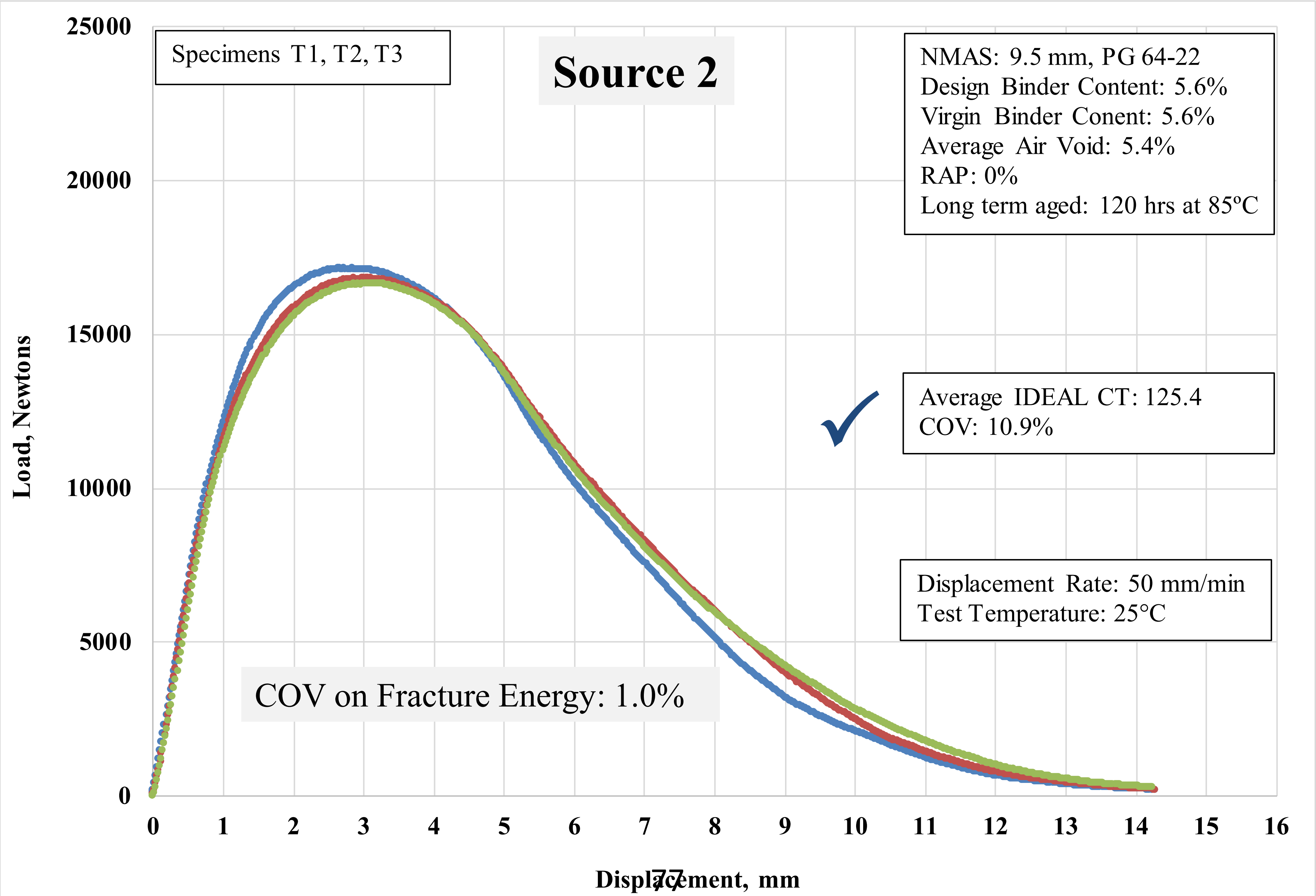
Test Repeatability

LTOA



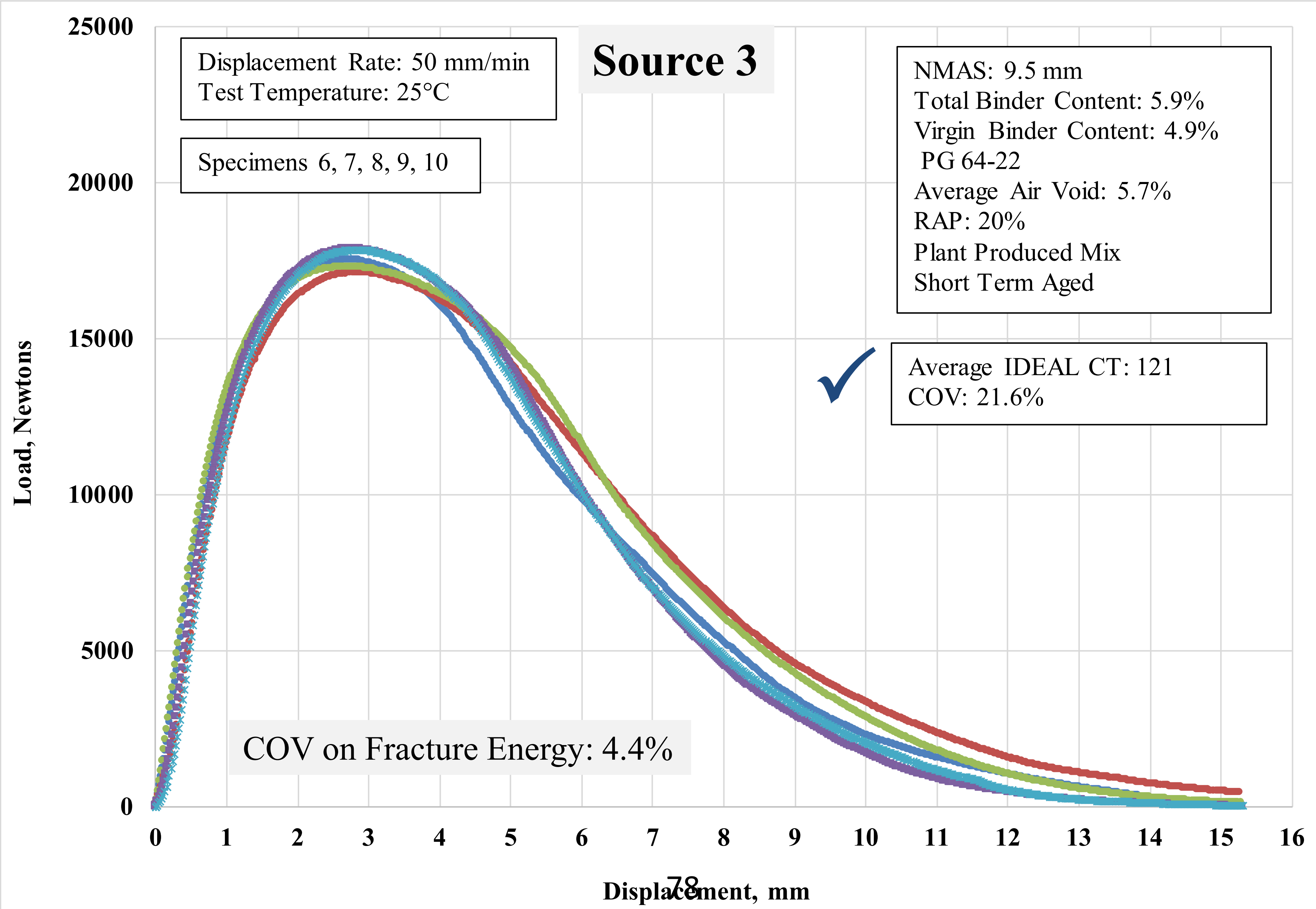
Test Repeatability

LTOA

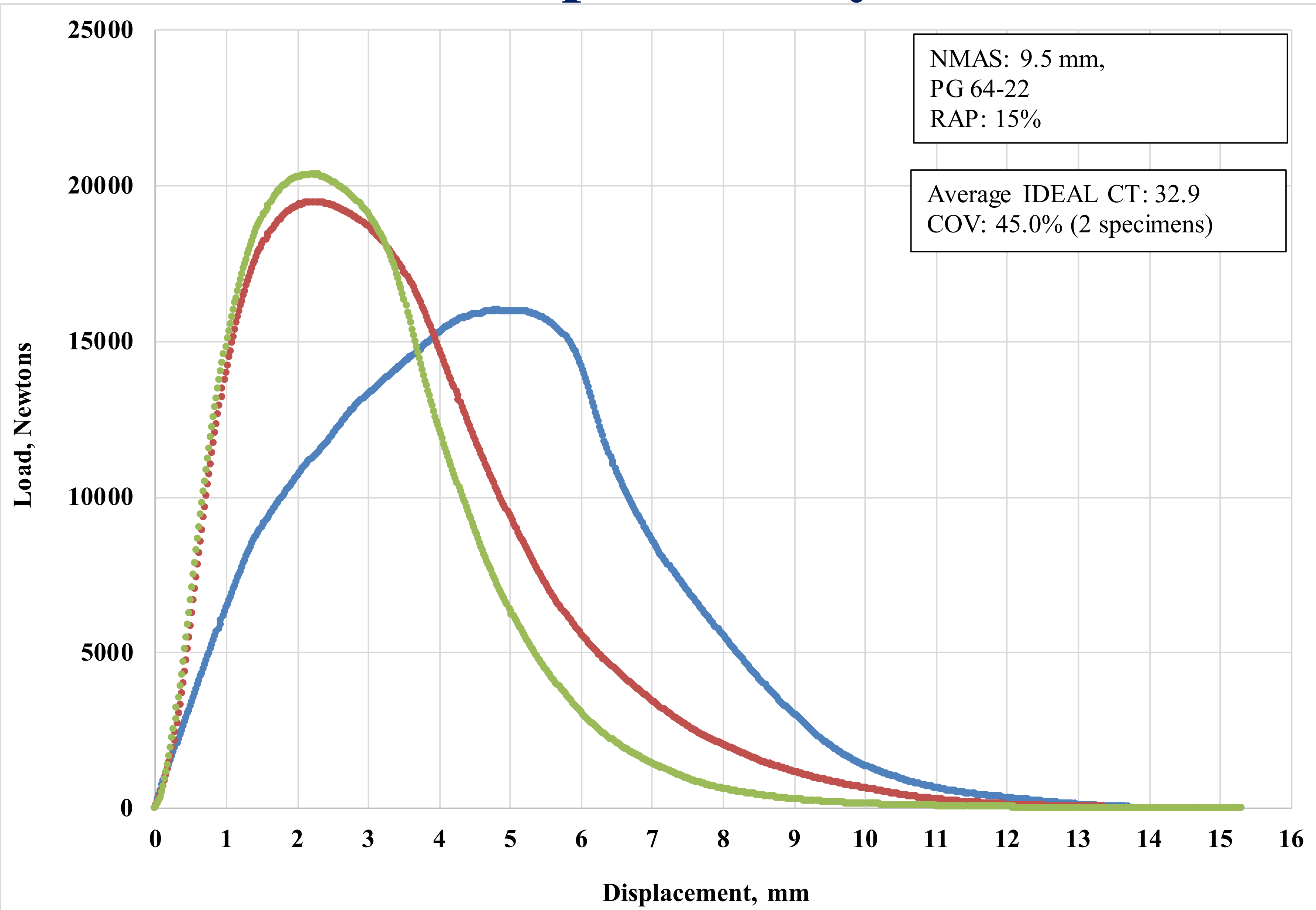


Test Repeatability

STOA



Test Repeatability



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Types of Mixes Tested (25 Mixes)

Source	# of Mixes	# of Plugs	Mix Origin	Mix Condition	NMAS, mm	Binder Grade	Binder Content	RAP
01	9	27	Lab Prod.	LTOA	9.5	58-28	5.2 to 6.2	0, 15, 25
						64-22		
						76-22		
02	9	27	Lab Prod.	LTOA	9.5	58-28	5.1 to 6.1	0, 15, 25
						64-22		
						76-22		
03	7	35	Plant Prod.	STOA	6.3	64-22	6.3	0
					6.3	76-22	6.9	0
					9.5 (3)	64-22	5.9 & 6.0	15.0, 20.0
					19 (2)	64-22	4.8 & 5.1	25.0, 28.5

Source of Mixes & Conditioning

Sources 1 and 2

Lab Prepared Mix → Long Term Aged (5 days @ 185°F)

LTOA

Source 3

Plant Prepared Mix → Short Term Aged

STOA

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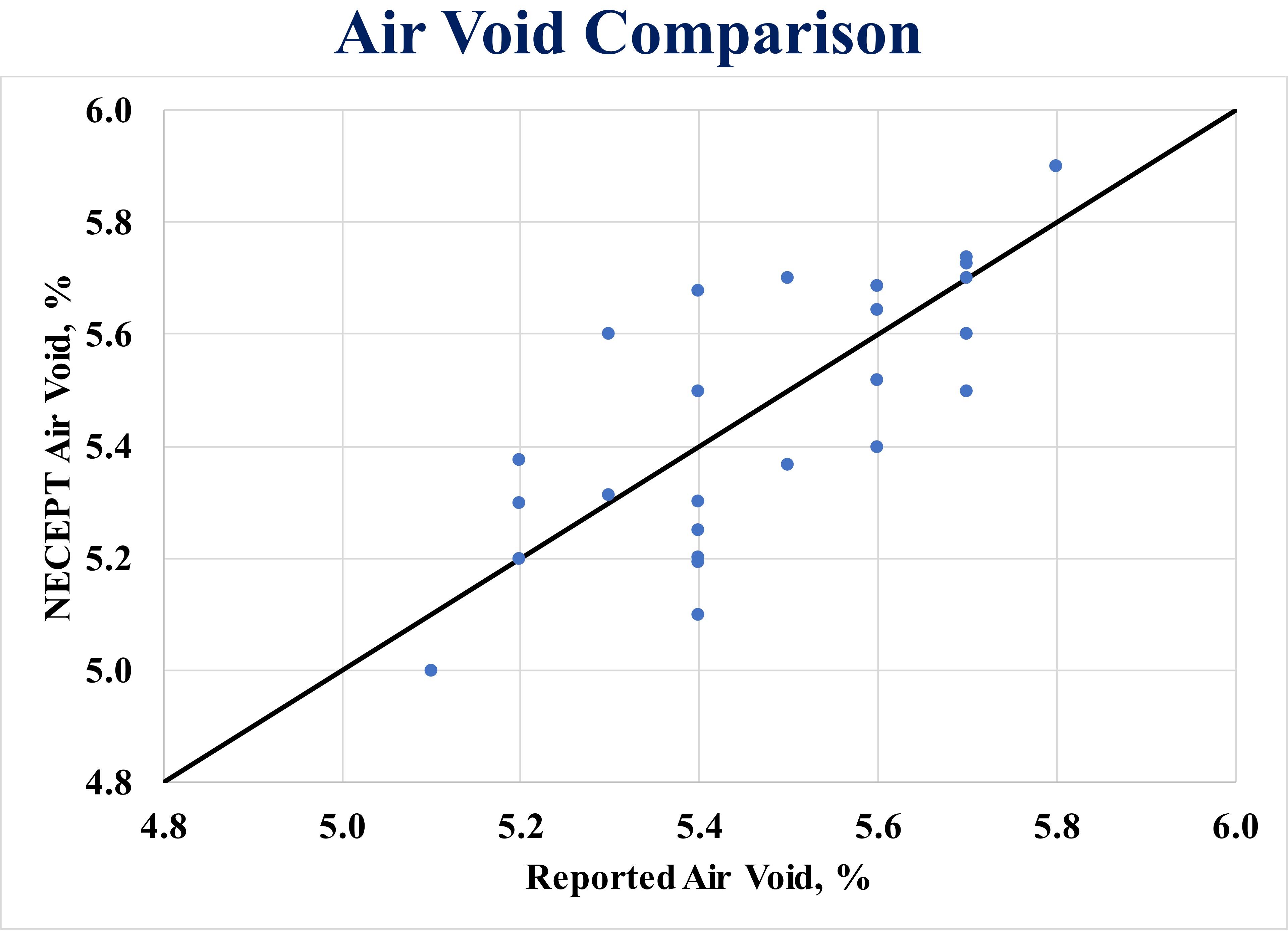
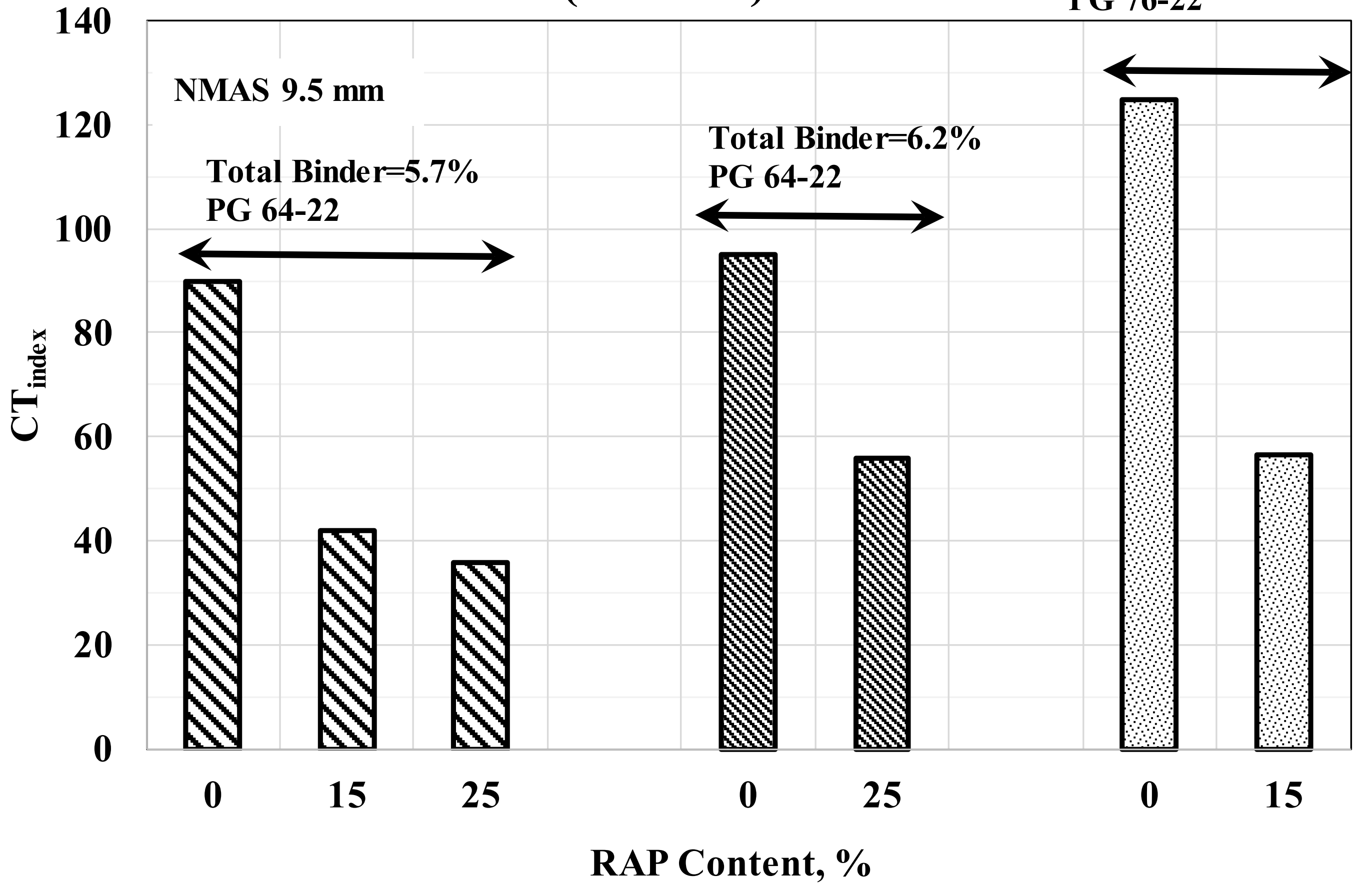

Air Void Comparison
NECEPT Air Void, %
Reported Air Void, %
6.0
5.8
5.6
5.4
5.2
5.0
4.8
4.8
5.0
5.2
5.4
5.6
5.8
6.0

Effect of RAP Content (Source 1)



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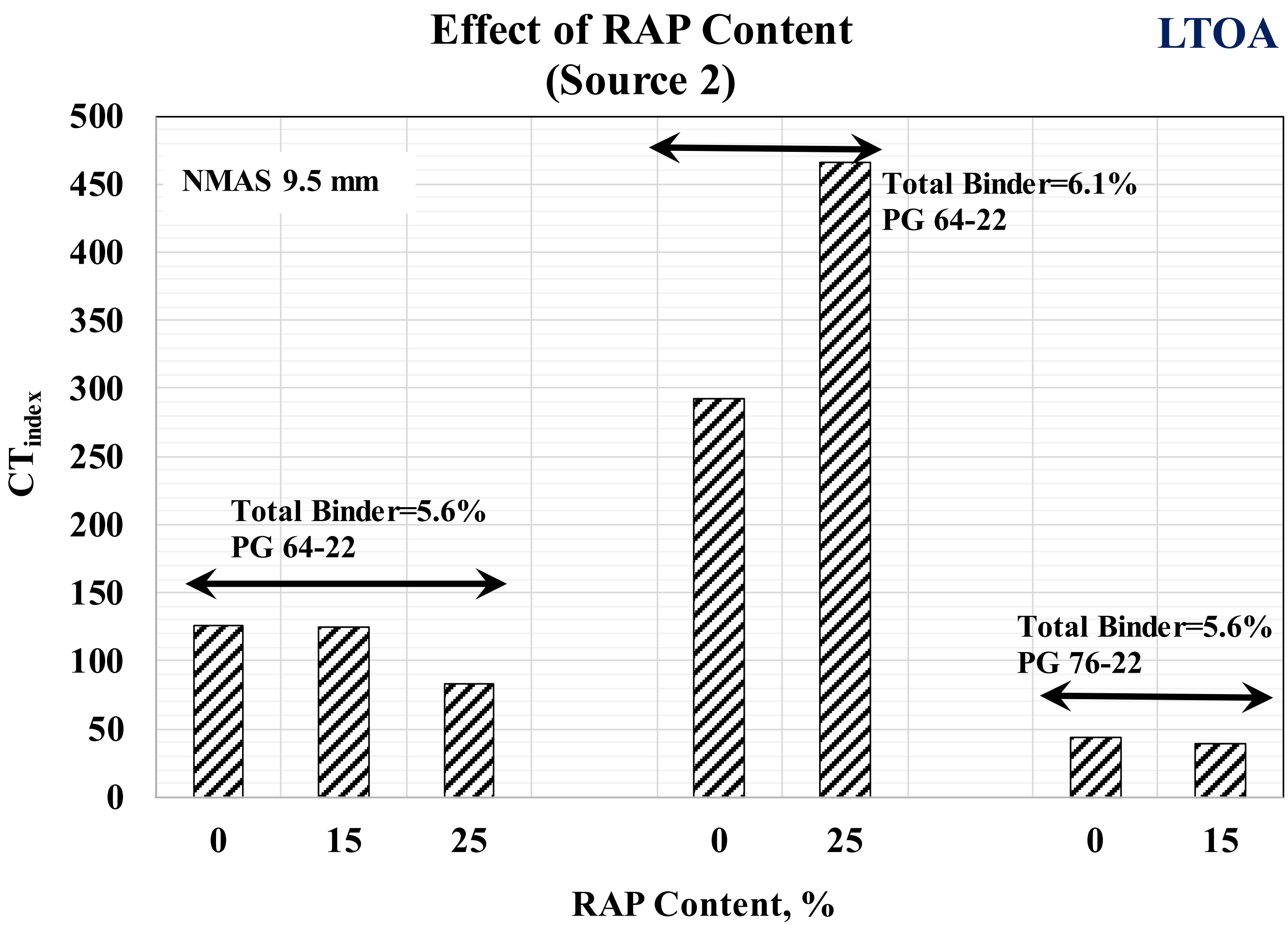

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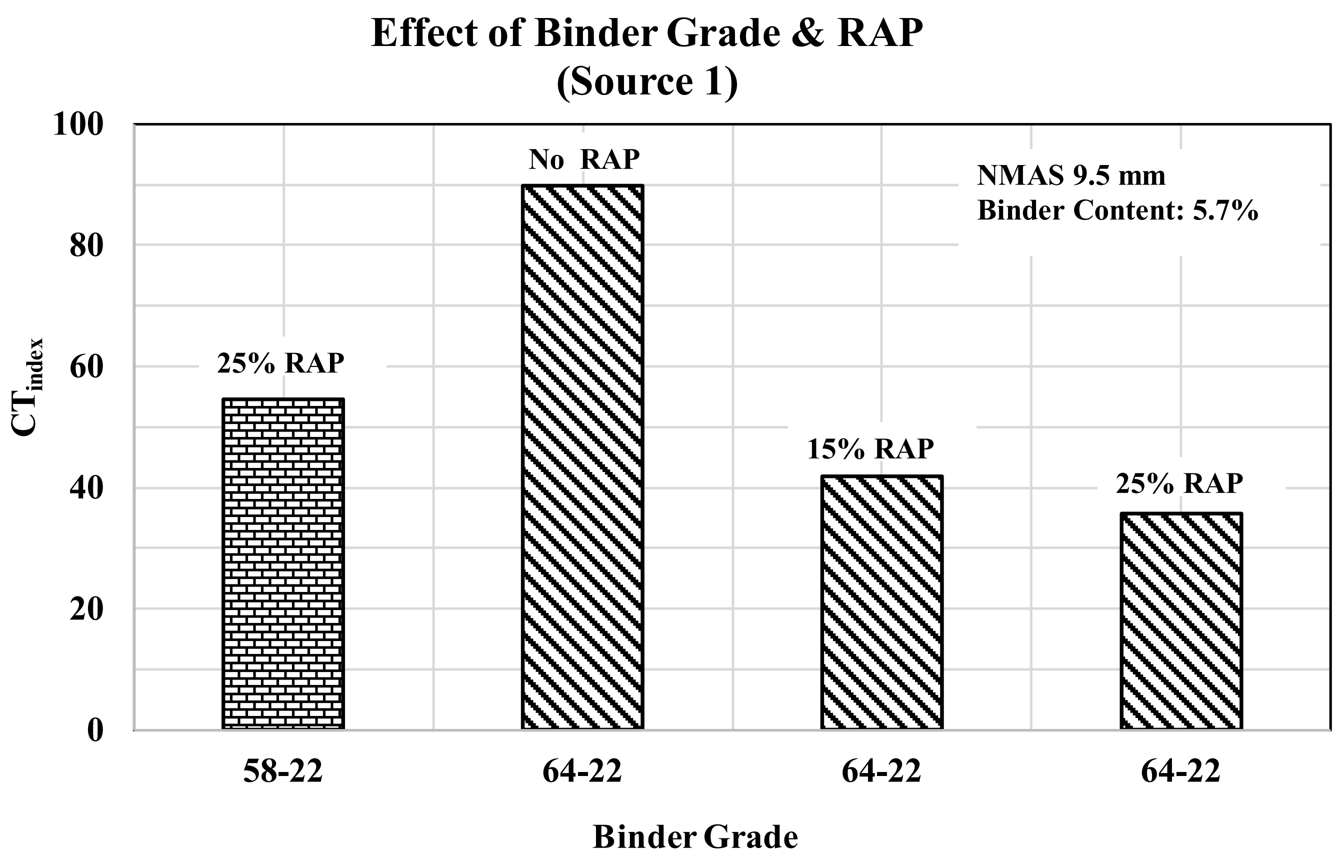
LTOA



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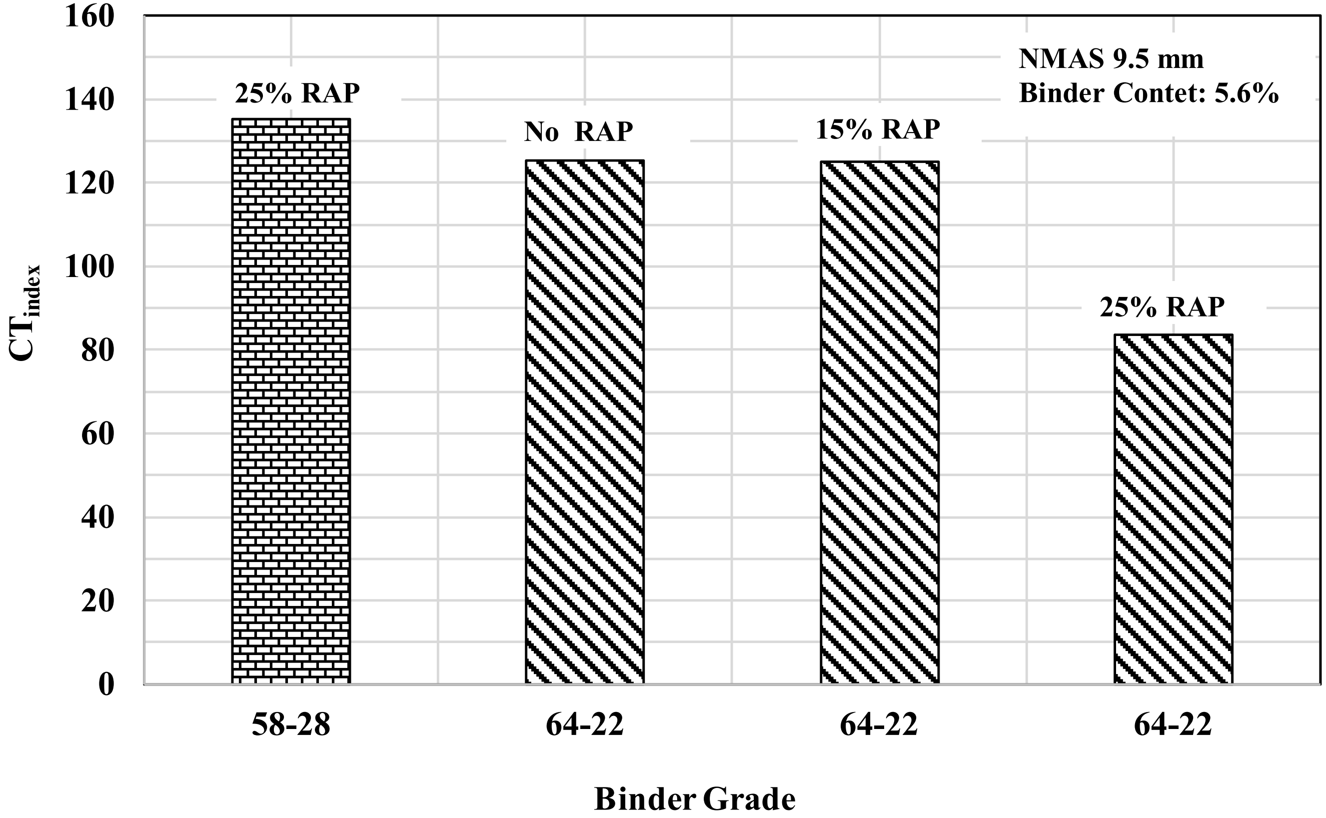
Effect of Binder Grade & RAP (Source 2)



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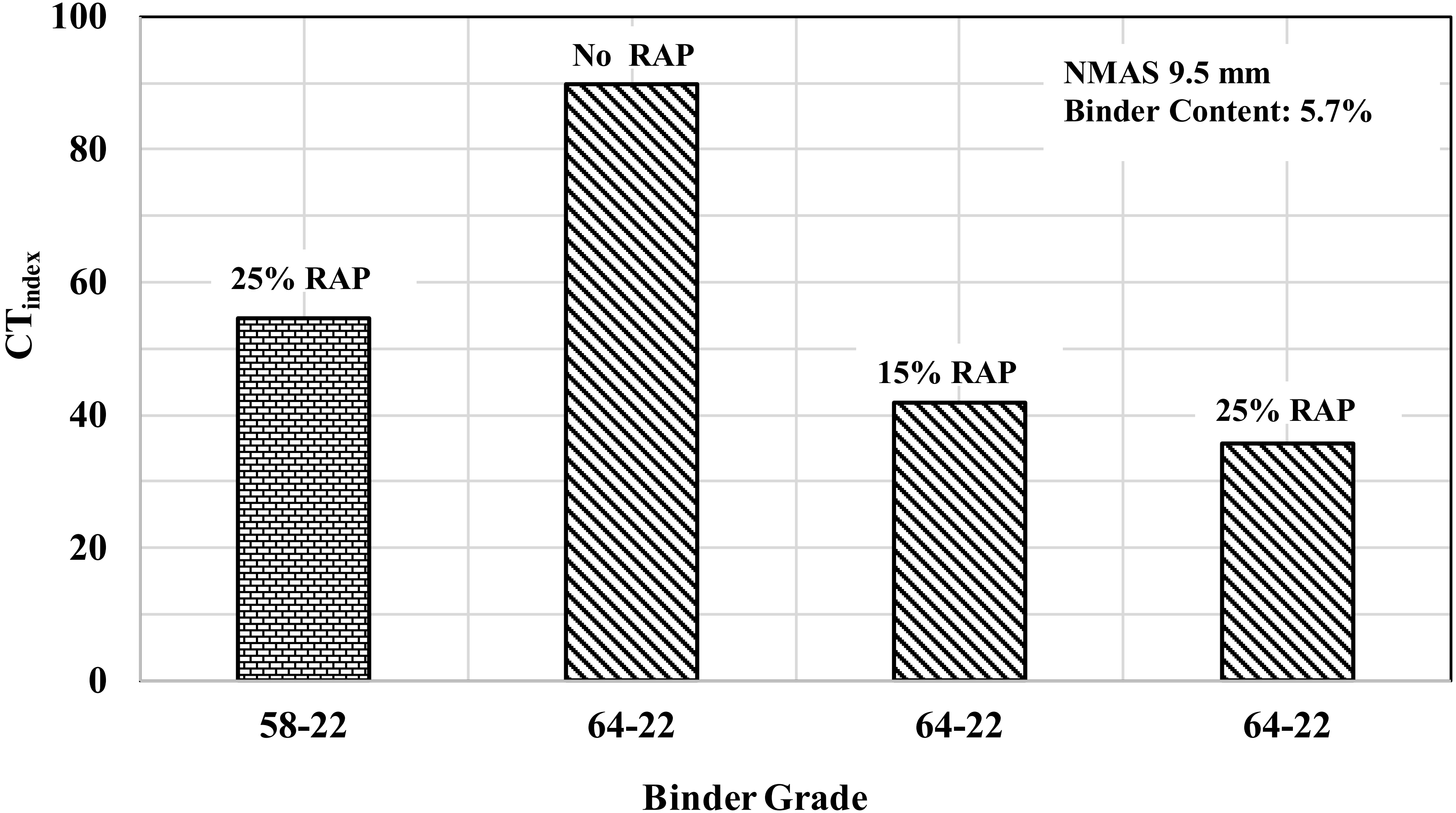
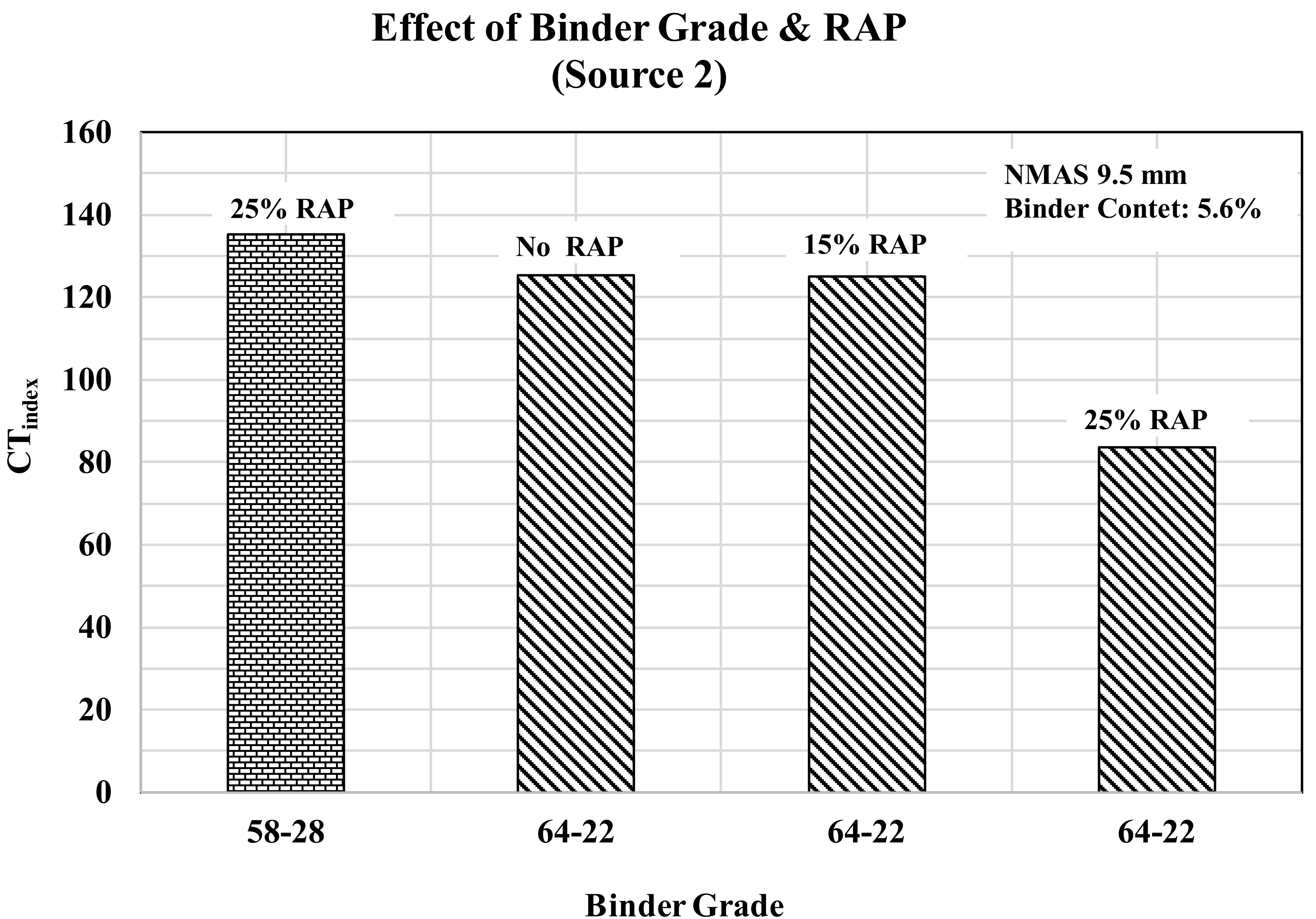
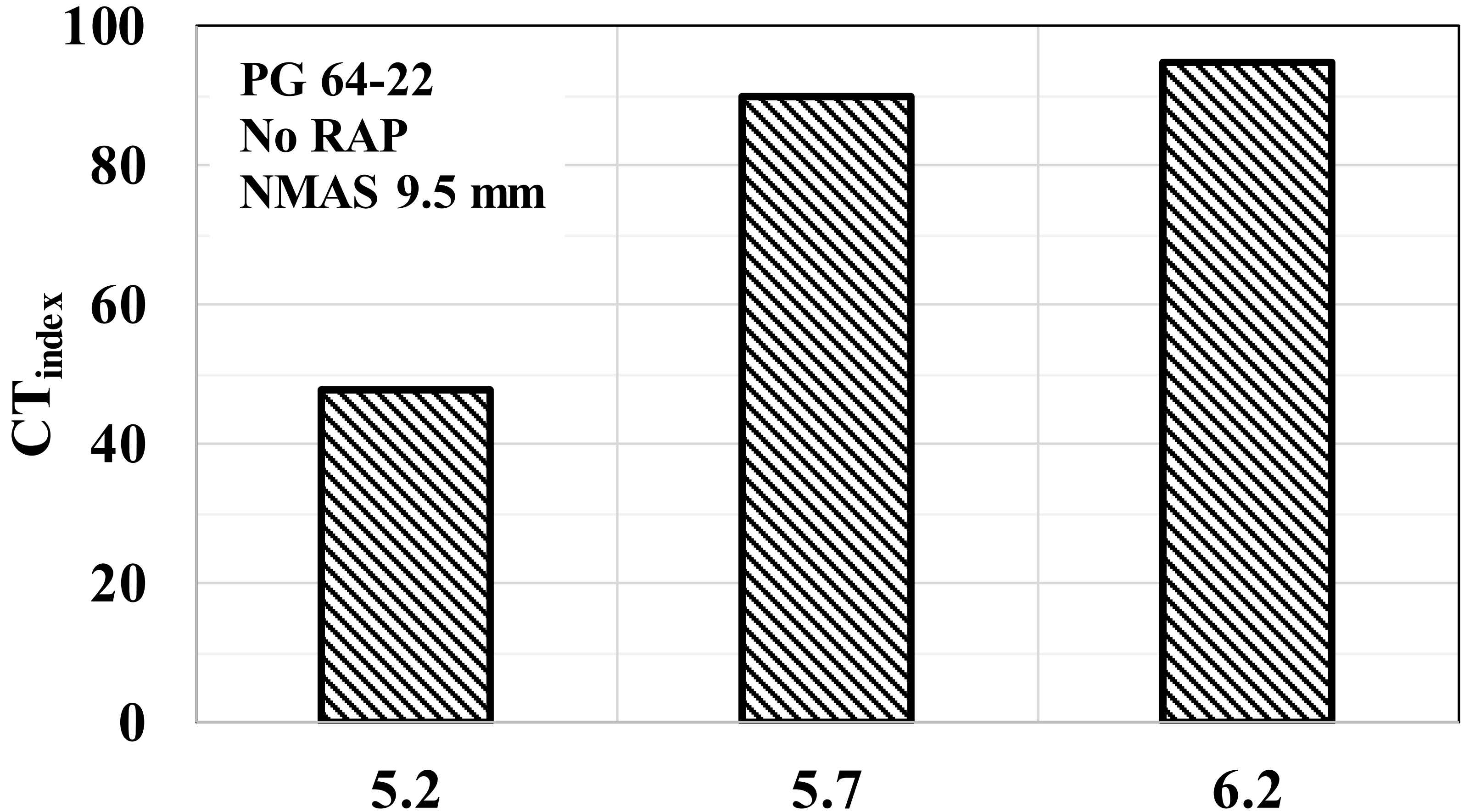
Effect of Binder Grade & RAP (Source 1)




Effect of Binder Grade & RAP
(Source 2)
NMAS 9.5 mm
Binder Contet: 5.6%
25% RAP
No RAP
15% RAP
25% RAP
CTindex
160
140
120
100
80
60
40
20
0
58-28
64-22
64-22
64-22
Binder Grade

LTOA

Effect of Binder Content (Source 1)



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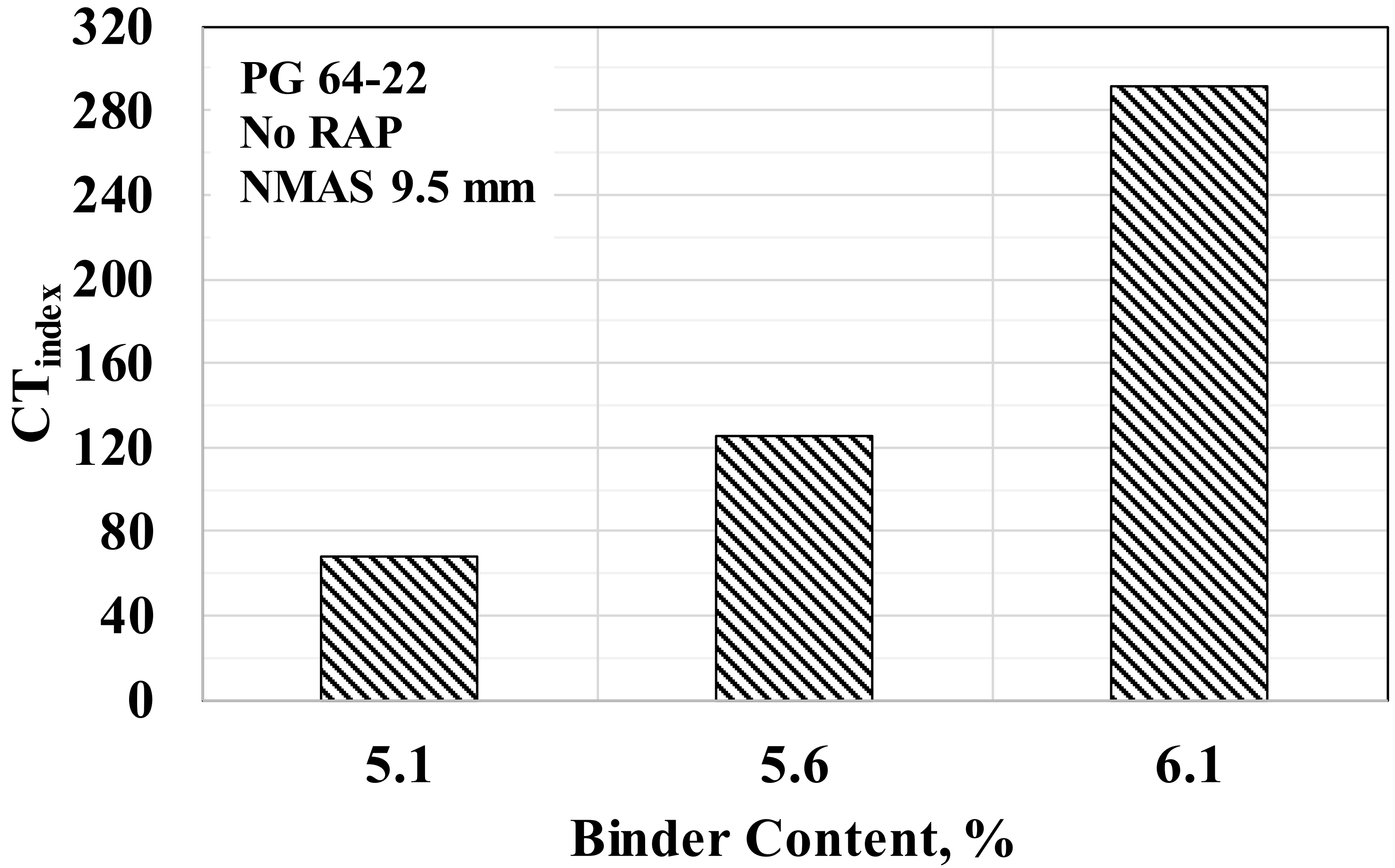
Effect of Binder Content (Source 2)



What COV should we use?

Criterion on COV	Number of Mixes
≥ 30%	5
≥ 25%	6
≥ 20%	7
≥ 15%	15
≥ 10%	20

COV: Coefficient of Variation

Total Number of Mixes: 23

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Summary & Conclusions

- Trend of Data very similar to SCB
- IDEAL-CT Range: **33 to 460**
- **In most cases, the test is very repeatable**
- COV mostly under 25%

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Summary & Conclusions

- Increasing binder increases flexibility

- Increasing RAP over 20% decreases flexibility

- Use of soft binder with high RAP: mixed results (RAP binder stiffness effect?)

Recommendations

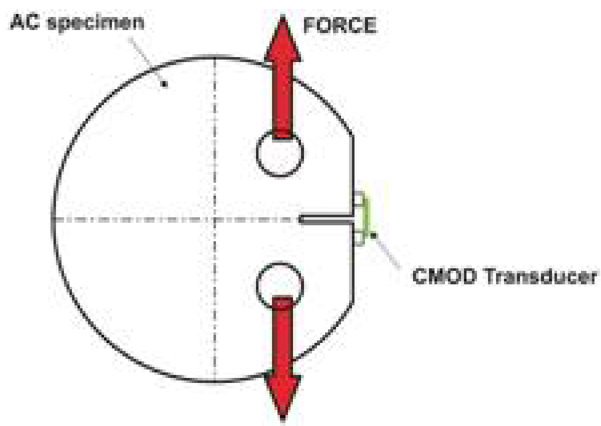
- Use four replicates

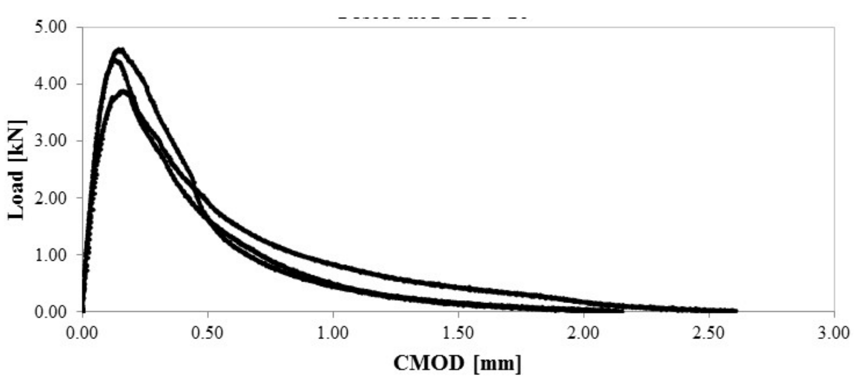
- Need a limit on COV

  - Round robin testing needed
  - Recommendation: 20% to 25%

Low Temperature Cracking Test

- **Disk-Shaped Compact Tension** (DCT) testing. (ASTM D7313)
  - Measures fracture energy
  - Gyratory samples %7.0 (+/- %1.0) air voids.
  - Test run at 10^0 C above the low PG mix designation. (-12^0C (10.4^0 F) for PG64-22)
  - Fracture energy requirements vary depending on mix type (SMA) and layer (wearing, binder)





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Thank You!

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Use of Crumb Rubber Modifier with Asphalt Mixes

PENN STATE

Acknowledgement

- PennDOT Sponsored Research
- Project Start Date: March 1, 2019
- Project Manager: Heather Sorce (PennDOT)
- Project Technical Advisor: Tim Ramirez (PennDOT)
- Researchers (Penn State NECEPT):
  - Scott Milander
  - Xuan Chen
  - Ali Sahraei

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Outline

- PennDOT CRM Projects
- CRM as Asphalt Binder Modifier
- Experimental Program in this Research
- Findings: CRM Modified Asphalt Binders
- Findings: CRM Modified Asphalt Mixtures
- Summary and Conclusions

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PennDOT Initiative

on Rubber Asphalt Pavements

Mix Type	County Name	County Code	Highway	Design ESALs	Construction Completion Date
Gap-Graded	Berks	6	SR 0078	>30M	October, 2012
	Snyder	54	SR 0015	3 to <30M	September, 2013
	Lawrence	37	SR 376	3 to <30M	September 2014
	Adams	1	SR 0015	3 to <30M	September, 2015
Dense-Graded	Centre	14	SR 0322	3 to <30M	May, 2016
	Luzerne	40	SR 0924	3 to <30M	June, 2016
	Indiana	32	SR 0954	0.3 to <3M	August, 2016
	Lancaster	36	SR 0272	0.3 to <3M	September, 2016
	Phil/Bucks	67/9	SR 0063	3 to <30M	October, 2016
	Westmoreland	64	SR 0366	3 to <30M	October, 2016

GG Mixes:

No RAP, %AC: 7.6-8.1, 12.5-mm NMAS

DG Mixes:

10-15% RAP, and one with no RAP, %AC: 4.8-6.2, 9.5-mm NMAS (except one)

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17% CRM
8.0% AC
12.5-mm NMAS
Snyder Co.
SR 0015
Sept. 2013
VOLVO

Outline

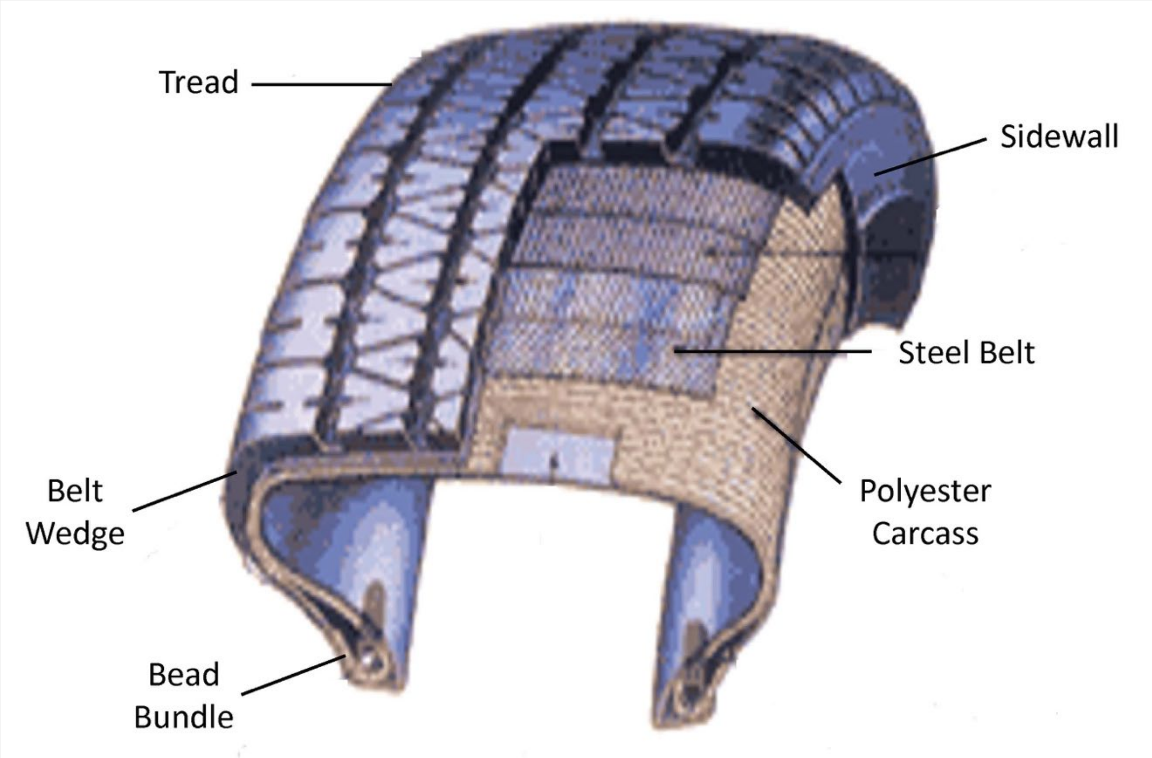
- PennDOT CRM Projects
- **CRM as Asphalt Binder Modifier**
- Experimental Program in this Research
- Findings: CRM Modified Asphalt Binders
- Findings: CRM Modified Asphalt Mixtures
- Summary and Conclusions

Related Terminology

- **CRM**: Crumb Rubber Modifier
- **Dry Process**: blend rubber particles in aggregate
- **Wet Process**: blend rubber particles in binder
  - Asphalt Rubber Binder: rubber content ≥ 15%
  - Rubberized Asphalt: rubber content < 15% (often through terminal blending if < 10%)

Note: percentages are by weight of the blend

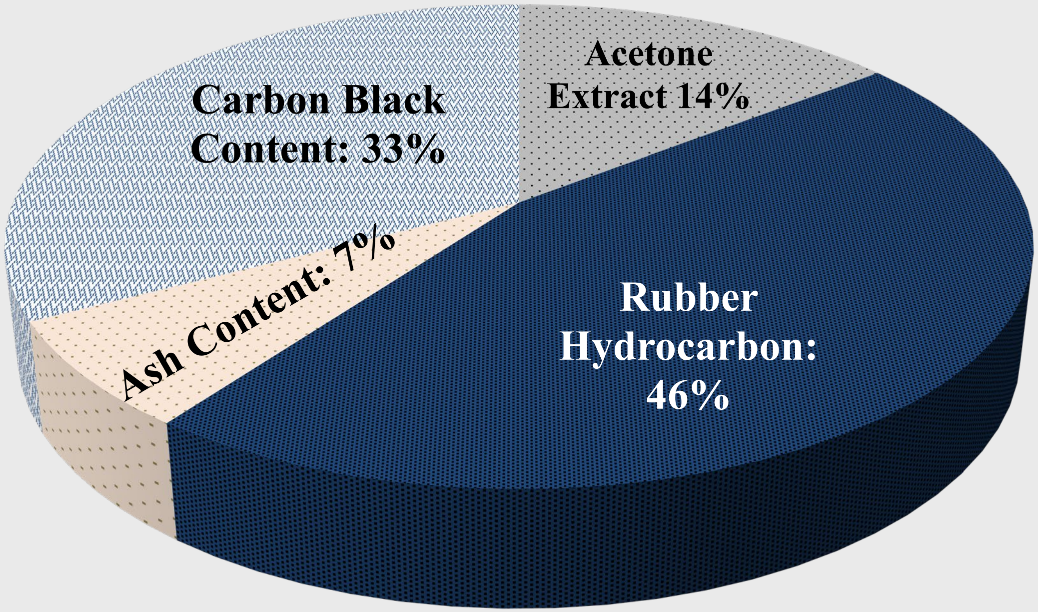
Rubber Tire Composition



Composition of a tire (Neto et al. 2006).

Rubber Tire Composition

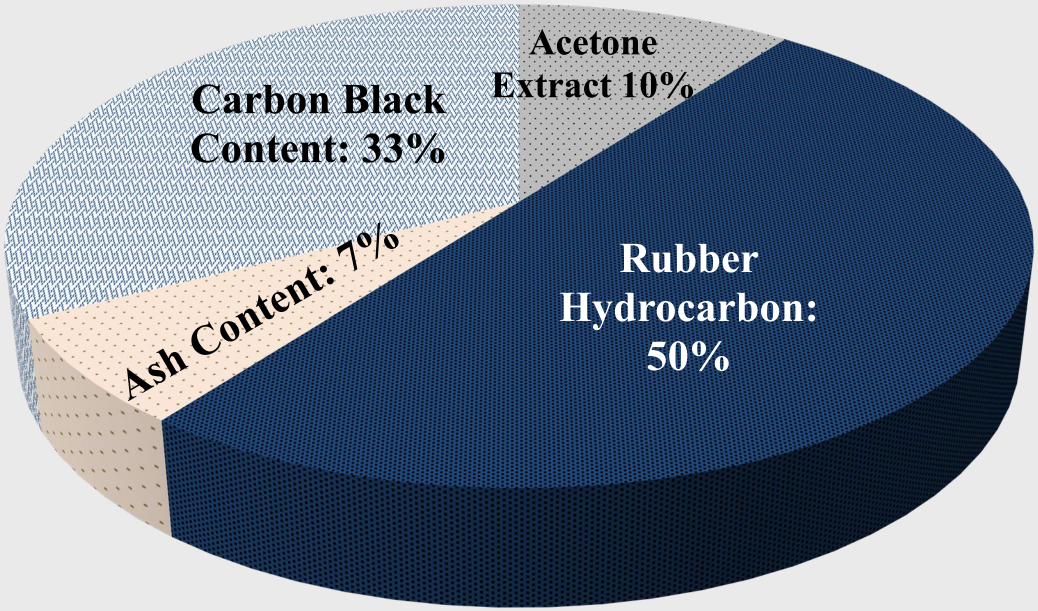
CRM 1: -#30 Mesh



ASTM D297 – 15(2019):
Standard Test Method of Rubber Products-Chemical Analysis

Rubber Tire Composition

CRM 2: -#20 Mesh



ASTM D297 – 15(2019):
Standard Test Method of Rubber Products-Chemical Analysis

Rubber Particle Size

- Designation based on ASMT D5603-19

- Example Mesh -#20: at least 99% pass #16 sieve.

- Typical range for asphalt use: -#14 mesh (1.4 mm) to -#80 mesh

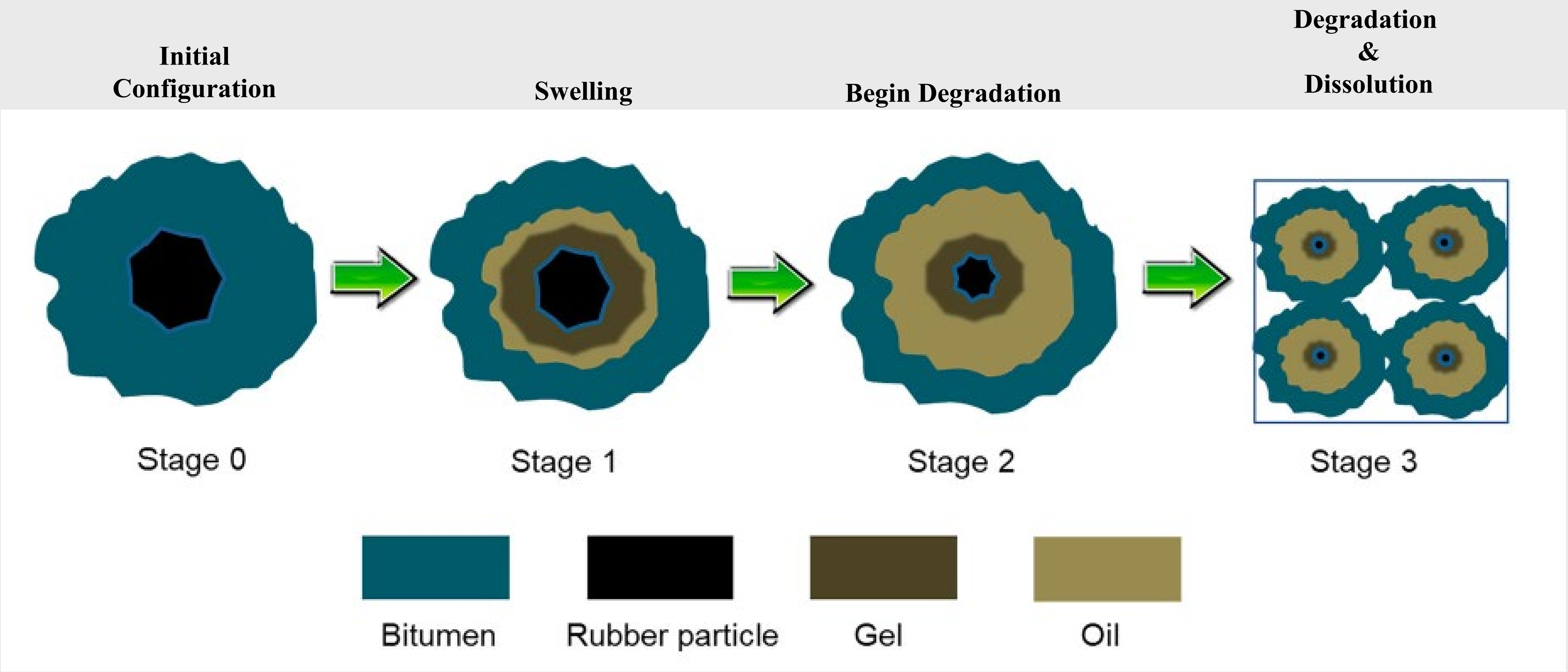
Terminally Blended CRM Binders

- Rubberized asphalt produced at terminal or refinery
- Finer size CRM (for example #50) used.
- Typically low rubber content (under 10%)
- Can be used in dense graded mixes

Terminally Blended CRM Binders

Contaminant	Maximum
Fiber Content	Max. 0.5% by weight
Moisture Content	Max. 0.75% by weight
Minerals Content	Max. 0.25% by weight
Metals	No visible metal particles as indicated by thorough stirring of a 50-gram sample with magnet, max. 0.01%

Asphalt-Rubber Interaction



Source: Wang, S., Cheng, D., and Xiao, F., 2017. Recent developments in the application of chemical approaches to rubberized asphalt. Construction and Building Materials, 131, 101–113.

Storage Stability

- Storage stability increases with
  - Higher Blending Temperature
  - Longer Blending time
  - Higher shear rate

- Compatibility between CRM and binder important

- Degree of stability reported as a separation index determined based on ASTM D7173

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Outline

- PennDOT CRM Projects
- CRM as Asphalt Binder Modifier
- **Experimental Program in this Research**
- Findings: CRM Modified Asphalt Binders
- Findings: CRM Modified Asphalt Mixtures
- Summary and Conclusions

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Research Study Factors

Factor	Levels		
CRM Content	10%, 15% (by mass of modified binder)		
CRM Size	Mesh -#30 and -#20		
Binder Grade	PG 64S-22 and PG 58S-28		
Aggregate Source	Limestone and Calcareous Sandstone		
Curing Level	Low	Intermediate	High

PG 58S-28:

from two different sources for the mixture work

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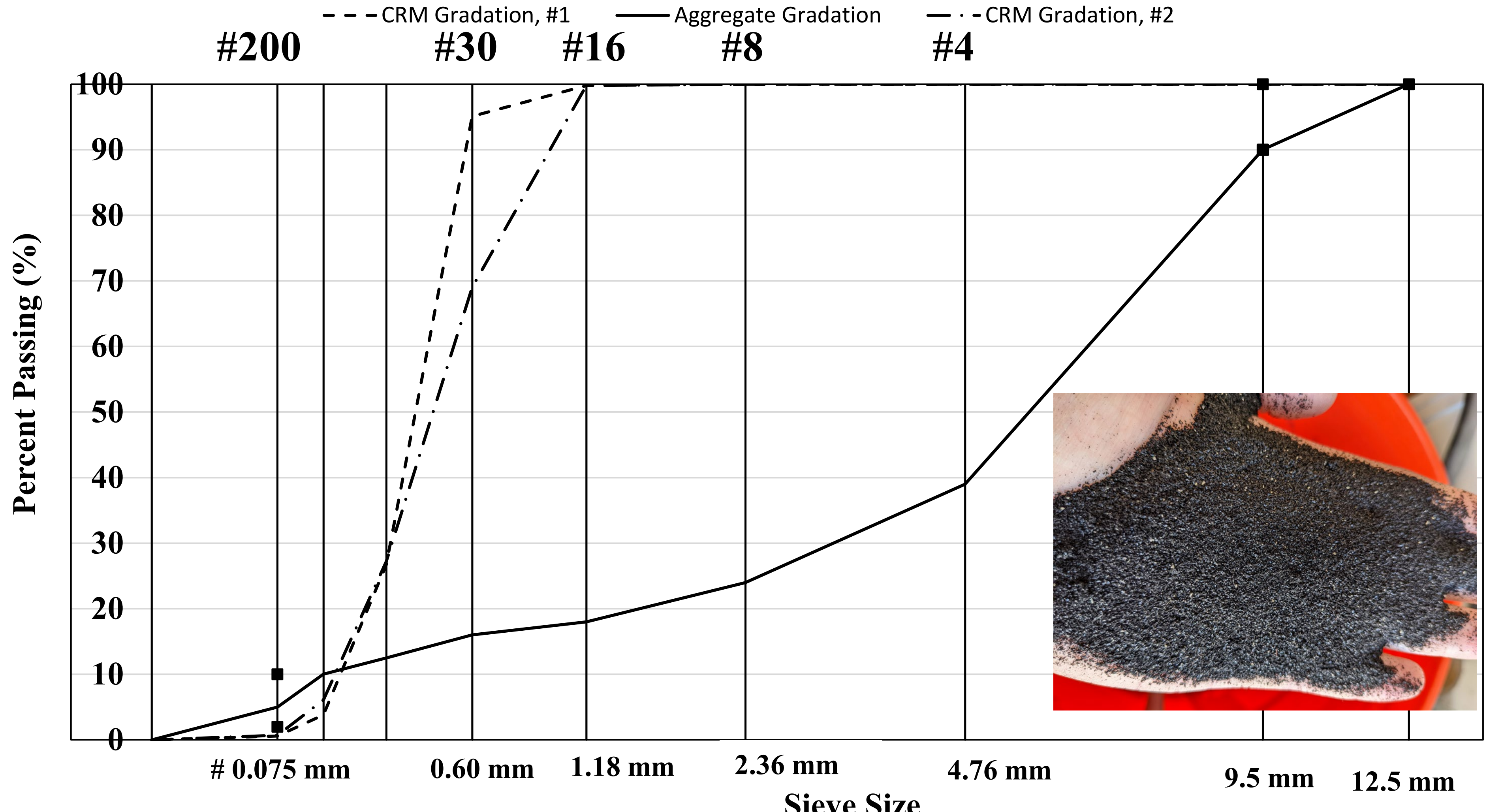
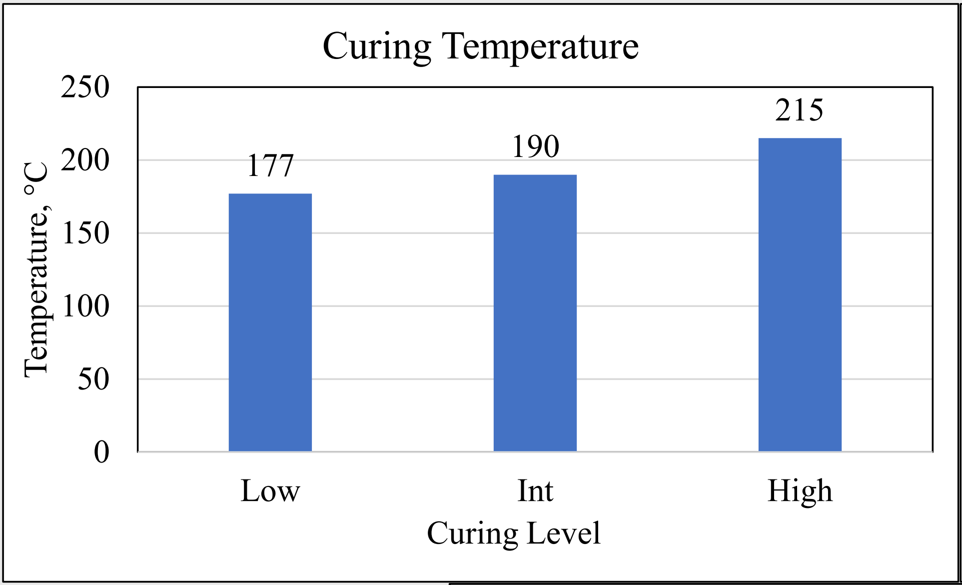
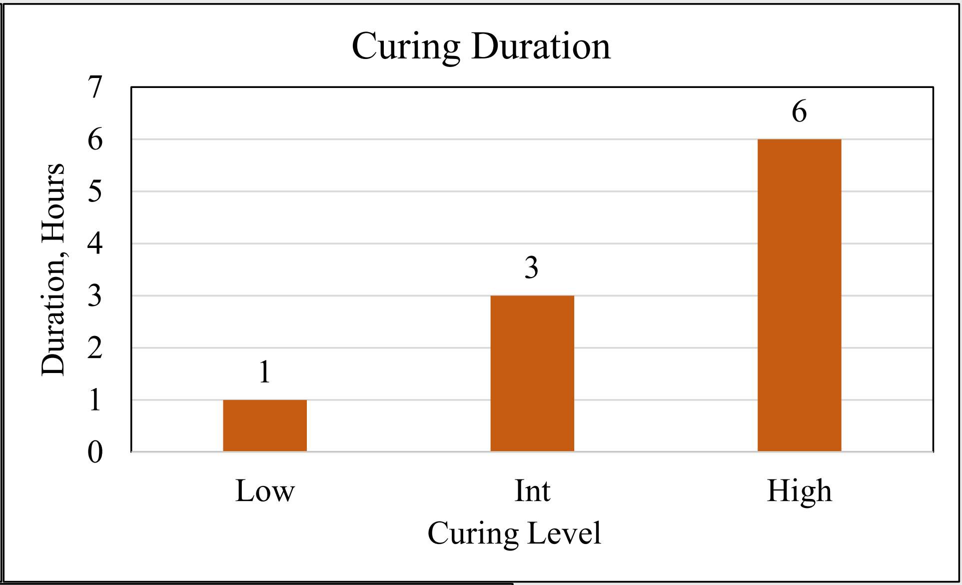
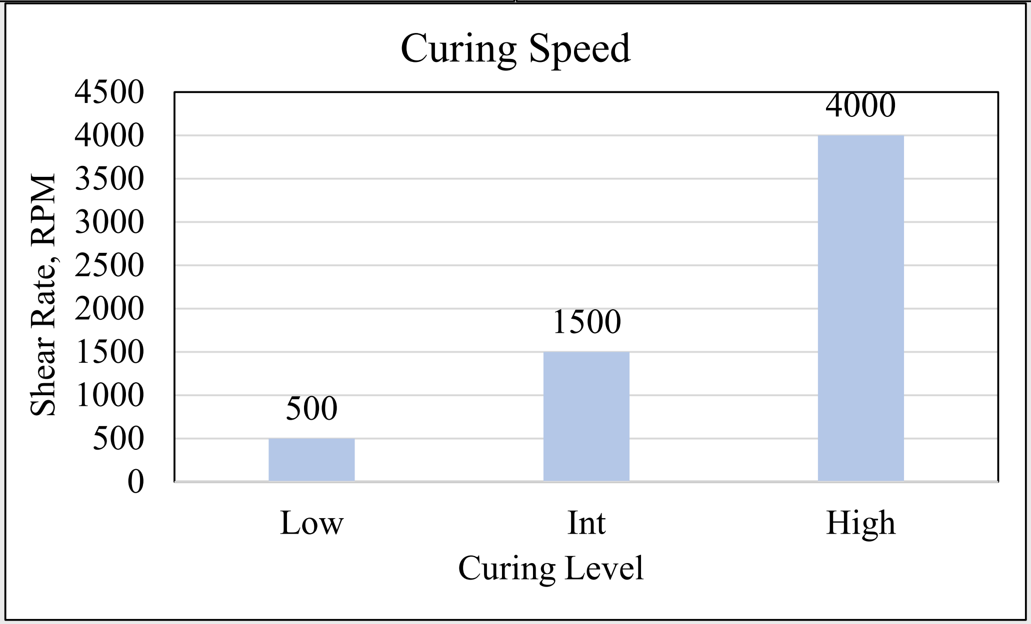
Particle Size Distribution (Gradations)



CRM-Binder Cure Levels



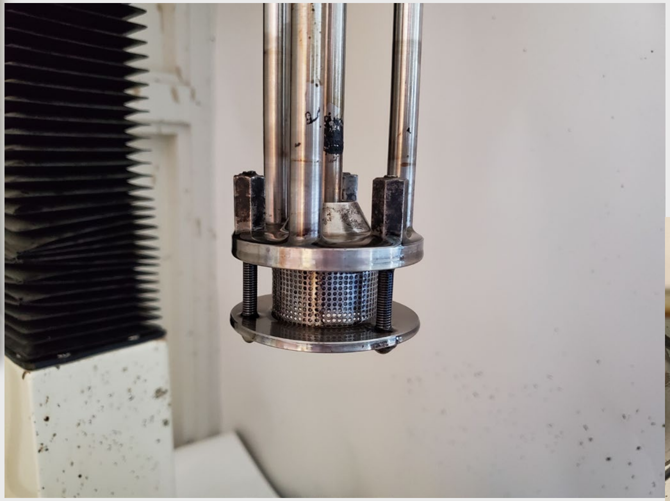




CRM Blending in the Lab

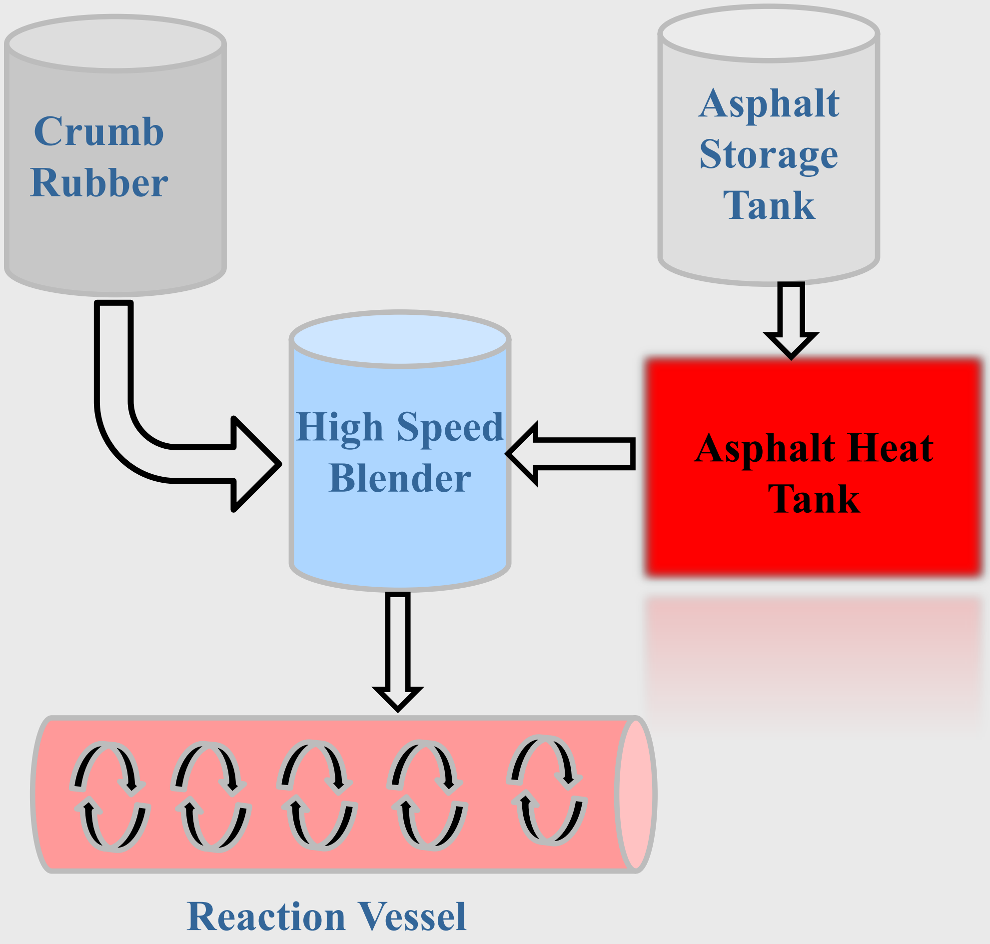
Blending equipment with heating mantle

Mixing Head



Incorporating CRM

Asphalt Rubber Blending Process (in the field)



Asphalt Rubber Blending Process

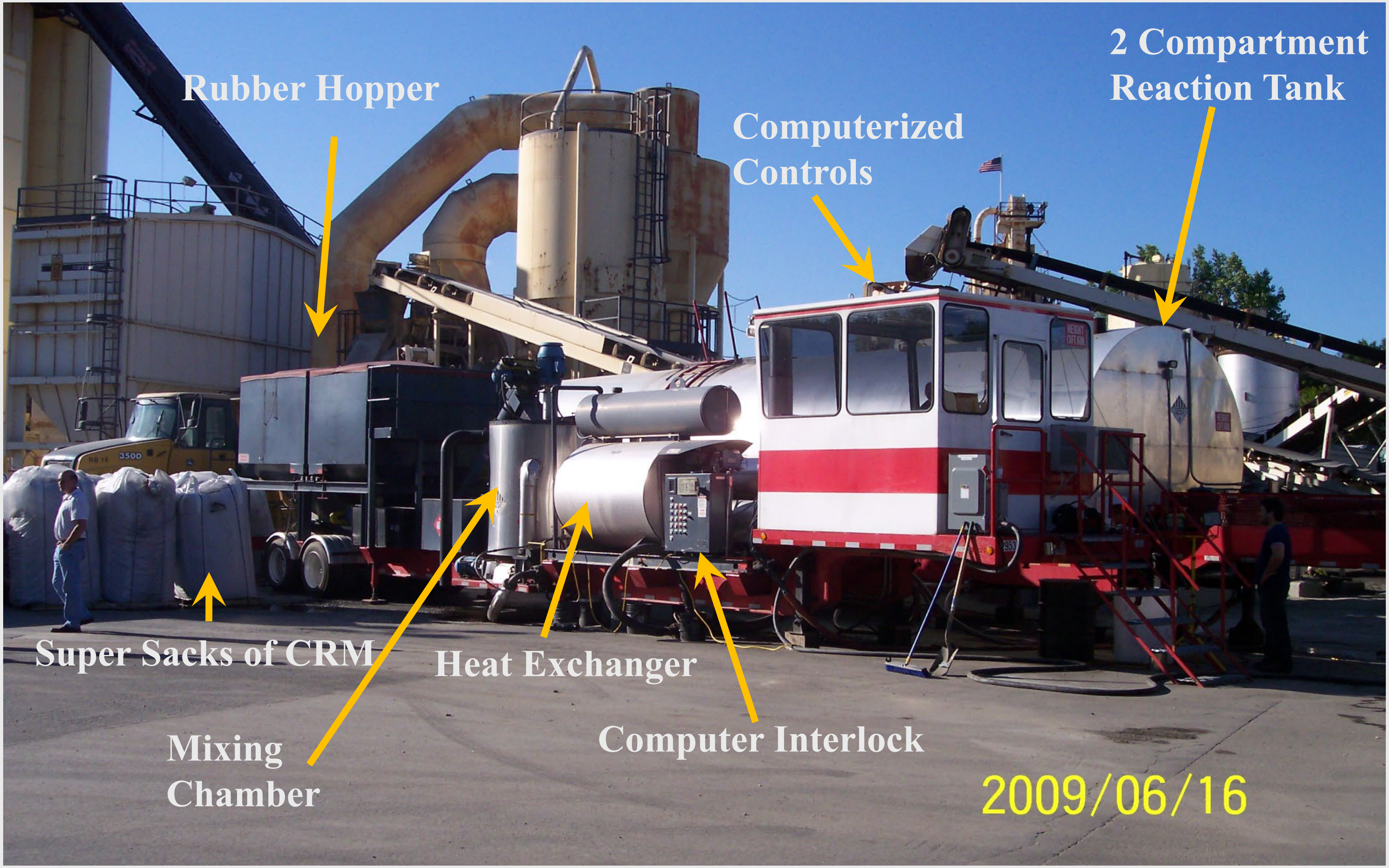


Photo: Courtesy of Mark Edsall, All States Materials Group

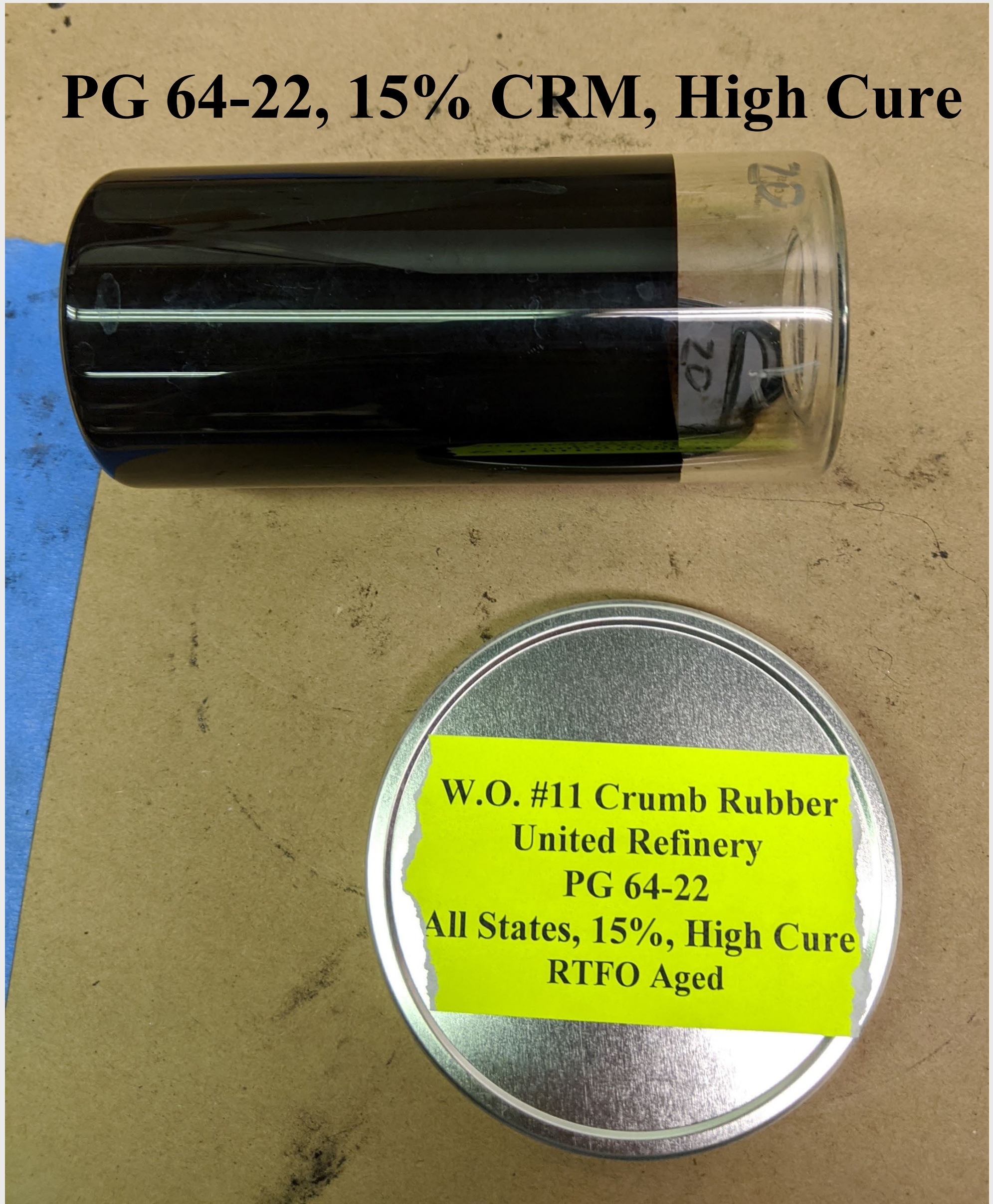
Low Cure versus High Cure

Low Cure

High Cure

15% CRM PG 58-28

Short-Term Conditioning

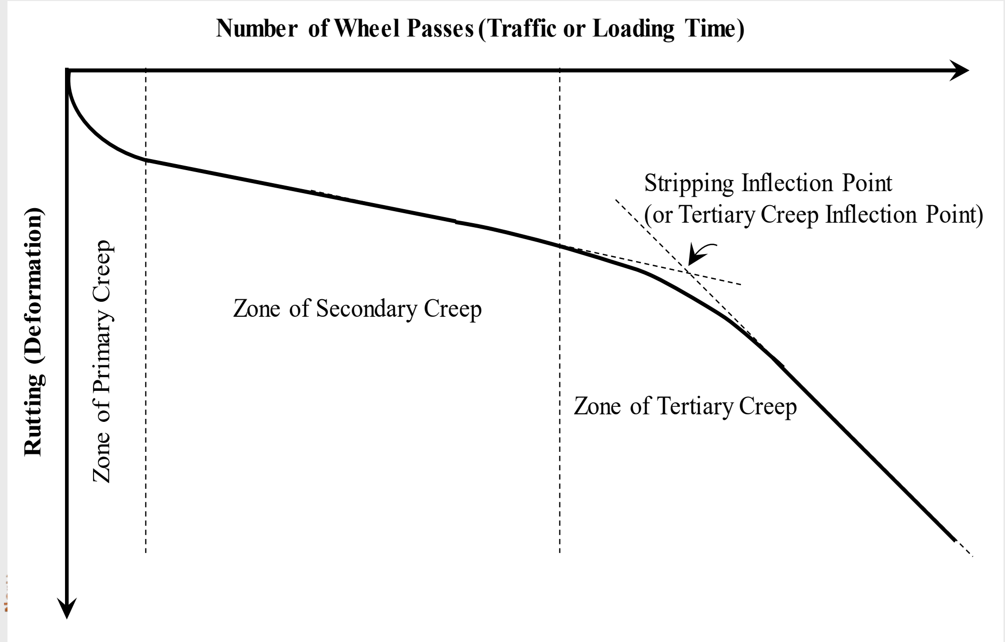


Binder Characterization Tests

- 1. Cure CRM Binders at Different Levels
- 2. Unaged, RTFO-aged, and PAV-aged
- 3. DSR, BBR, MSCR

Mixture Performance Tests

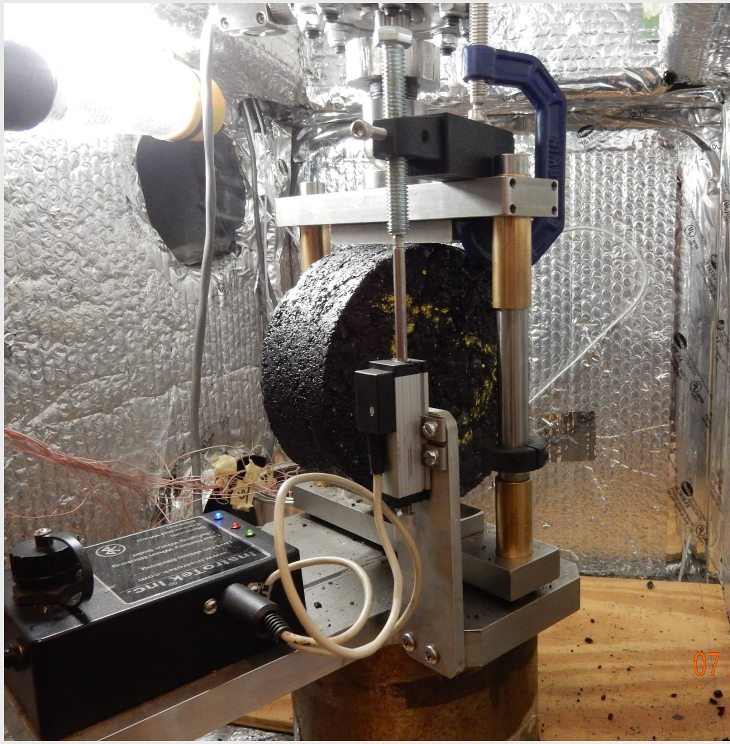
- Hamburg Wheel Tracking
  - AASHTO T 324
  - 150-mm diameter, 62-mm tall
  - Trimmed at the side to deliver track
  - 20,000 passes, 50C

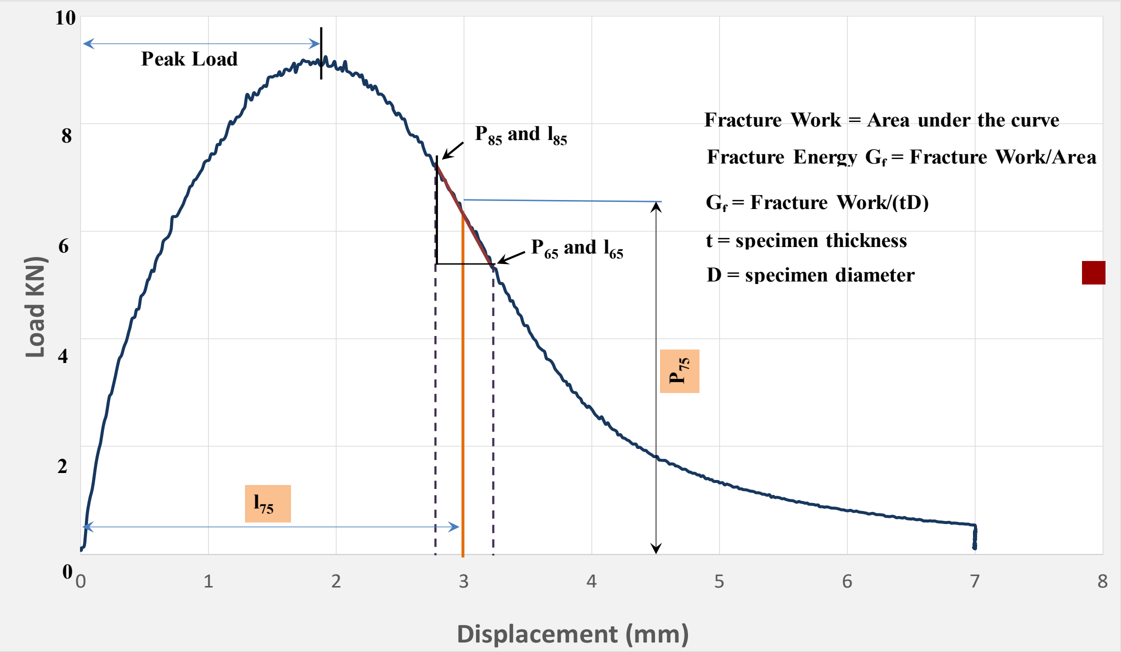


- Measure Resistance to
  - Rutting
  - Moisture Damage

Mixture Performance Tests

- IDEAL-CT
  - ASTM D8225-19
  - 150-mm diameter, 62-mm thick
  - 50 mm/min loading, 25C

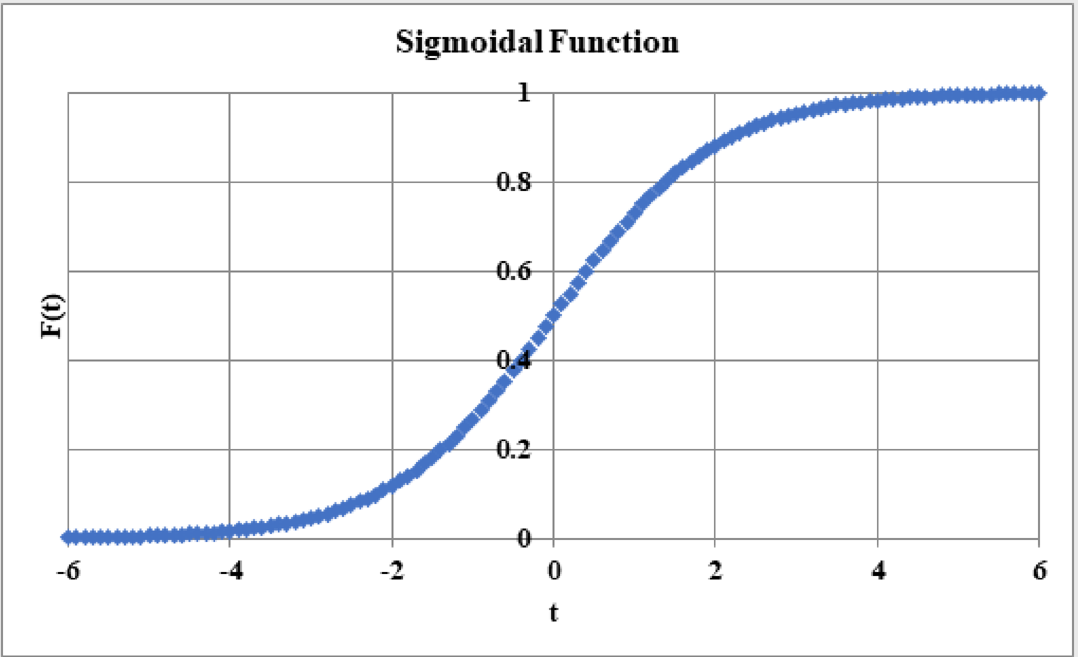




- Measure Resistance to
  - Cracking

Mixture Performance Tests

- Dynamic Modulus
  - AASHTO T 342
  - 100-mm diameter, 150-mm tall
  - Multiple temperatures, freqs.



- Measure Engineering Properties of the Mix
  - Modulus (Stiffness)
  - Phase Angle

Outline

- PennDOT CRM Projects
- CRM as Asphalt Binder Modifier
- Experimental Program in this Research
- **Findings: CRM Modified Asphalt Binders**
- Findings: CRM Modified Asphalt Mixtures
- Summary and Conclusions

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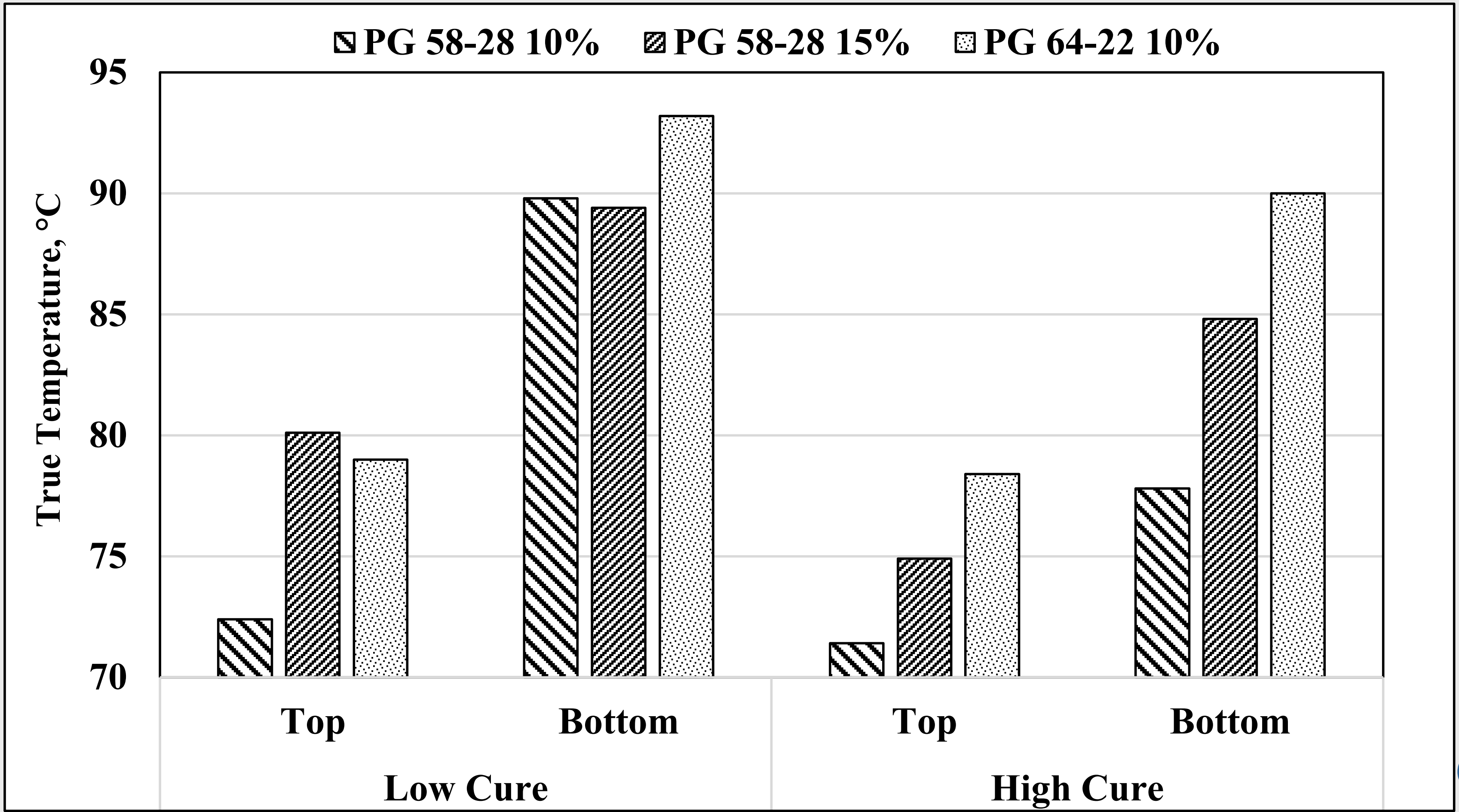
Storage Stability (ASTM D7173-14)

A measure of degree of incompatibility

Vertical Tube in 163 ± 5°C oven, 48 ± 1 hr.
Freeze at -10 ± 10°C for 4 hrs.



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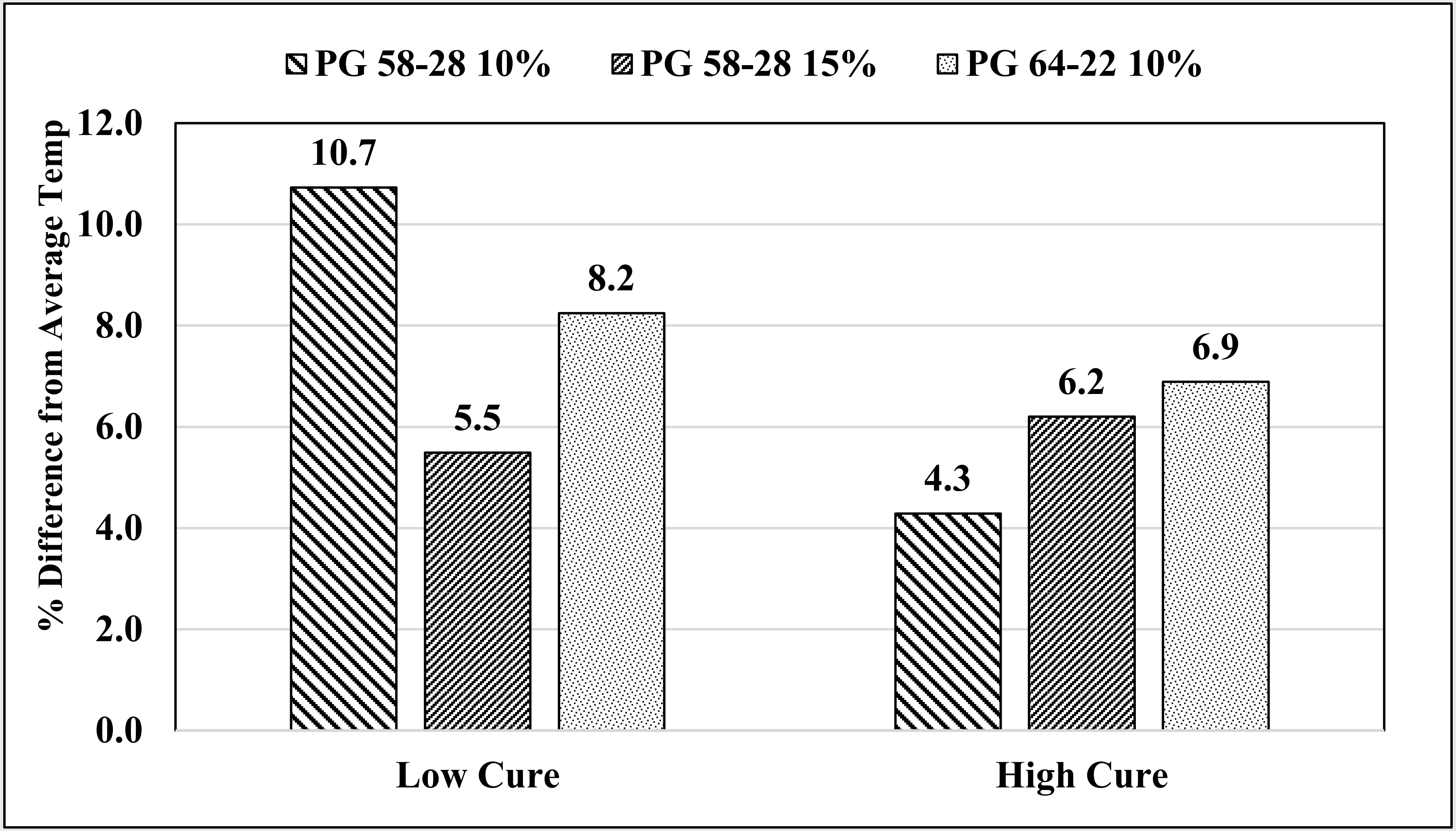
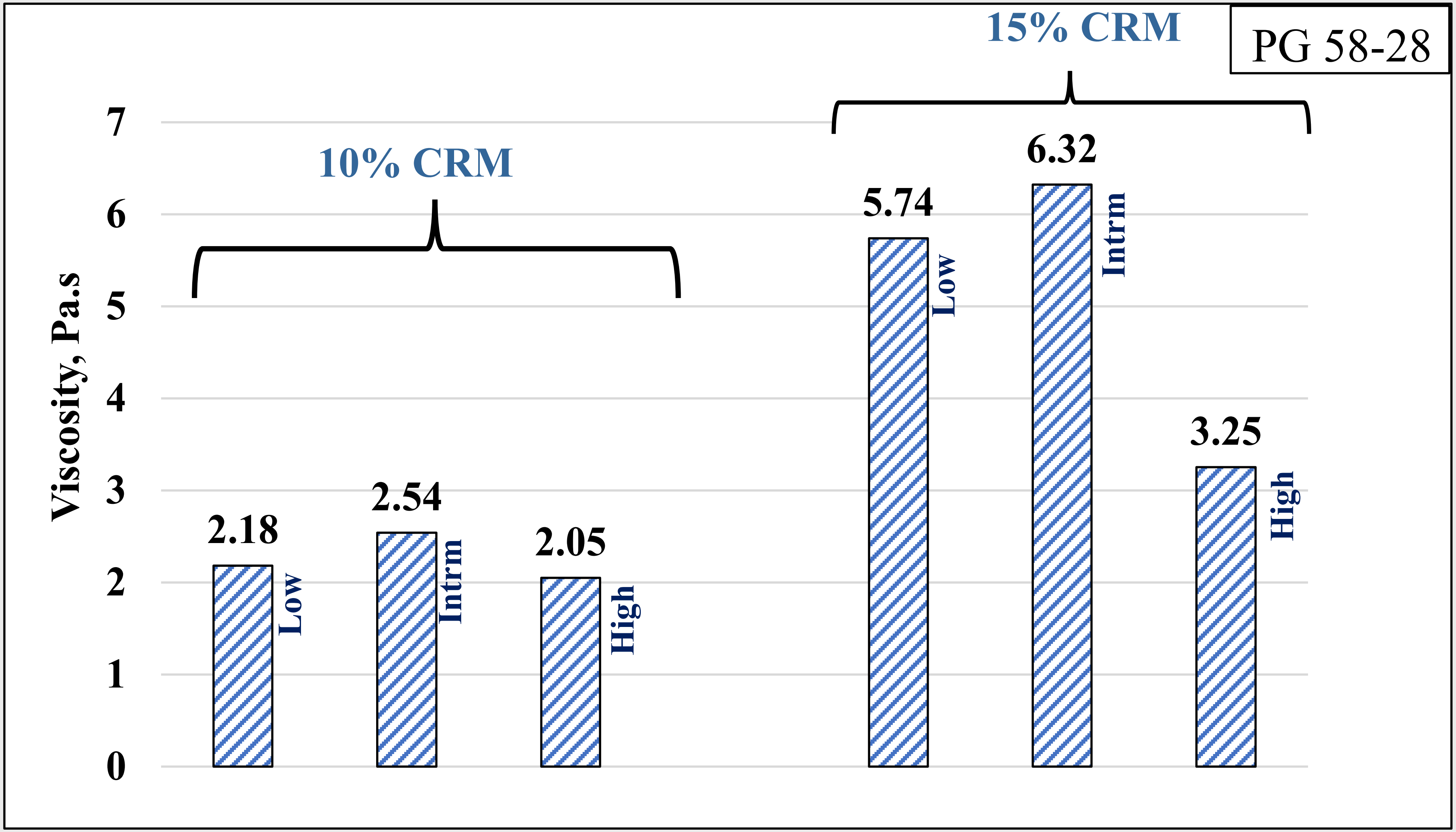
Storage Stability (ASTM D7173-14)

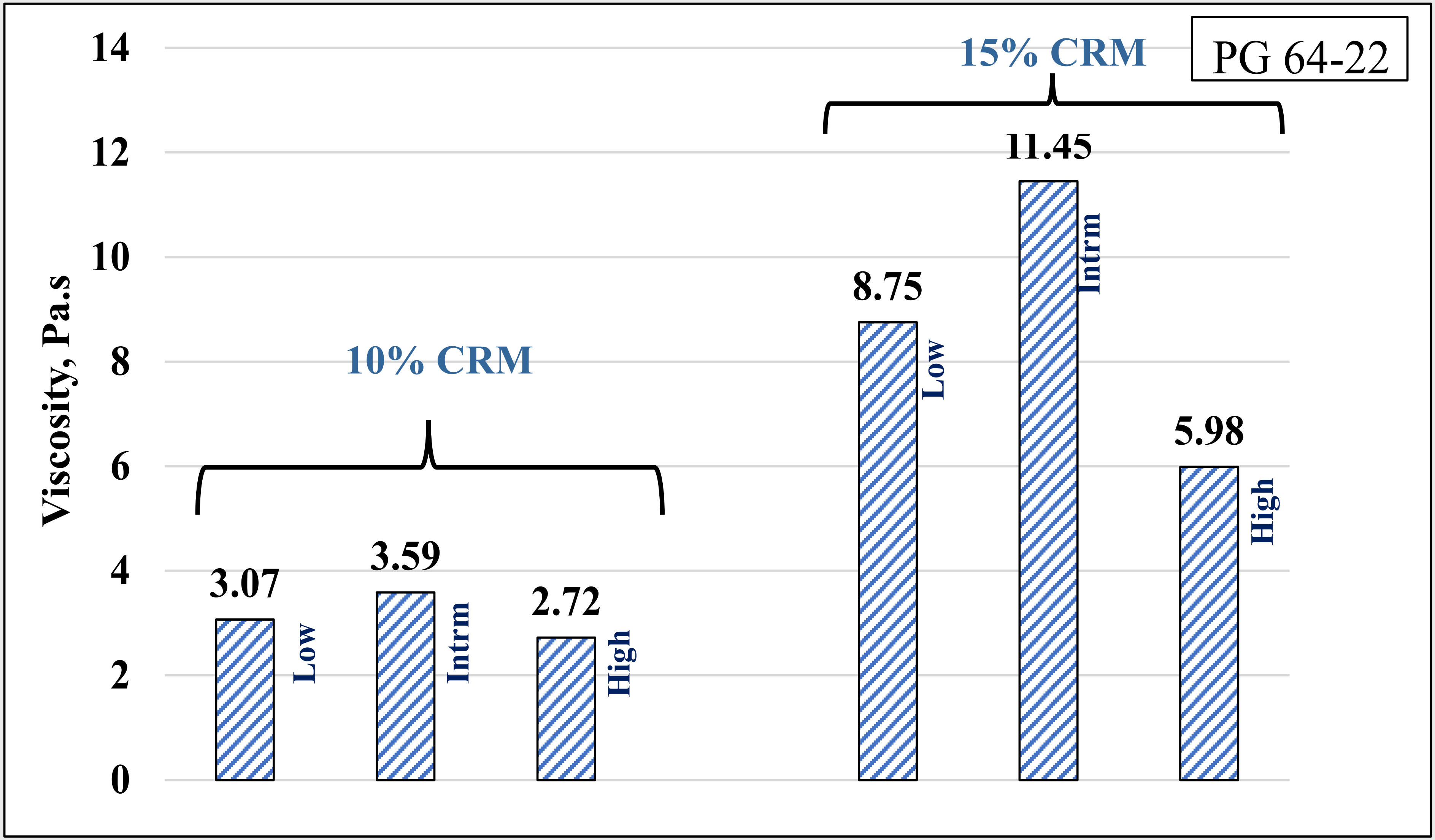


Binder Viscosity



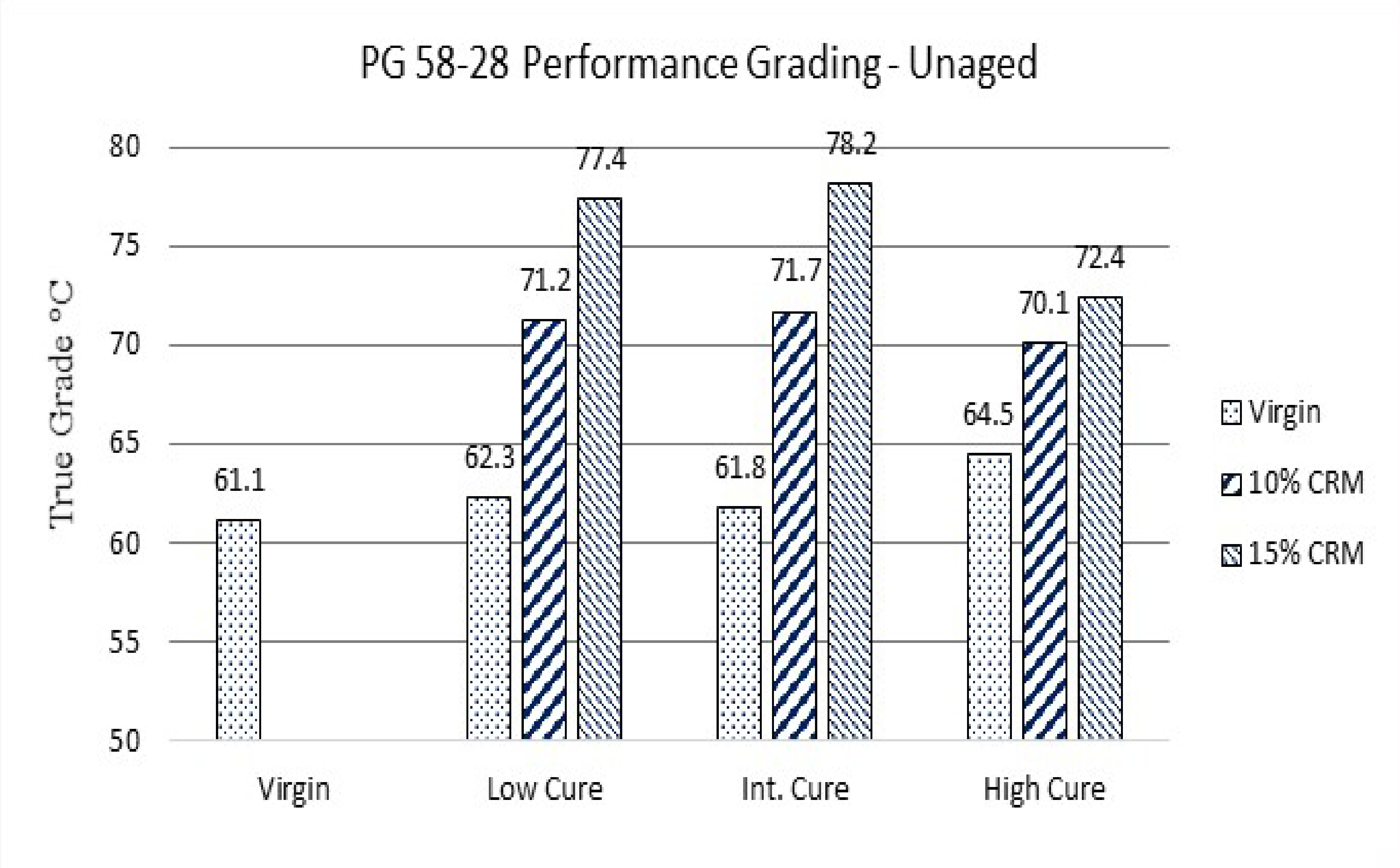
Test Temperature: 135°C

Binder Viscosity

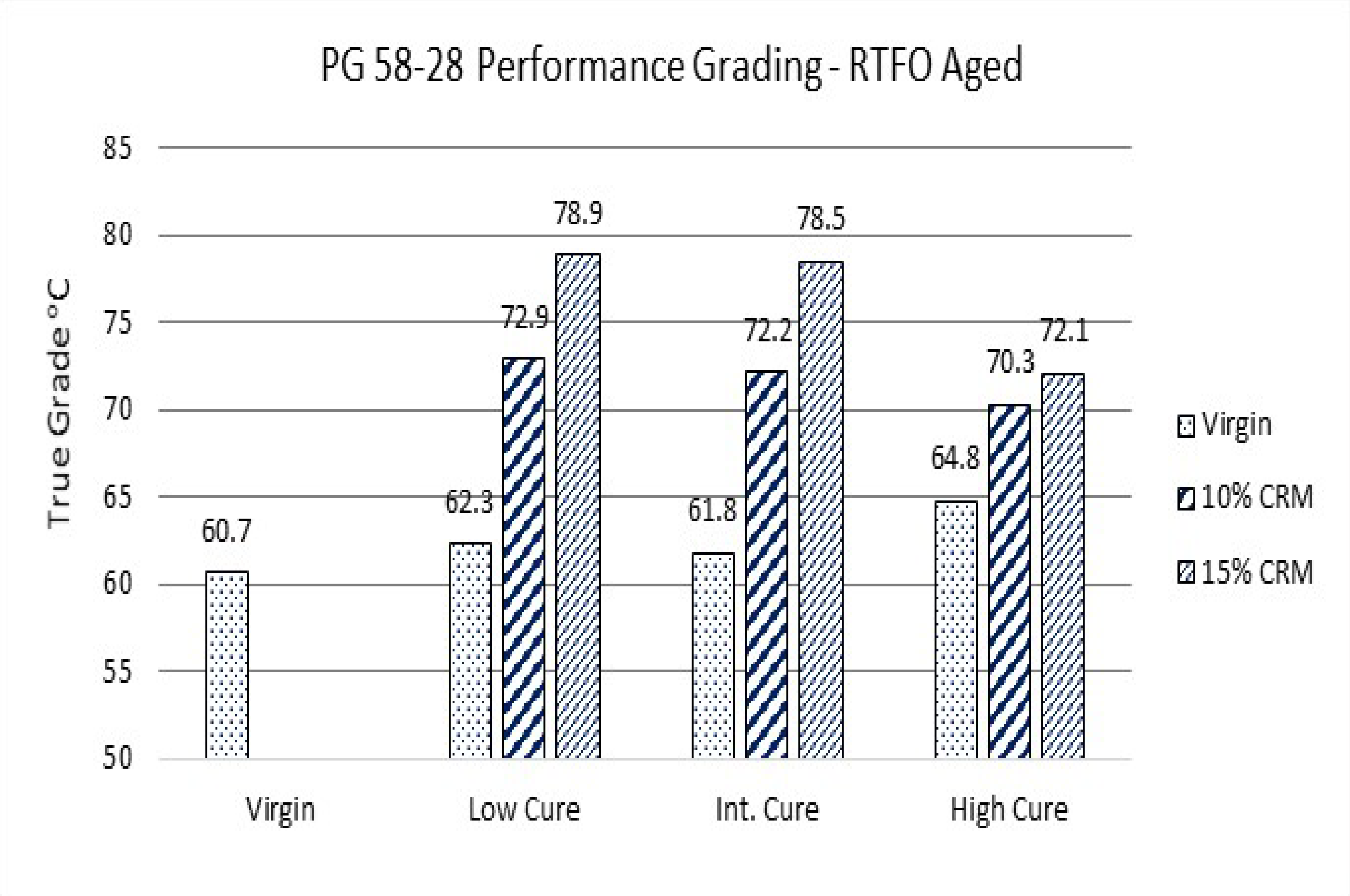


Test Temperature: 135°C

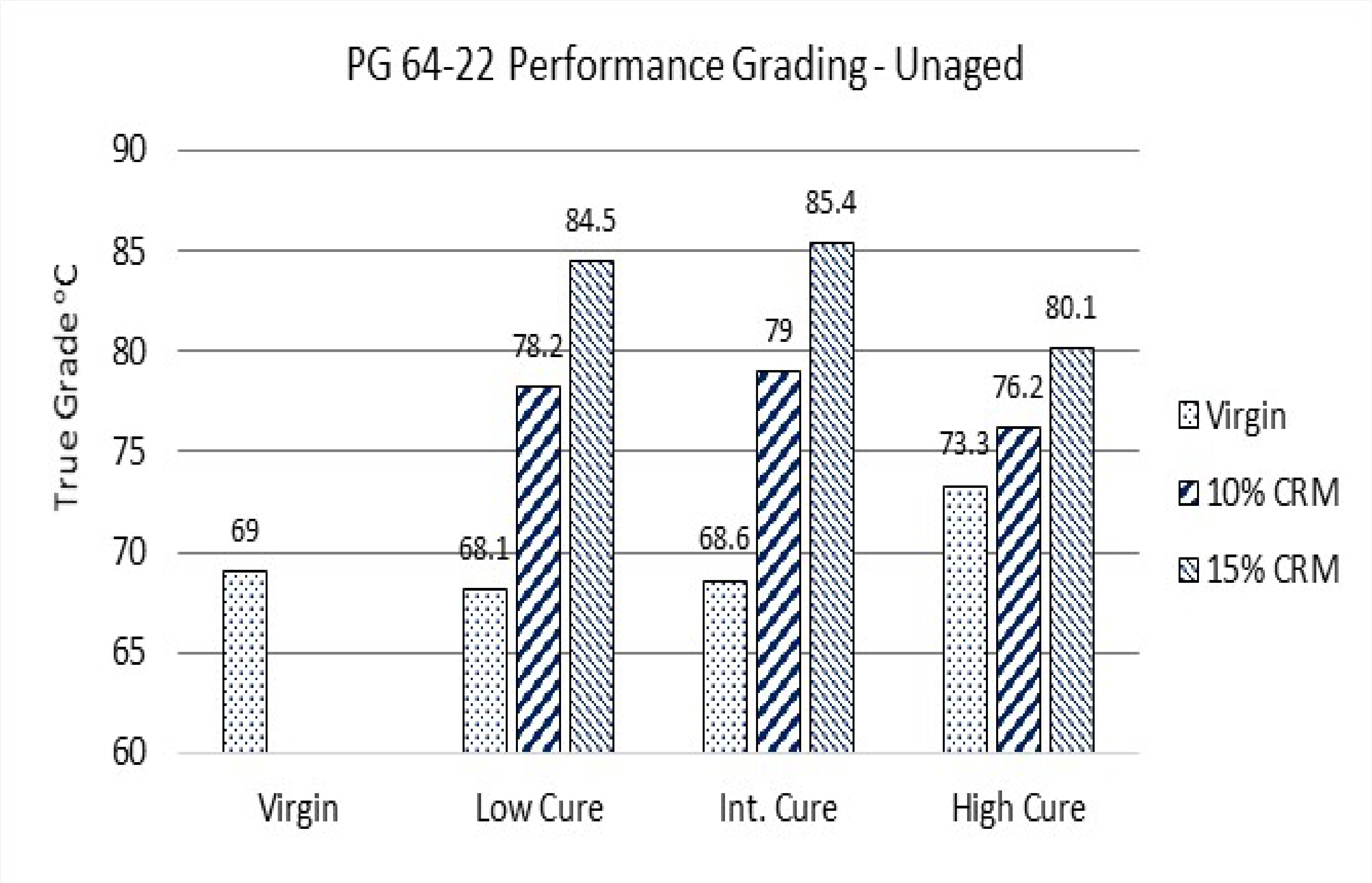
Binder PG


PG 58-28 Performance Grading - Unaged
True Grade °C
80
75
70
65
60
55
50
61.1
62.3
71.2
77.4
61.8
71.7
78.2
64.5
70.1
72.4
Virgin
Low Cure
Int. Cure
High Cure
Virgin
10% CRM
15% CRM

Binder PG

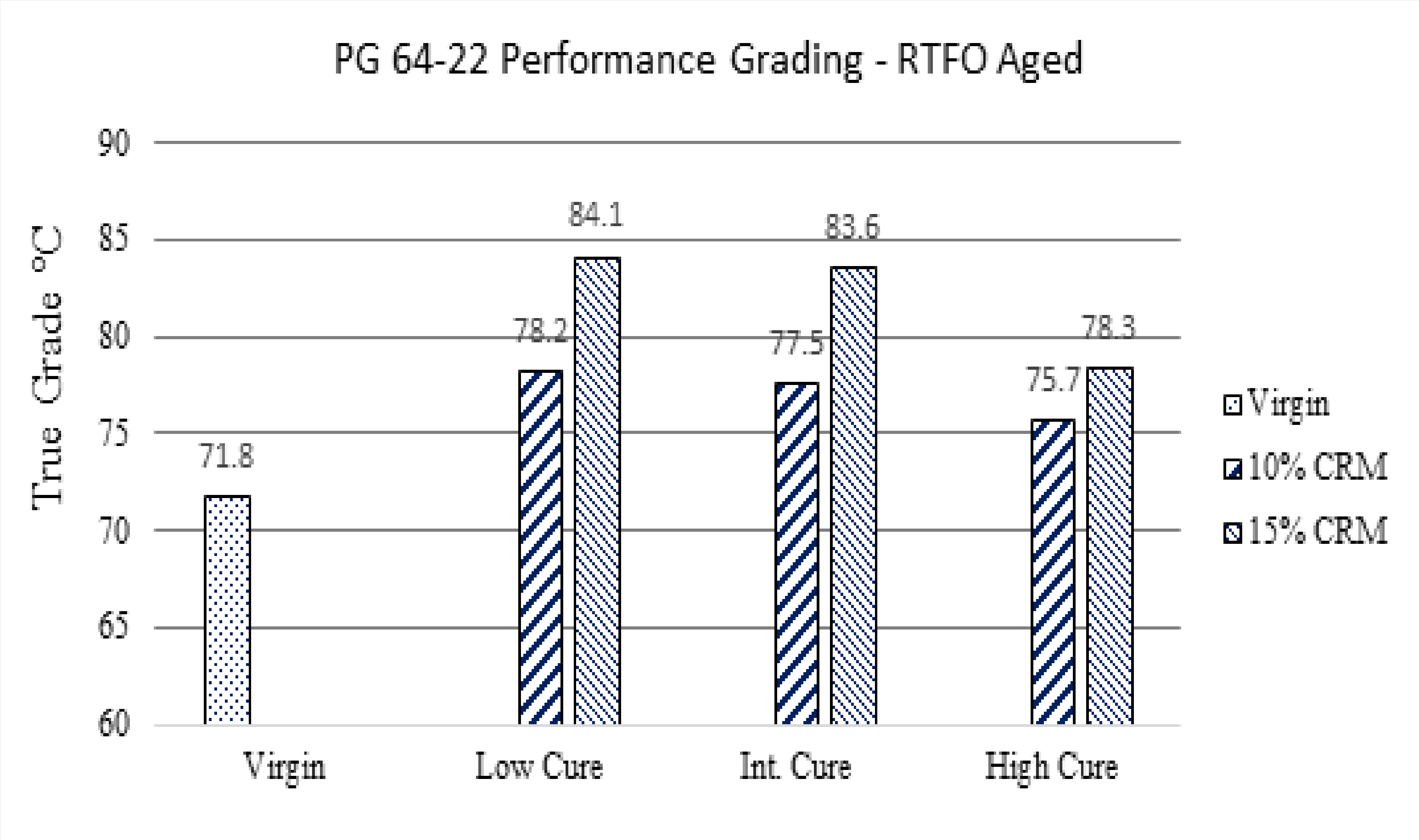

PG 58-28 Performance Grading - RTFO Aged
True Grade °C
85
80
75
70
65
60
55
50
60.7
62.3
72.9
78.9
61.8
72.2
78.5
64.8
70.3
72.1
Virgin
Low Cure
Int. Cure
High Cure
Virgin
10% CRM
15% CRM

Binder PG



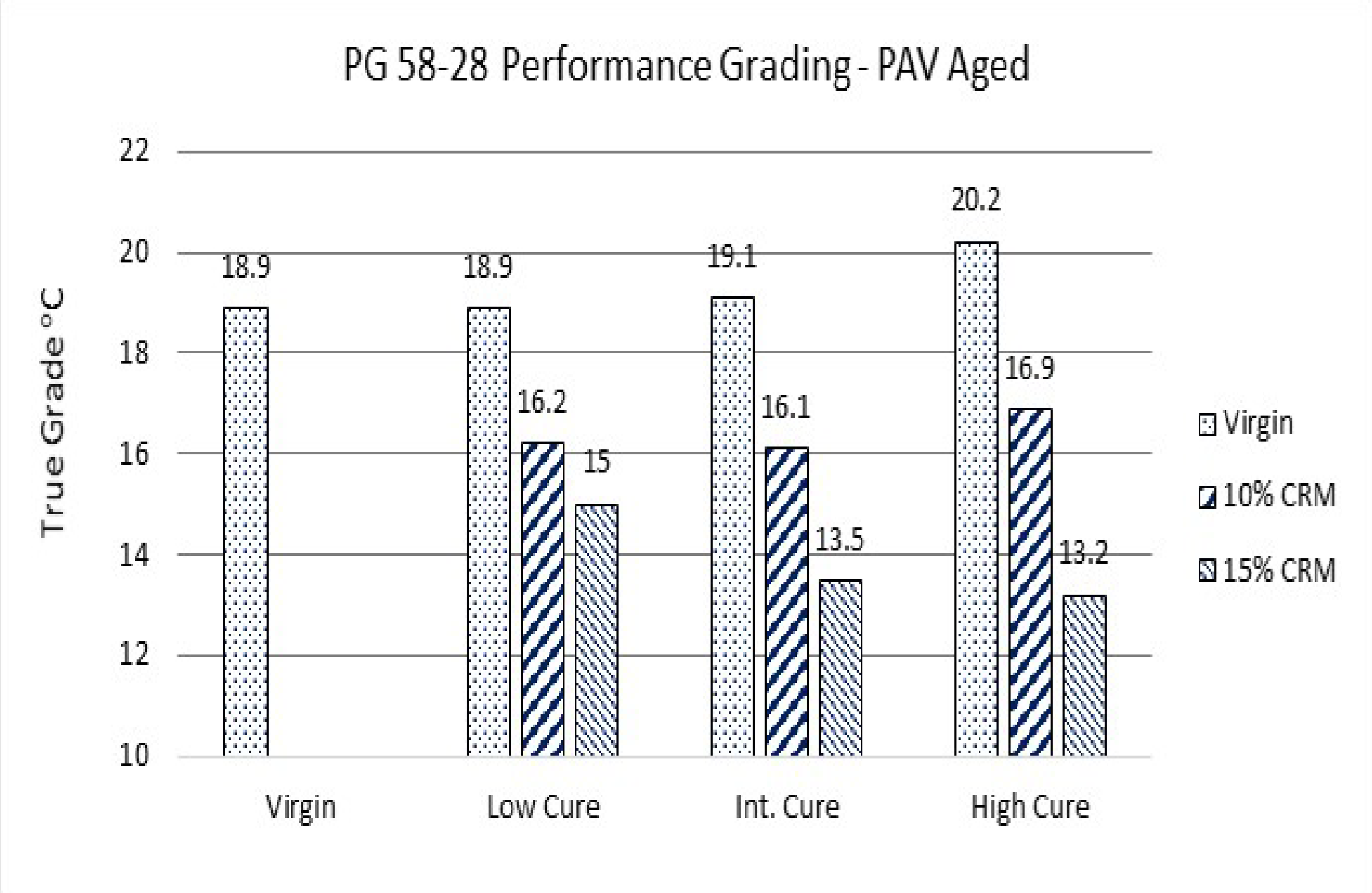
PG 64-22 Performance Grading - Unaged
True Grade °C
90
85
80
75
70
65
60
69
68.1
78.2
84.5
68.6
79
85.4
73.3
76.2
80.1
Virgin
Low Cure
Int. Cure
High Cure
Virgin
10% CRM
15% CRM

Binder PG


PG 64-22 Performance Grading - RTFO Aged
True Grade °C
90
85
80
75
70
65
60
71.8
78.2
84.1
77.5
83.6
75.7
78.3
Virgin
Low Cure
Int. Cure
High Cure
Virgin
10% CRM
15% CRM

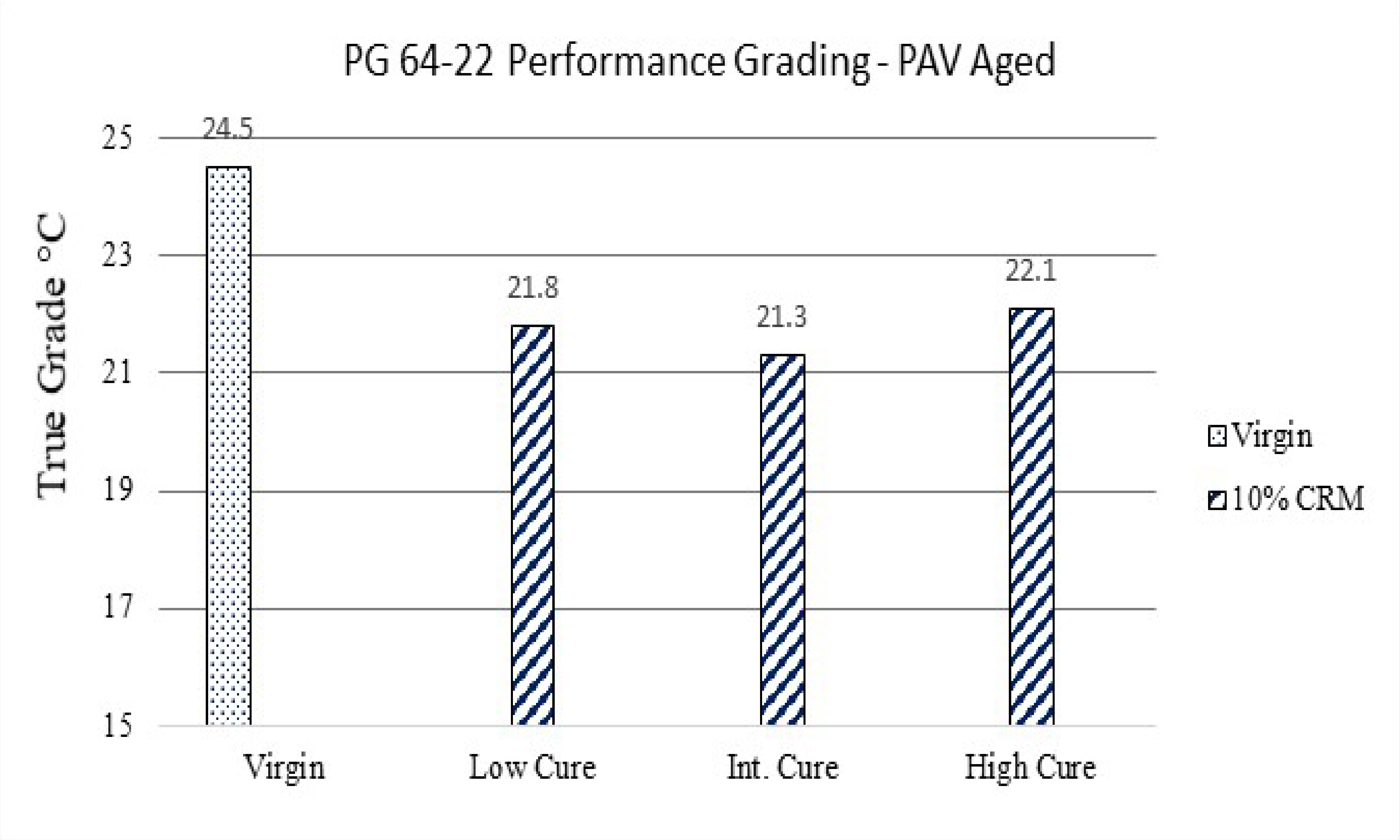
Binder PG

Intermediate Temperature

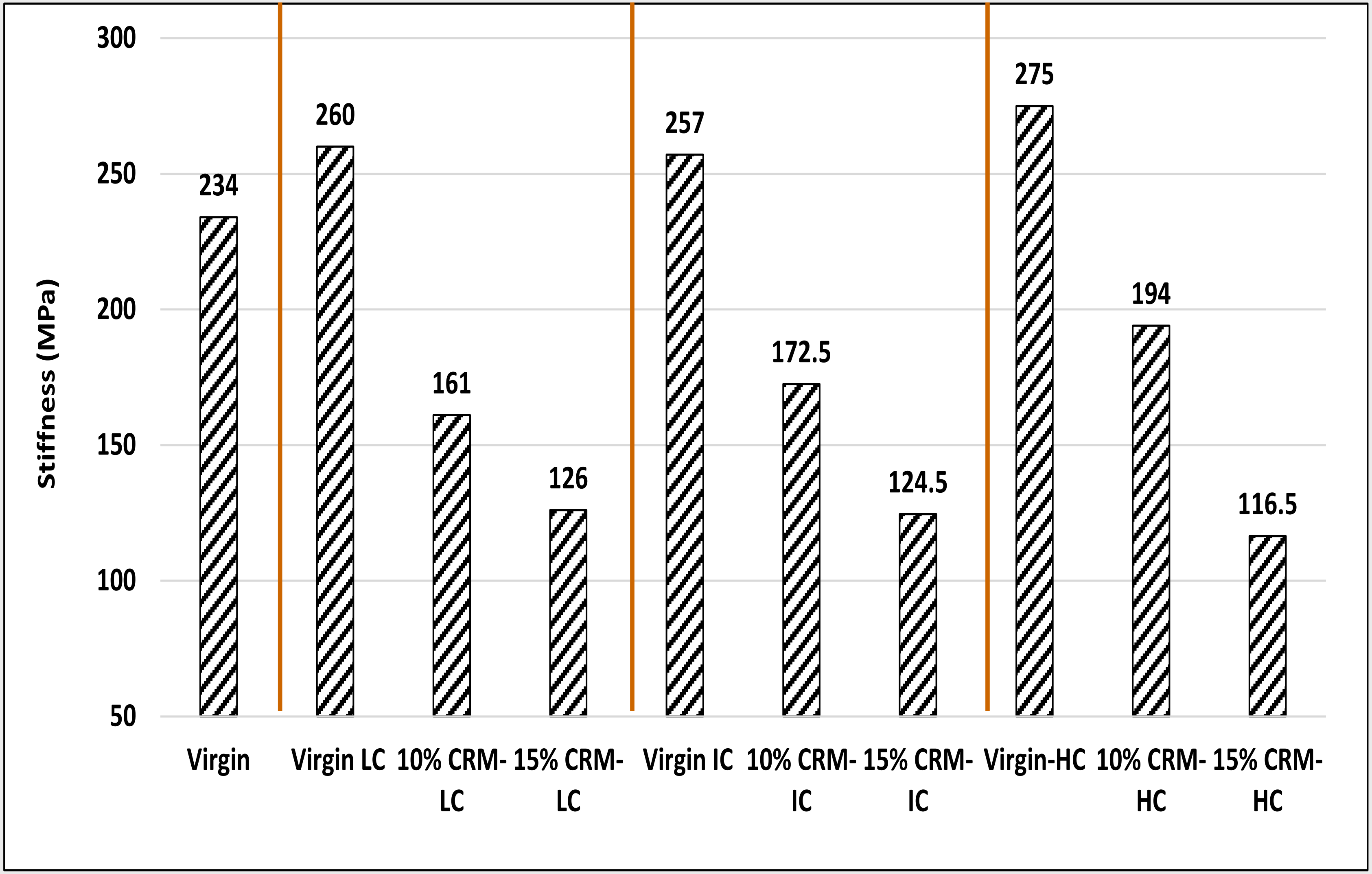


Binder PG

Intermediate Temperature

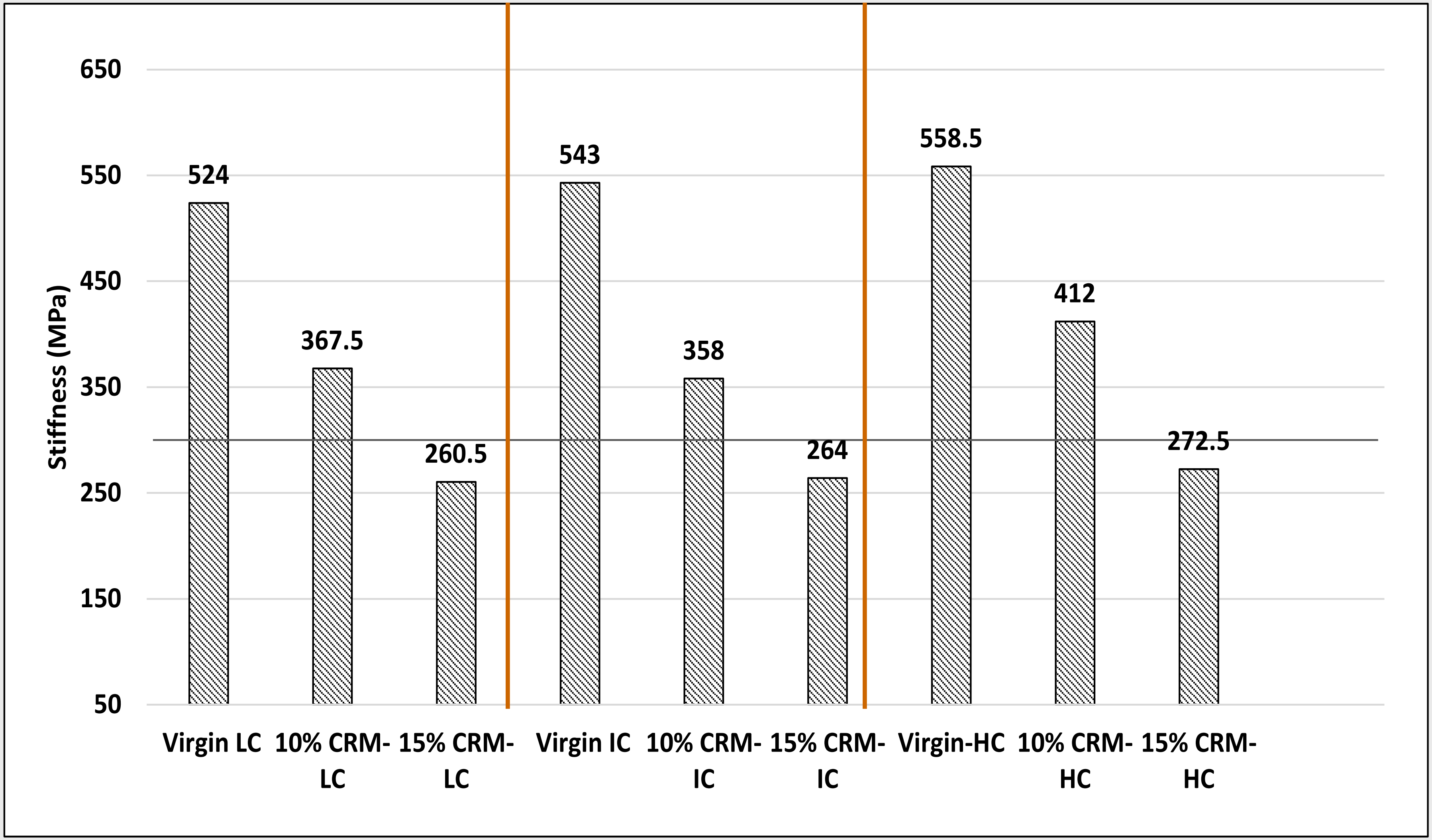


BBR Stiffness



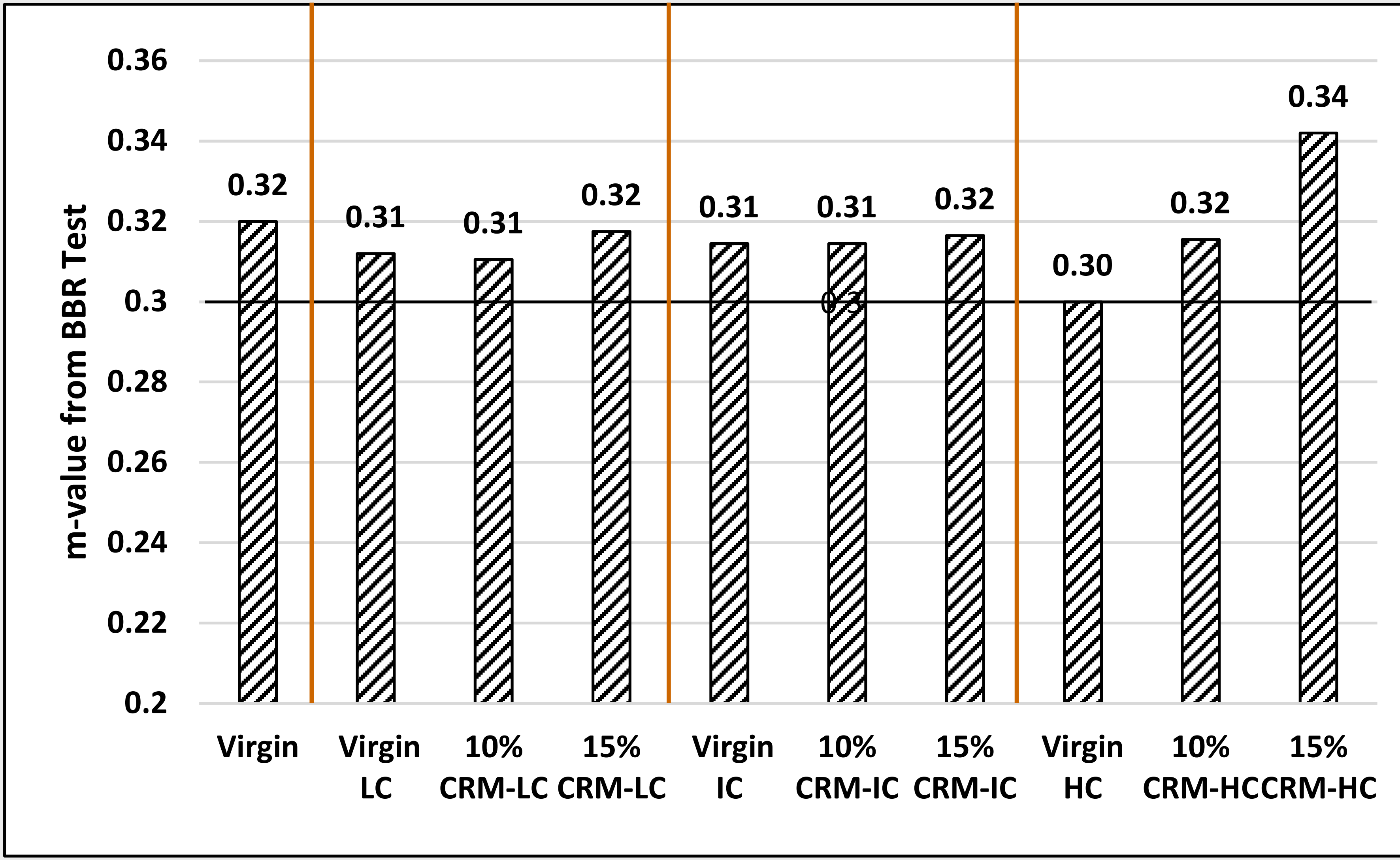
Test Temperature: -18°C

BBR Stiffness



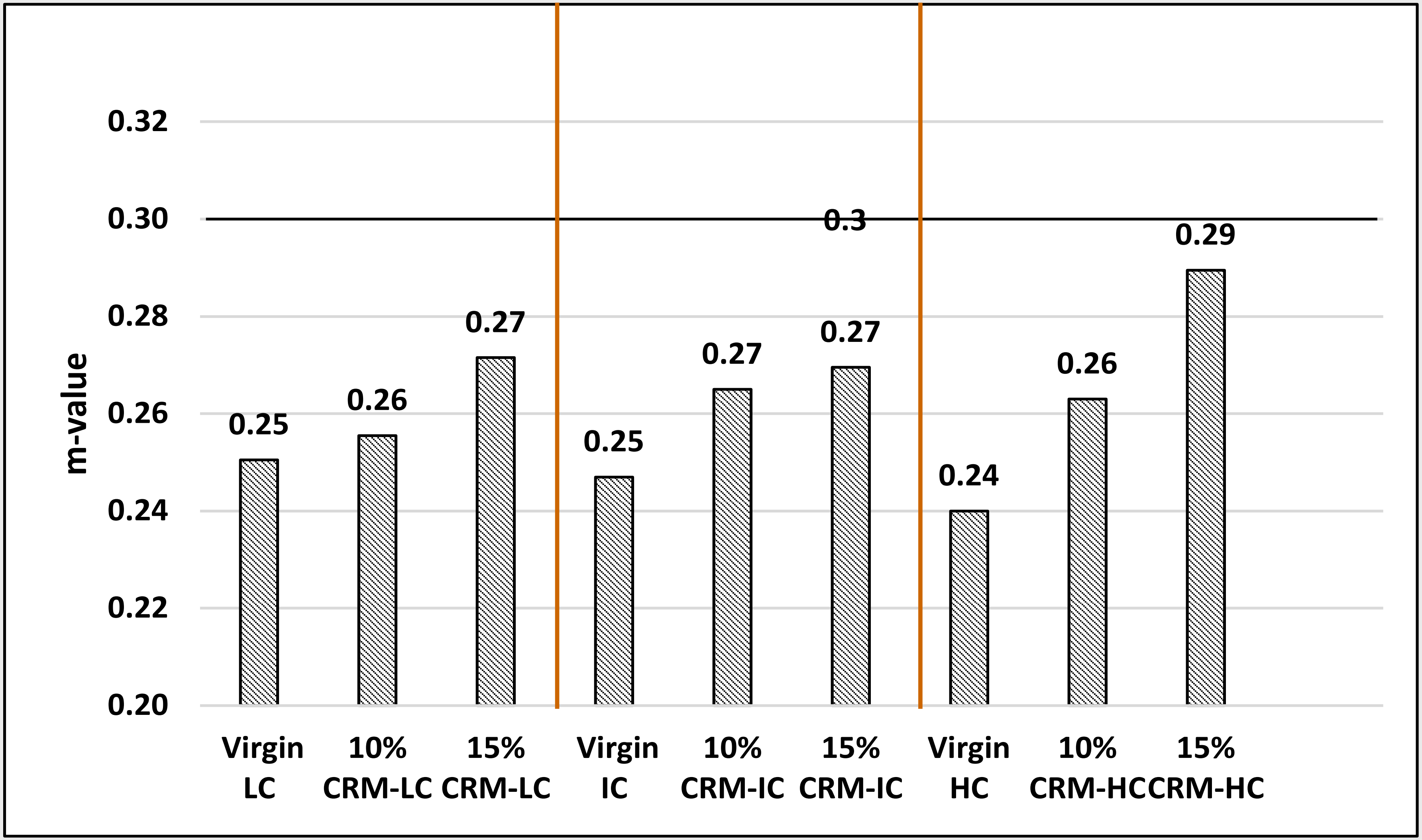
Test Temperature: -24°C

BBR m-value



Test Temperature: -18°C

BBR m-value



Test Temperature: -24°C

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Binder ΔTc

Cure Level	CRM %	ΔTc, °C
Low	15	-4.99
Intermediate	15	-4.90
High	15	-1.76
Low	10	-3.46
Intermediate	10	-2.55
High	10	-1.63
Low	0	-0.15
Intermediate	0	0.13
High	0	-0.75
No Cure	0	-0.16

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- PennDOT CRM Projects
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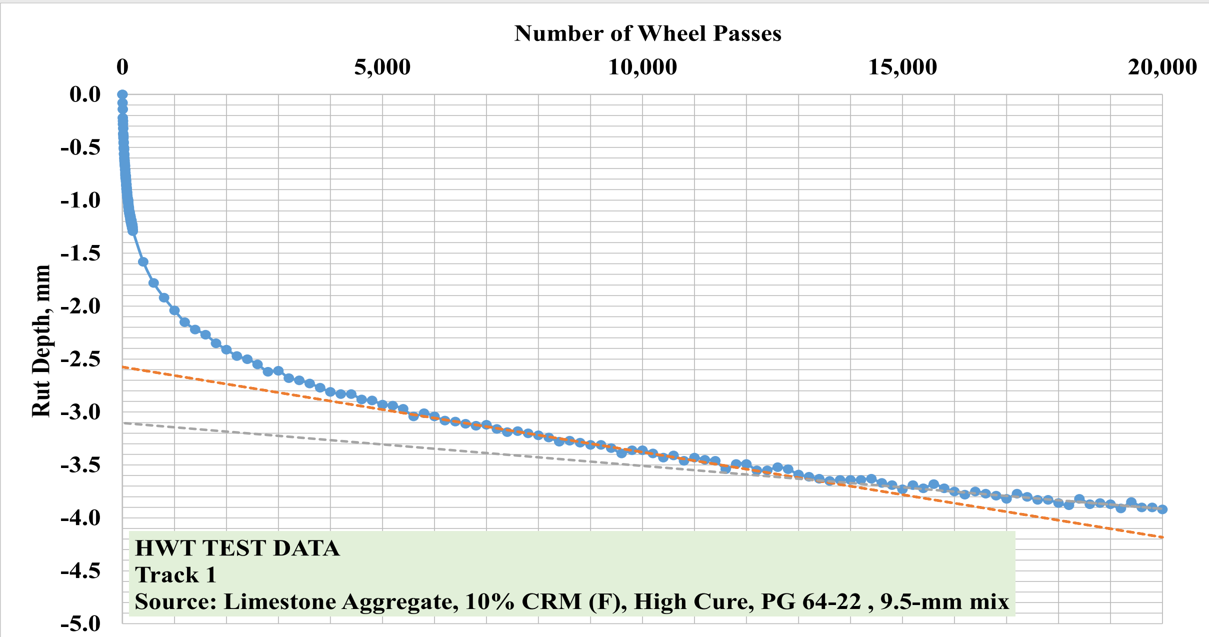
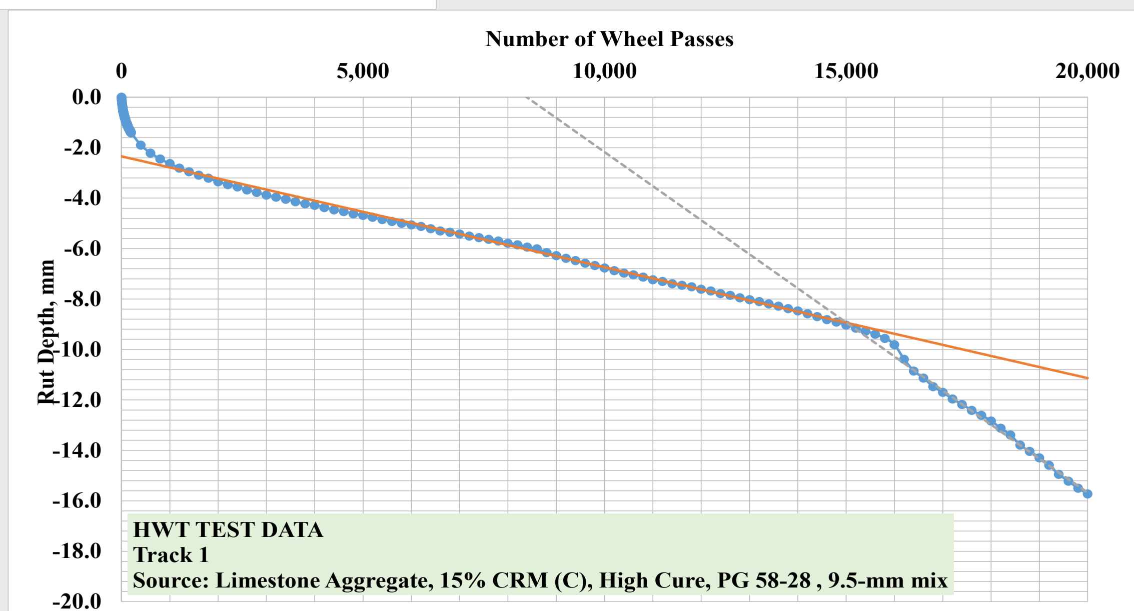
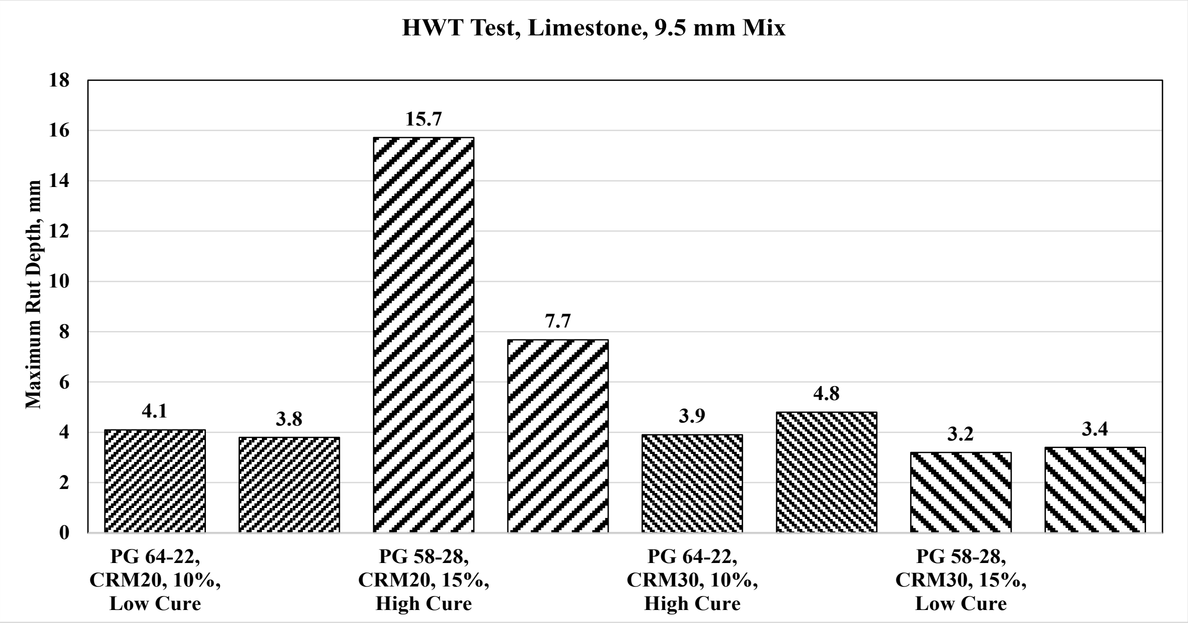
- **Findings: CRM Modified Asphalt Mixtures**
- Summary and Conclusions

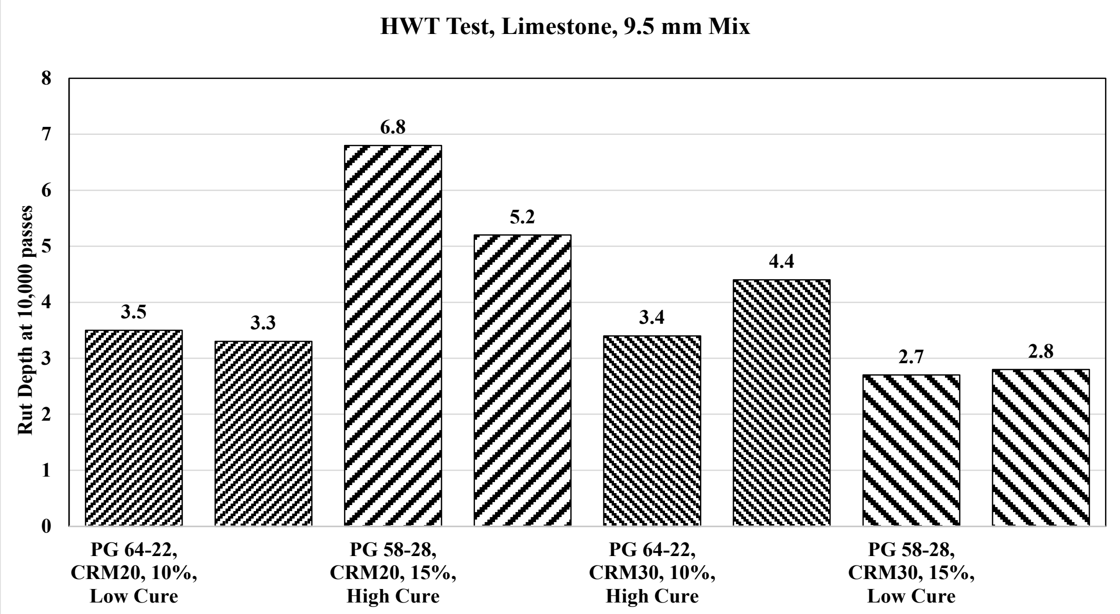
HWT Test Results



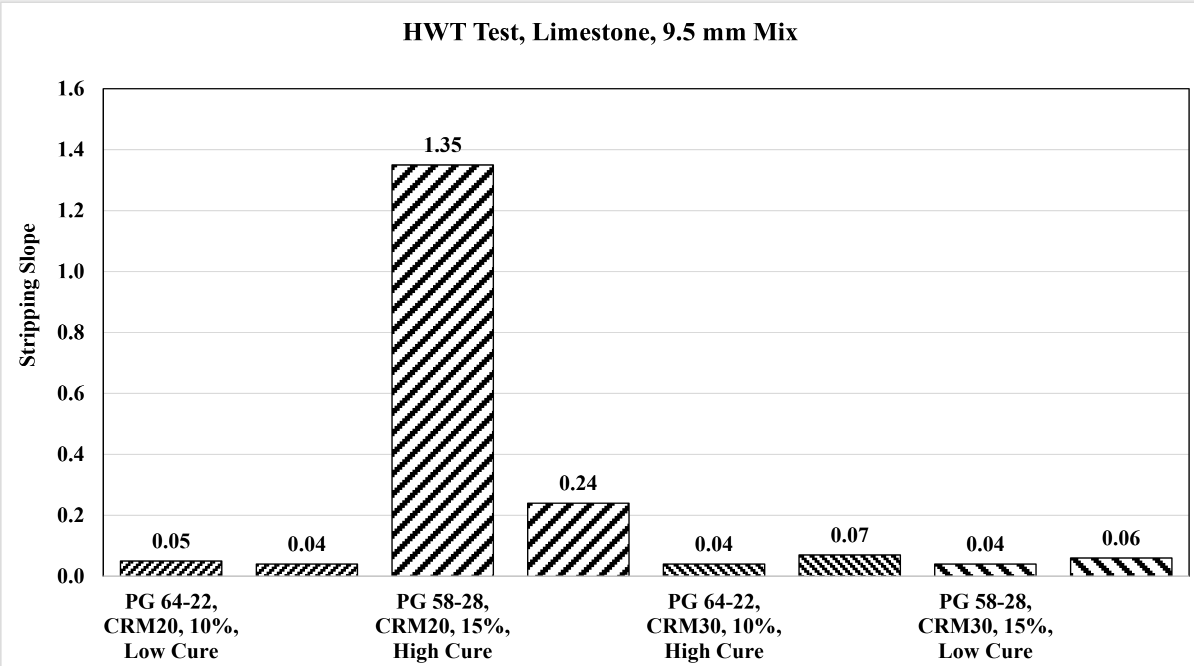


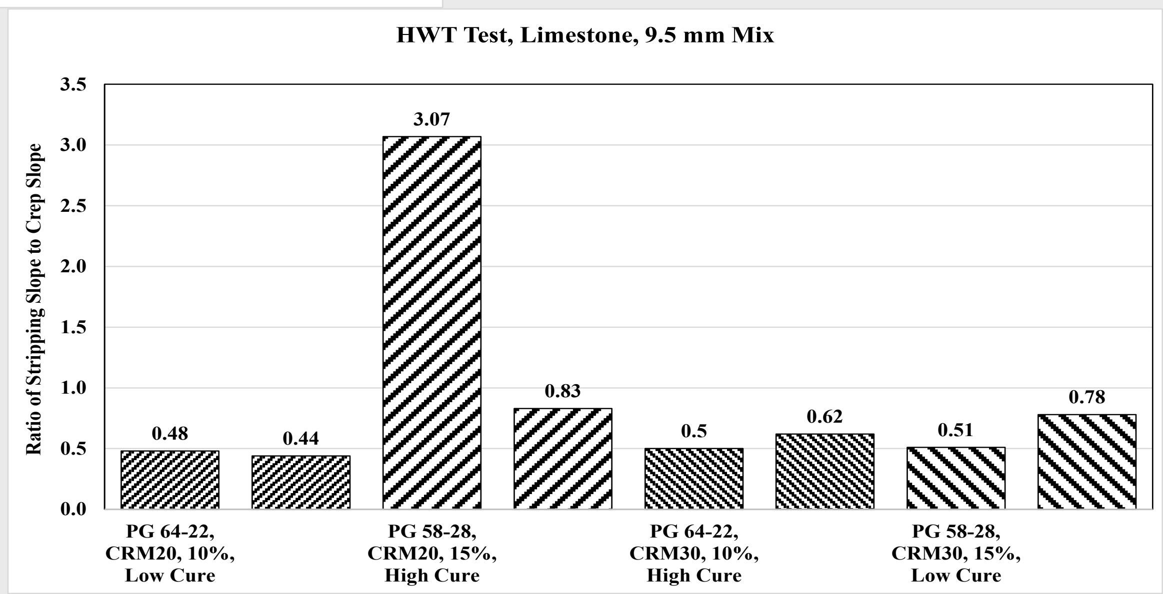
HWT Test Results



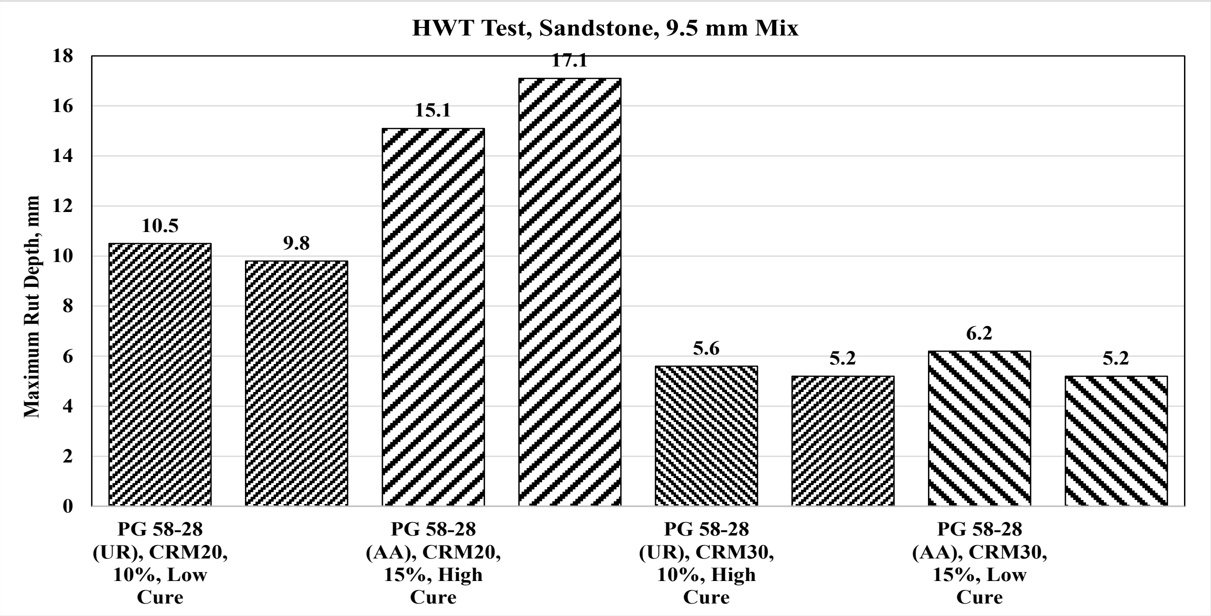


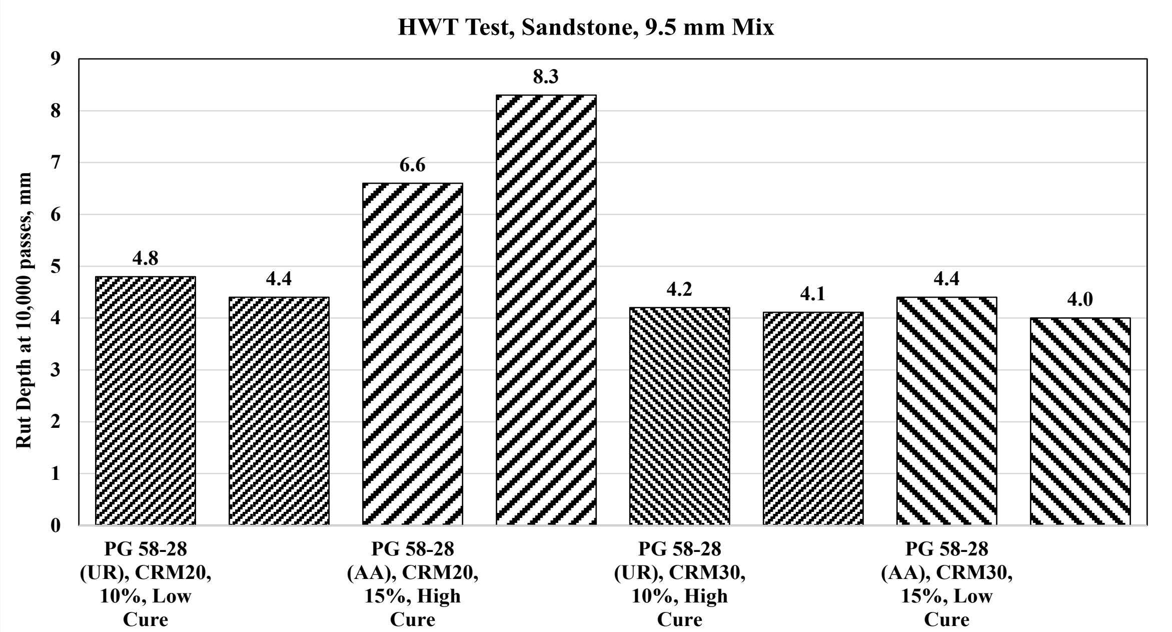
HWT Test Results



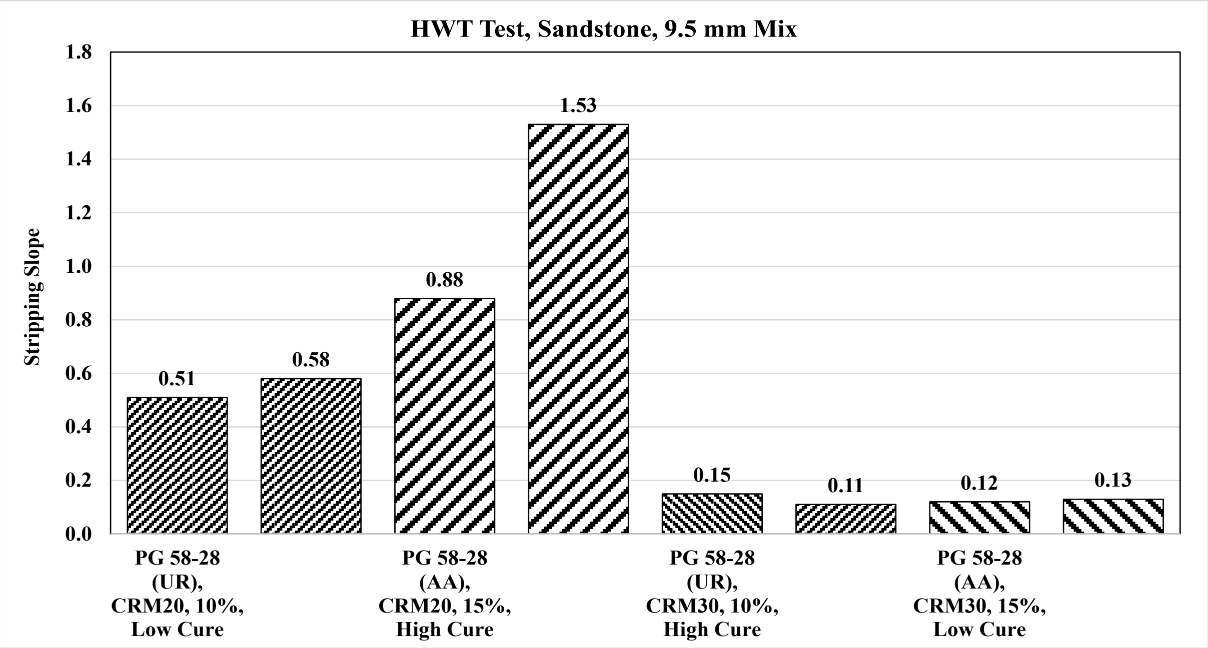


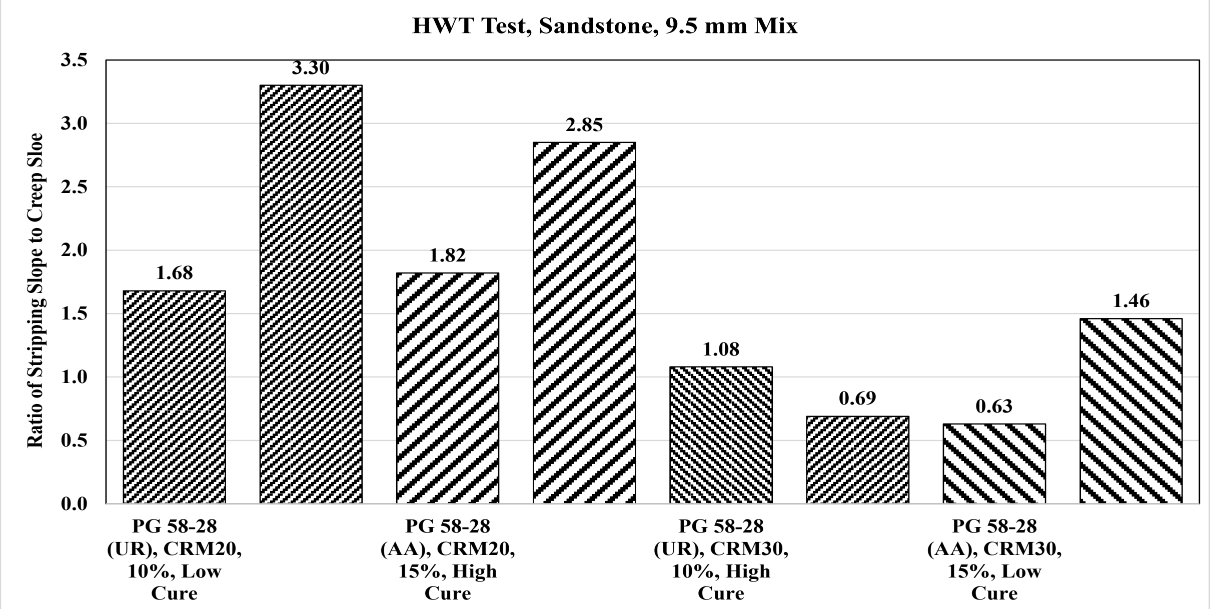
HWT Test Results



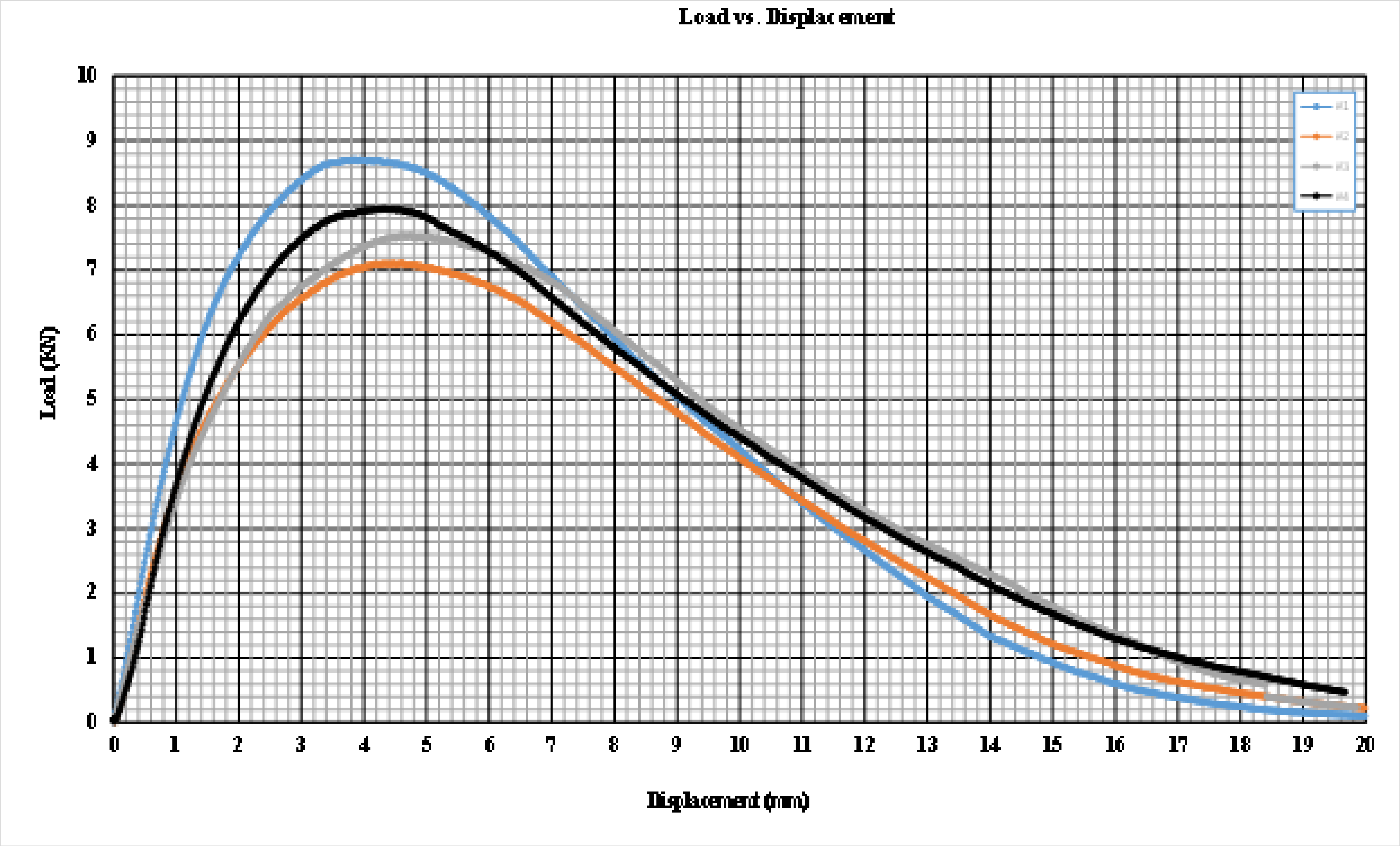


HWT Test Results

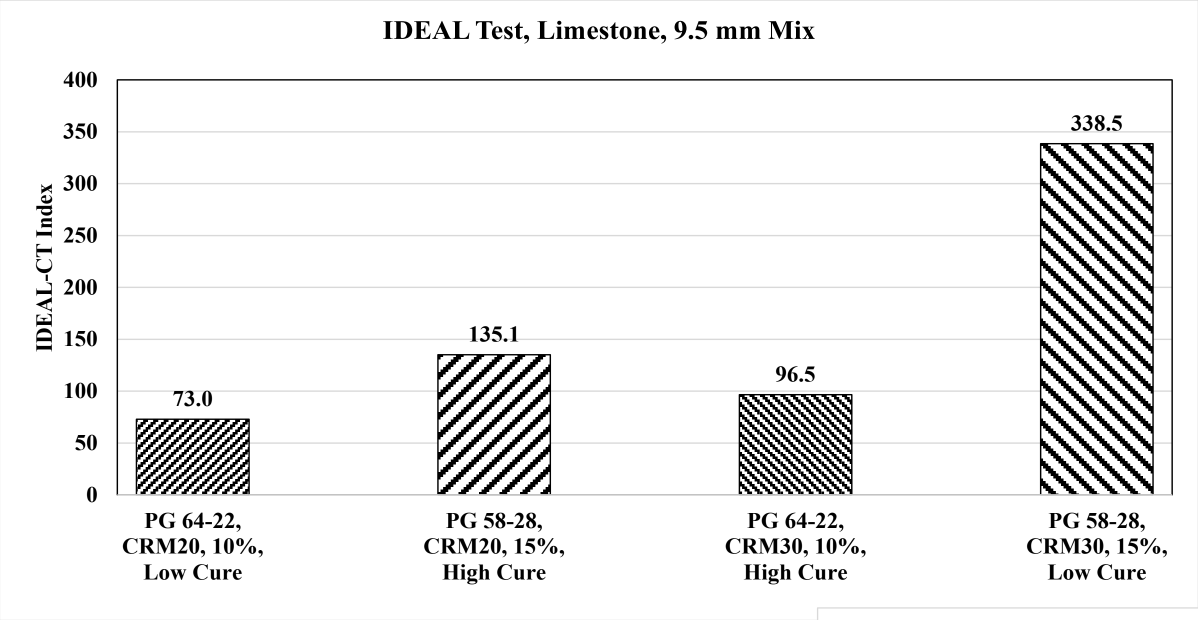


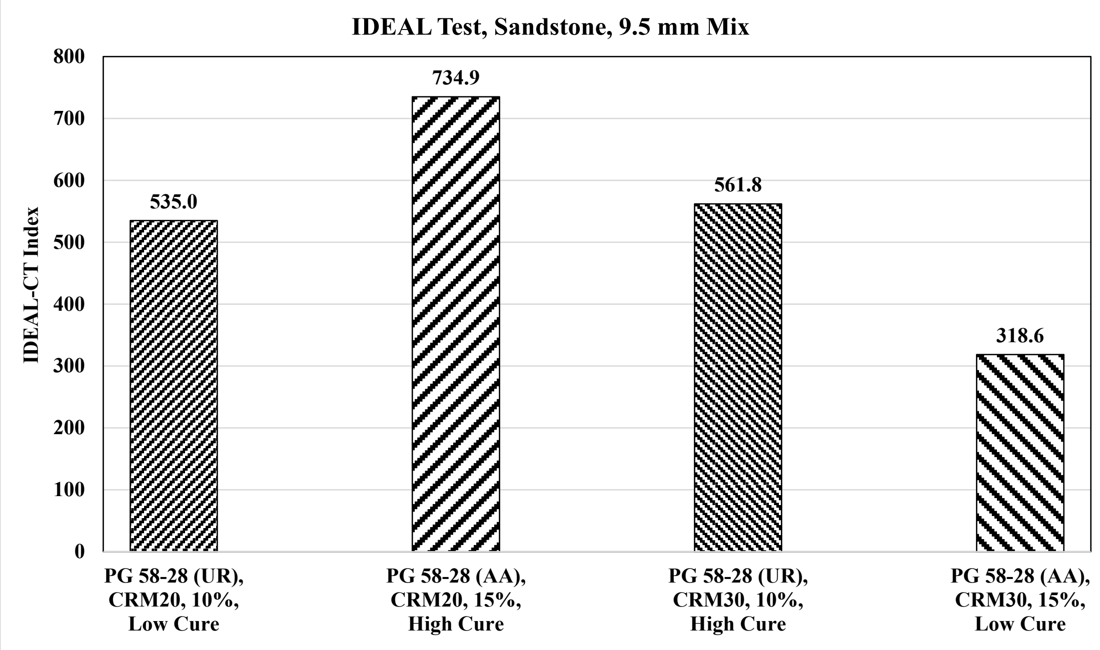


IDEAL-CT Test Results



IDEAL-CT Test Results





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IDEAL-CT Test Results

Agg. Source	Binder Grade	CRM Type	CRM %	CRM Cure Level	COV (%)
Limestone	64-22	#20	10	L	17.2
	58-28	#20	15	H	0.5
	64-22	#30	10	H	6.1
	58-28	#30	15	L	7.7
Sandstone	58-28	#20	10	L	14.4
	58-28	#20	15	H	14.0
	58-28	#30	10	H	15.9
	58-28	#30	15	L	20.0

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NECEPT

Outline

- PennDOT CRM Projects
- CRM as Asphalt Binder Modifier
- Experimental Program in this Research
- Findings: CRM Modified Asphalt Binders
- Findings: CRM Modified Asphalt Mixtures
- **Summary and Conclusions**

Summary

- Evaluated the effect of CRM on asphalt binder and mixture
  - Two CRM mesh sizes (-#30 and -#20)
  - Two binder grades (PG 58S-28 and PG 64S-22)
  - Two aggregate sources (limestone and sandstone)
  - Three curing levels (low, intermediate, high)
- Conducted
  - Binder rheological tests
  - Mix design (volumetric)
  - Mixture performance tests
  - Analysis/Usage Guide

Conclusions

Effect on Asphalt Binder

- Behavior of rubber asphalt binder heavily depends on curing level.
- CRM increases binder viscosity.
- Low cure has larger impact on viscosity than high cure.
- CRM bumps the binder grade one or two levels.
- CRM decreases low temperature stiffness.
- Low cure increases ΔTc (not a good case).

Conclusions

Effect on Asphalt Mixture

- CRM increases design binder content (DBC)
- High cure results in lower DBC increase compared with low cure
- CRM improves rutting resistance and moisture damage resistance compared with unmodified binders
- CRM mixes show high level of flexibility at intermediate temperature


Thank You!