Update on WMA Lab Foaming Research

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Acknowledgment

Acknowledgment

- The research presented here was sponsored by the Ohio Department of Transportation (ODOT) and the Federal Highway Administration (FHWA).
- The researcher team would like to thank Mr. David Powers for his valuable comments and suggestions throughout this project.

Background

Background

- In recent years, there has been an increased interest in using a new type of asphalt mixture called warm mix asphalt (WMA).
- Key benefits of WMA include:
  - Reduced emissions during production
  - Improved field compaction
  - Improved working conditions
  - Ability to use higher RAP contents

Background

- Various WMA technologies have been proposed in the past few years:
  - Chemical and organic additives
  - Foamed asphalt binders
- Foamed WMA produced by water injection has received increased interest and use in Ohio since it requires a one-time plant modification and does not require the use of costly additives.

Background

- ODOT started this project with the main objective of developing a laboratory procedure by which foamed WMA mixtures can be produced.
- Developing such procedure will allow preparing laboratory specimens to evaluate the performance of foamed WMA mixtures and thereby comparing it to traditional hot mix asphalt (HMA).

Objectives

Objectives

- Develop a procedure by which foamed WMA mixtures can be prepared in the laboratory.
- Evaluate the performance of foamed WMA mixtures with regard to moisture induced damage and rutting susceptibility.
- Compare the performance of foamed WMA mixtures to traditional HMA mixtures.

Material Description and Mix Design

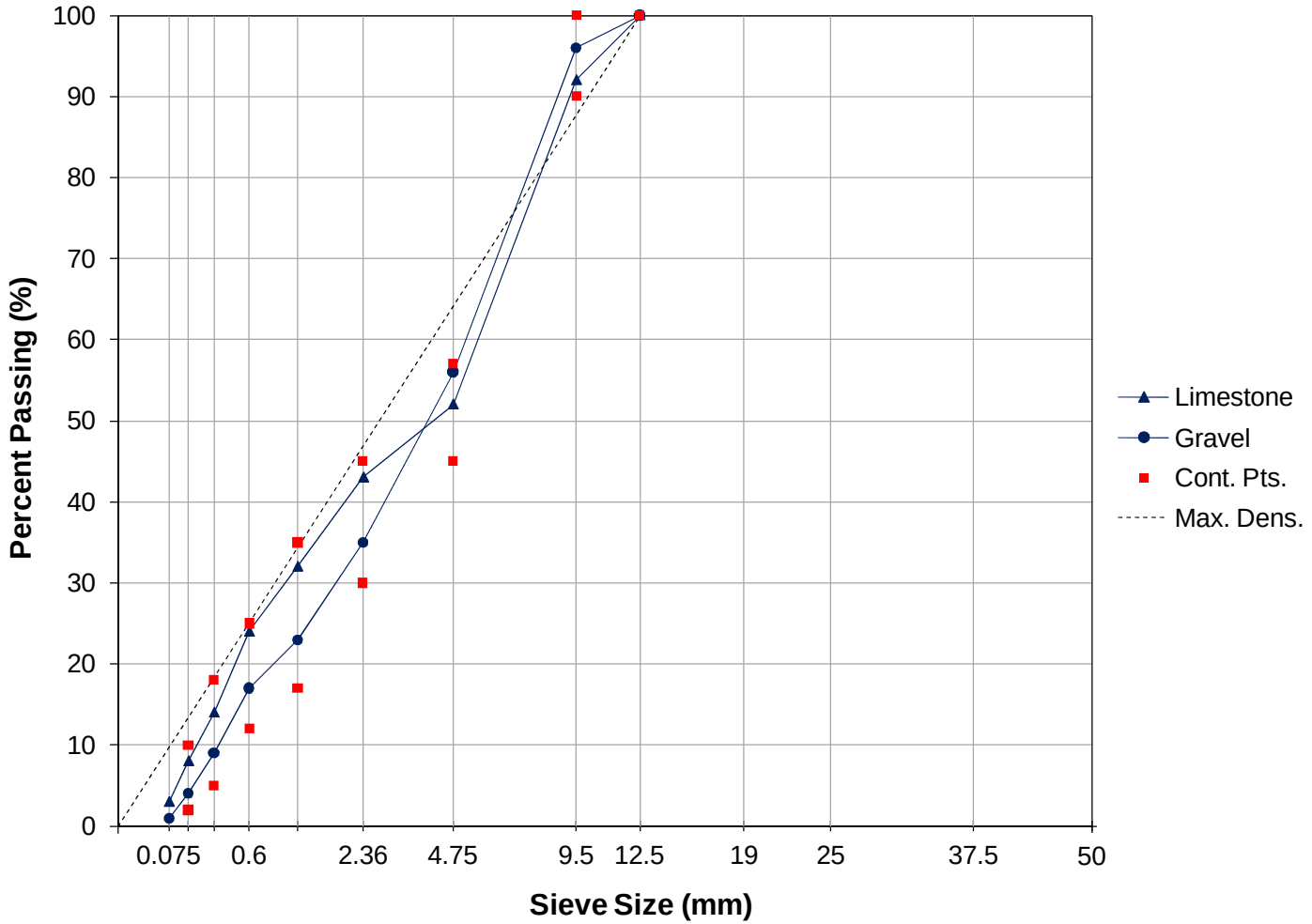
Material Description

- Aggregates:
  - Limestone
  - Natural Gravel
- Asphalt binders:
  - PG 64-22 (Neat)
  - PG 70-22M (Modified)

Mix Design

- Item 441 Type 1 surface mix subjected to medium traffic.
- The optimum asphalt binder content was selected using the Marshall mix design method.
- The same content was used for both HMA and foamed WMA mixtures.

Selected Aggregate Gradation

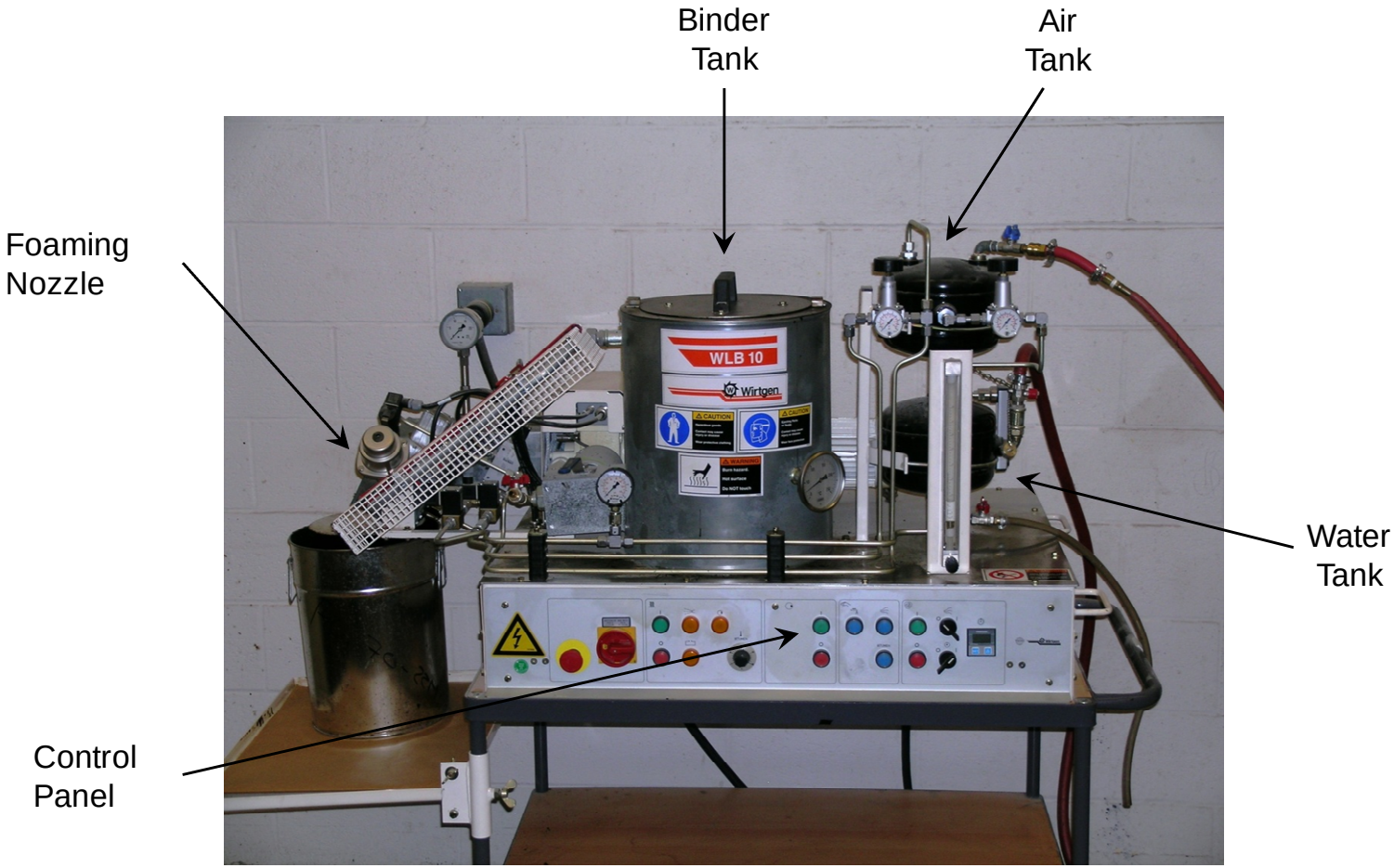


Mix Design Results

		Natural Gravel		Limestone	
Criteria	Required	PG 64-22	PG 70-22M	PG 64-22	PG 70-22M
Stability (lb)	Min 1200	1673	2300	3200	4217
Flow (0.01 in.)	8-16	10.5	10.6	13	13.5
VMA (%)	Min 16	15.5	15.5	16.7	16.6
Air Voids (%)	3.5	3.5	3.5	3.5	3.5
AC% Range	5.8-10	6	6	6.4	6.5
F-T Ratio	2	+2	+2	-2	-2
F/A Ratio	Max 1.2	0.17	0.17	0.47	0.46

Production of Foamed WMA Mixtures

Production of Foamed WMA



Production of Foamed WMA

- The foamed WMA mixtures were produced at mixing and compaction temperatures 30°F lower than that used for HMA.
- The foamed asphalt binder was produced using a 1.8% foaming water content.
- The foamed asphalt binder was produced using 5 bar (≈ 72 psi) water pressure and 4 bar (≈ 58 psi) air pressure, as recommended by Wirtgen, Inc.

Summary of Observations

Summary of Observations

- Aggregate Coating:
  - Aggregates were fully coated with a thin film of asphalt for both foamed WMA and HMA mixtures even though lower mixing temperature was used for the foamed WMA mixtures.
- Workability and Compactability:
  - Foamed WMA mixtures were found to be more workable and easily compacted in comparison to HMA.

Summary of Observations

- Rice Specific Gravity:
  - WMA-FA mixtures had slightly lower G_{mm} values than HMA mixtures. This might have been caused by two factors:
    1. The presence of entrapped air bubbles within the foamed asphalt binder even after mixing.
    2. A slight reduction in asphalt binder absorption in the case of WMA-FA mixtures.

WLB10
Asphalt Foaming Device

Advantages of WLB10

- Ability to prepare a large number of specimens
- Ability to adjust temperatures
- Ability to produce the asphalt binder at pre-specified quantities
- Easily cleaned, maintained, and operated

Disadvantages of WLB10

- Discharged amount of foamed asphalt has to be checked before actual preparation of mixtures
- Experience is needed to ensure consistency
- Relatively long starting period (1 to 2 hrs)

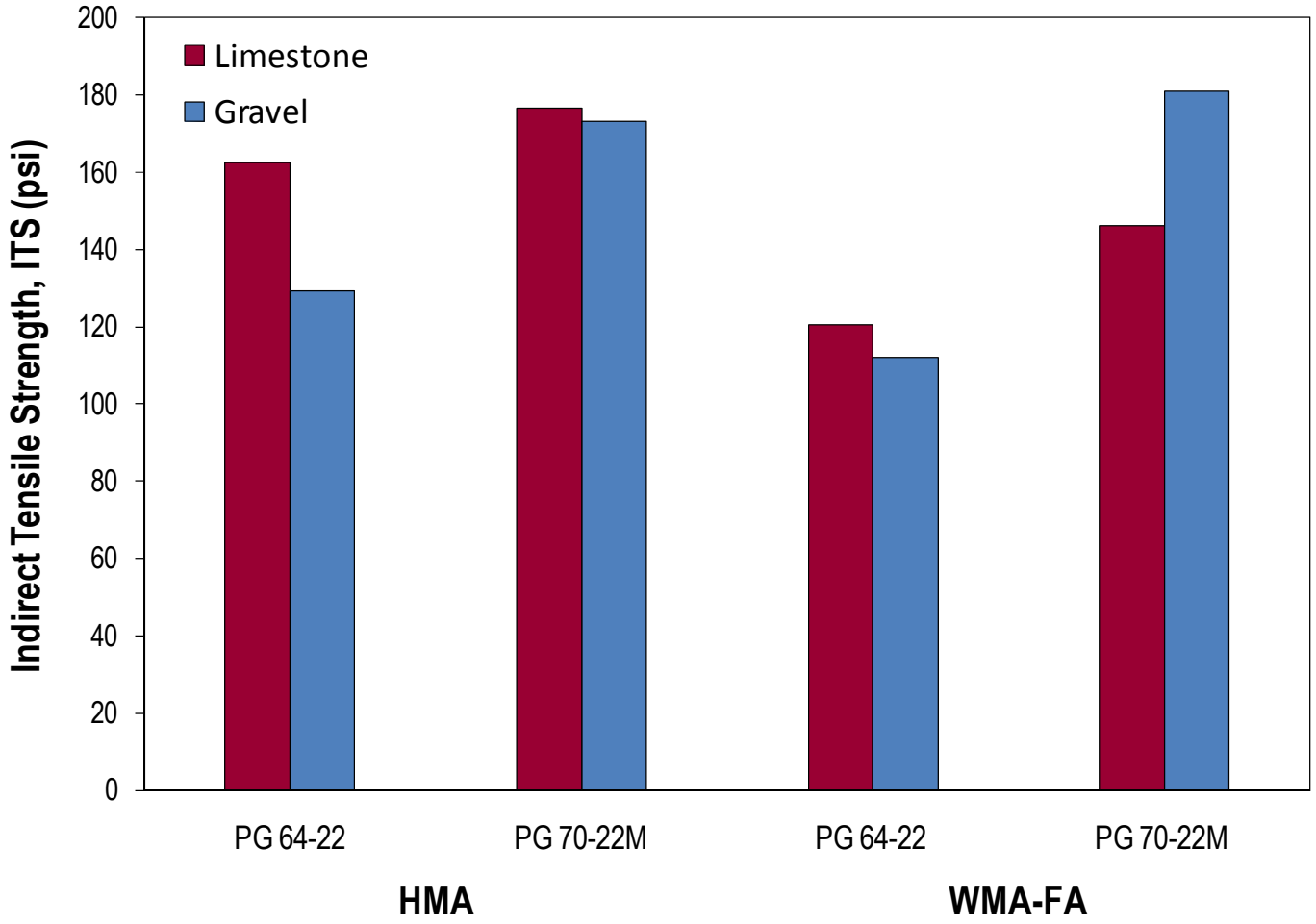
Testing Plan

Testing Plan

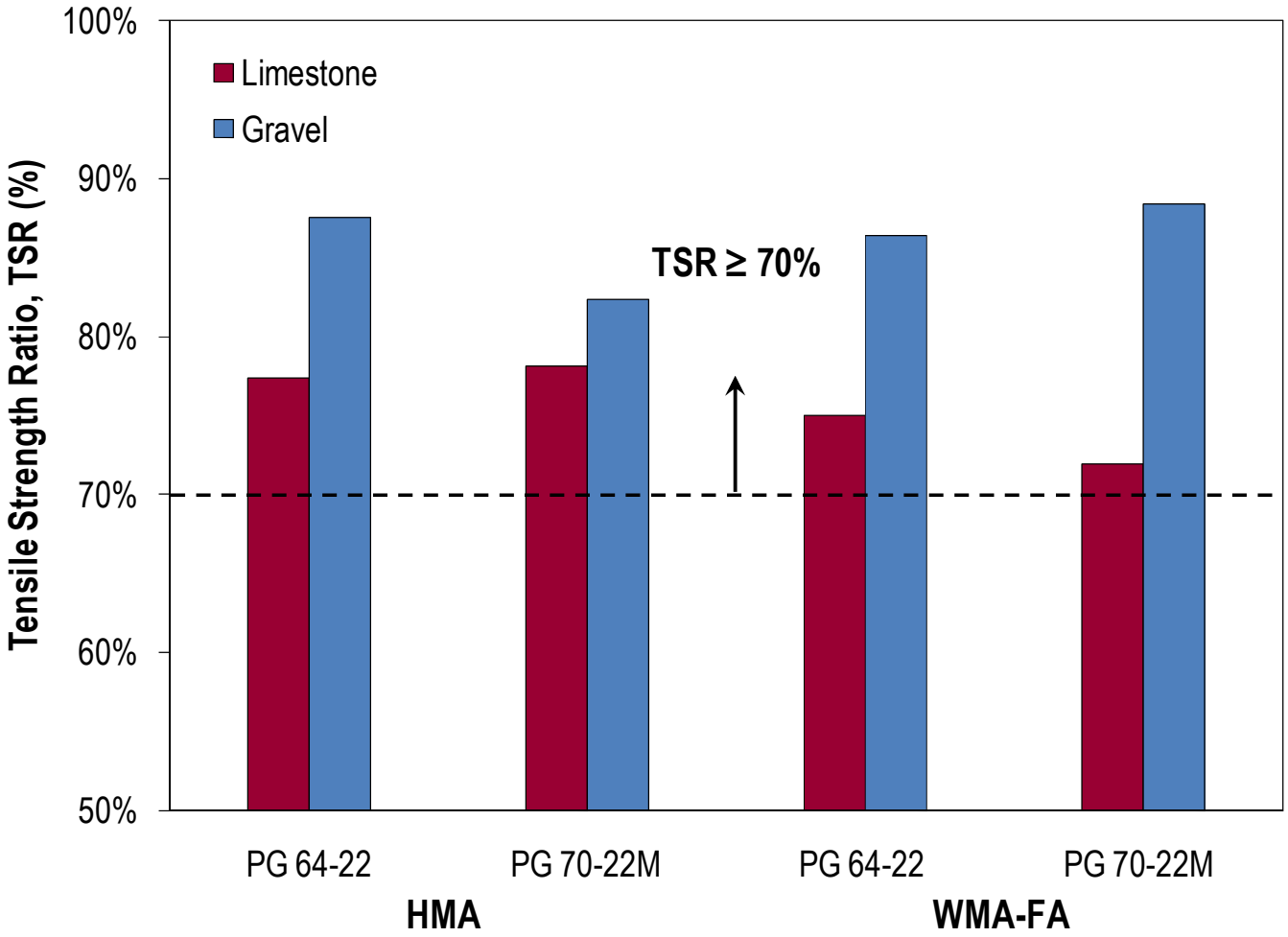
- Three tests were used:
  - Modified Lottman Test (AASHTO T283)
  - Asphalt Pavement Analyzer (APA) Test
  - Dynamic Modulus |E*| Test

Summary of Results

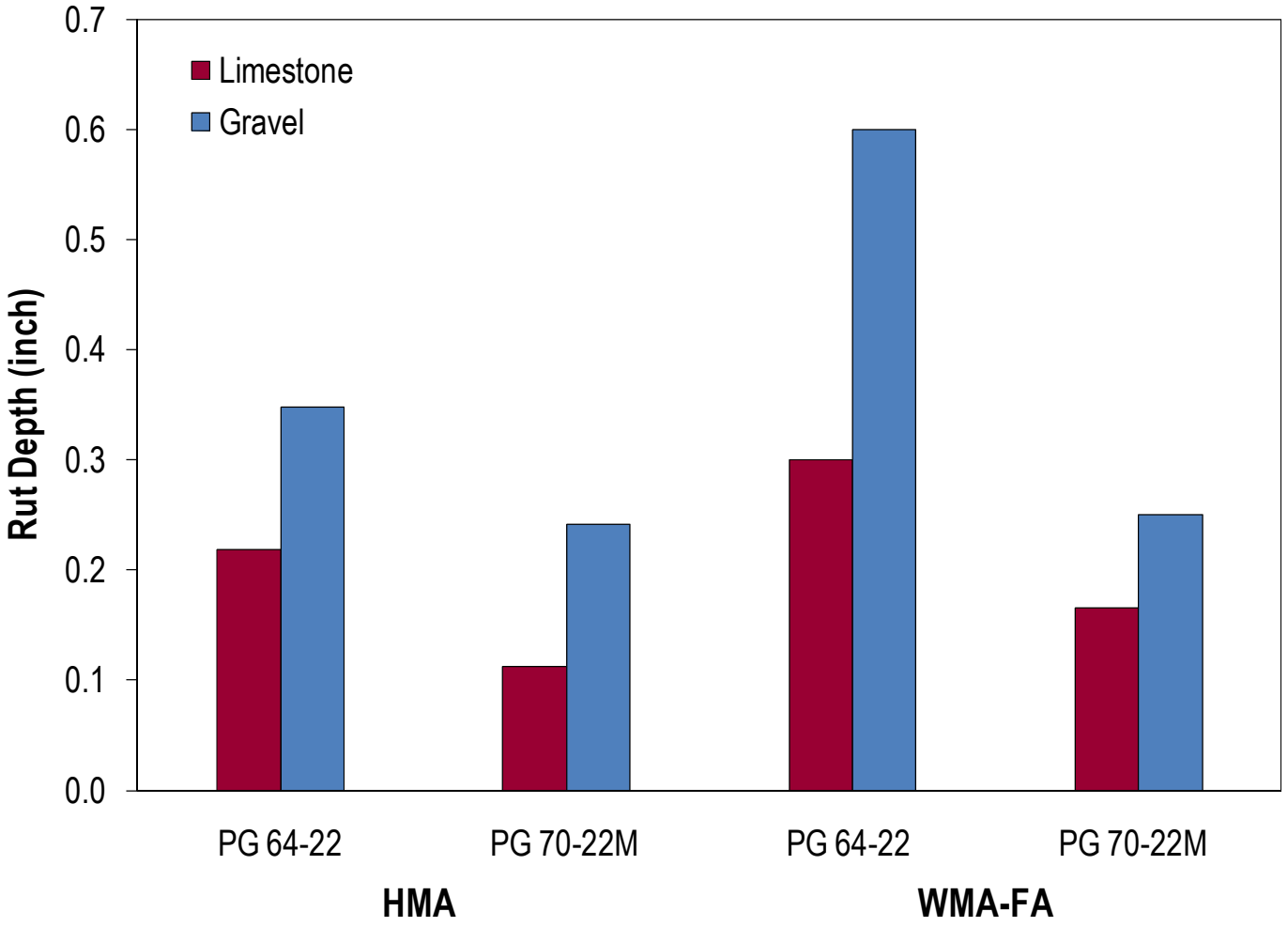
AASHTO T283


Limestone
Gravel
Indirect Tensile Strength, ITS (psi)
200
180
160
140
120
100
80
60
40
20
0
PG 64-22
PG 70-22M
PG 64-22
PG 70-22M
HMA
WMA-FA

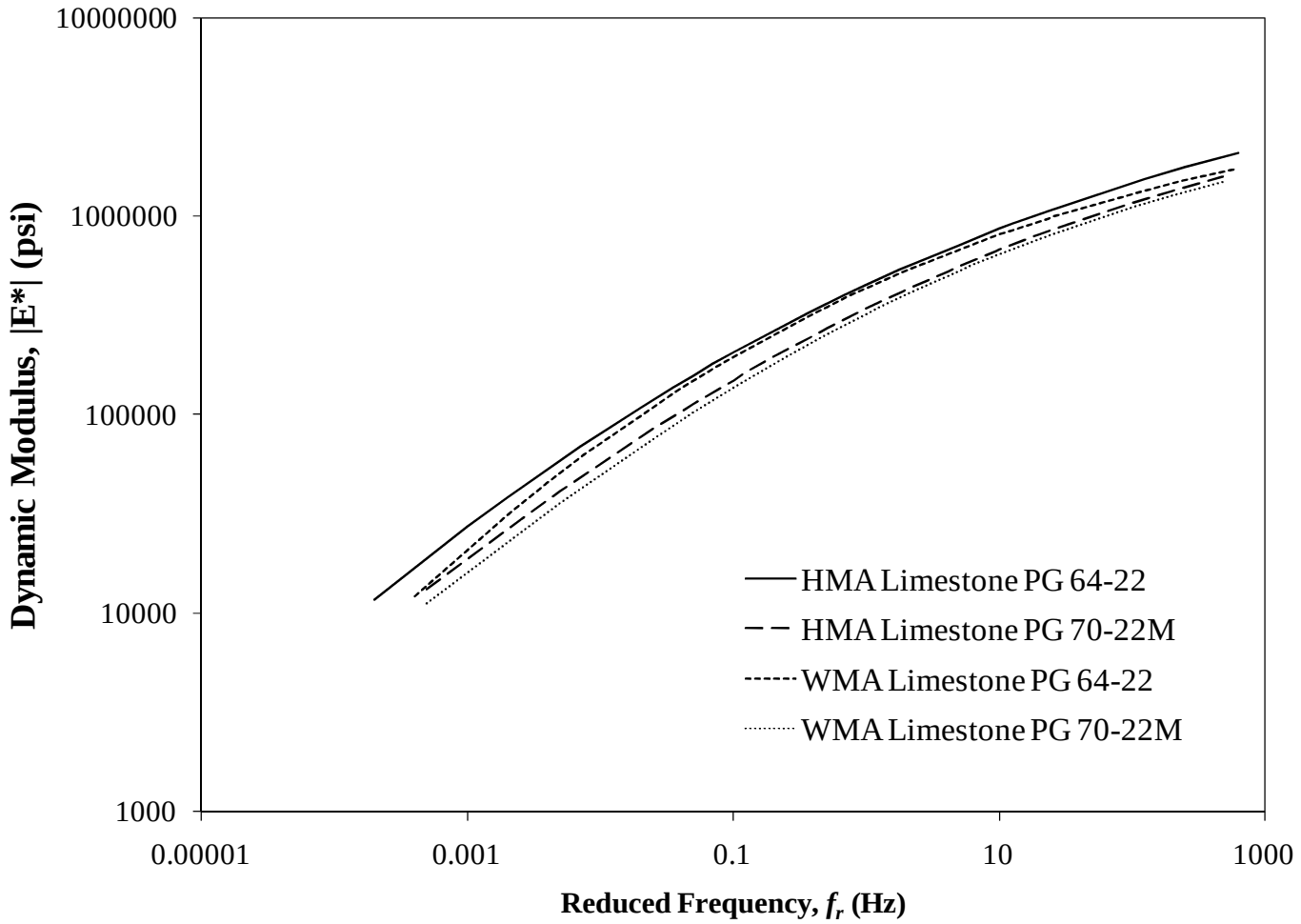
AASHTO T283


100%
90%
80%
70%
60%
50%
Tensile Strength Ratio, TSR (%)
Limestone
Gravel
TSR ≥ 70%
PG 64-22
PG 70-22M
PG 64-22
PG 70-22M
HMA
WMA-FA

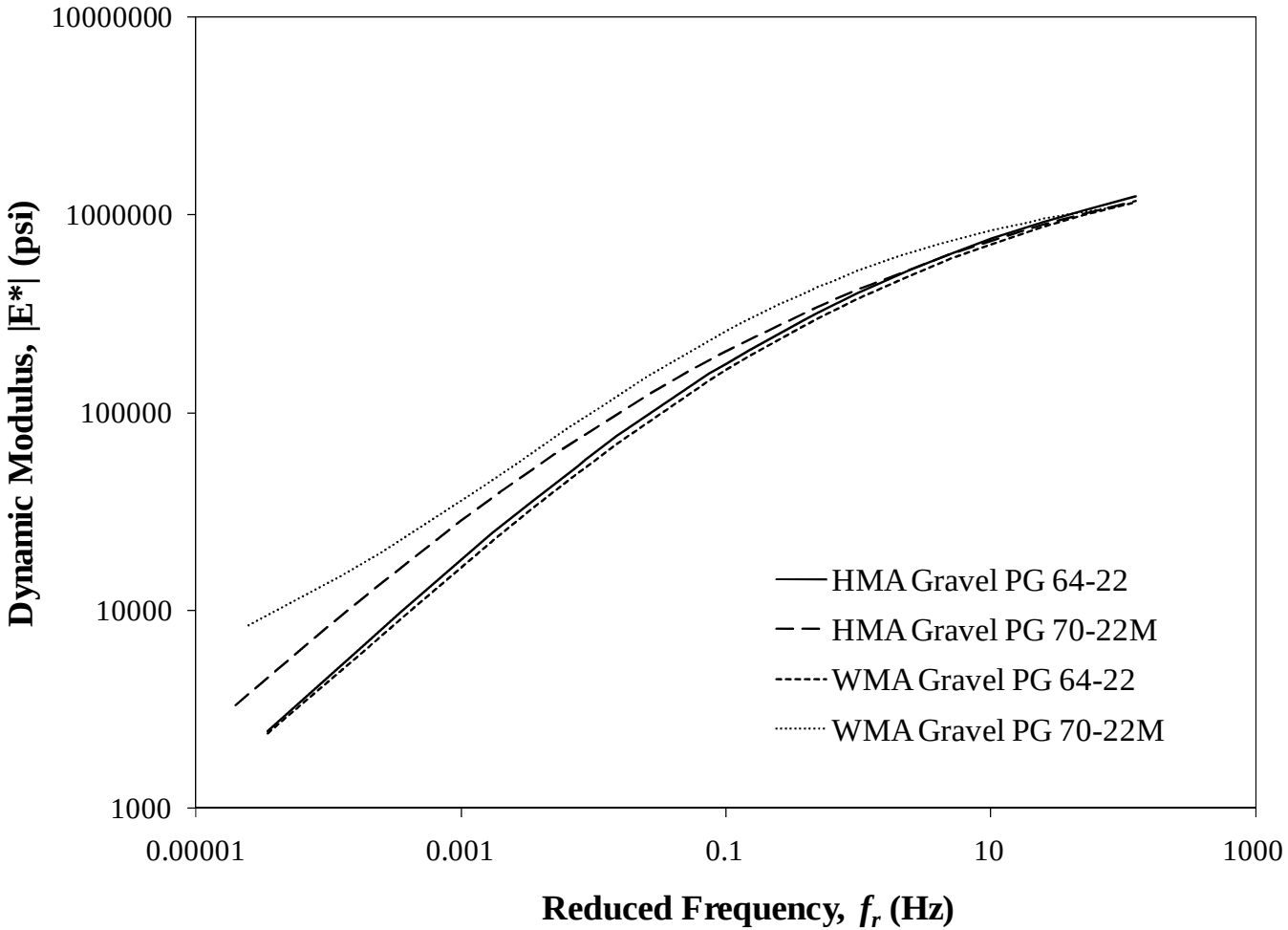
APA Test


0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Rut Depth (inch)
Limestone
Gravel
PG 64-22
PG 70-22M
PG 64-22
PG 70-22M
HMA
WMA-FA

Dynamic Modulus



Dynamic Modulus



Conclusions

Conclusions

- General:
  - The neat and modified asphalt binders (PG 64-22 and PG 70-22M, resp.) were successfully foamed using the WLB10 foaming asphalt device.
  - As expected, the neat asphalt binder had a slightly higher expansion ratio; and hence was easier to foam than the modified asphalt binder.

Conclusions

- Indirect Tensile Strength:
  - Foamed WMA mixtures exhibited lower ITS values than the corresponding HMA mixtures. This can be attributed to the softening of the asphalt binder due to foaming, reduced foamed asphalt binder absorption, and lower binder aging in the case of the WMA.

Conclusions

- Moisture Susceptibility:
  - Foamed WMA mixtures had slightly lower TSR values than the HMA mixtures. However, the difference was found to be statistically insignificant.
  - Furthermore, both mixtures met ODOT's minimum TSR requirement of 70% for medium traffic.

Conclusions

- Rutting:
  - The foamed WMA mixtures had higher rut depths than the HMA mixtures.
  - All rut depth values were lower than 0.35 inch except for the foamed WMA mixtures prepared using natural gravel and PG 64-22, which had an average rut depth of 0.6 inch.
  - Therefore, ODOT is encouraged to examine the performance of recently constructed projects using this material combination to validate this observation.

Conclusions

- Dynamic Modulus:
  - The dynamic modulus was mainly affected by the aggregate type and to a less extent by the type of the asphalt binder.
  - The difference between the |E*| values of the foamed WMA and the HMA was statistically insignificant.

Recommendations for Implementation

Recommendations

- Foamed WMA seems to be a viable alternative to HMA as a paving material for roadways subjected to low to medium traffic levels.
- However, the performance of this material has to be evaluated for permanent deformation.
- Therefore, it is recommended to modify ODOT C&MS Item 441 to include a permanent deformation test as part of the mix design procedure to ensure satisfactory field performance.

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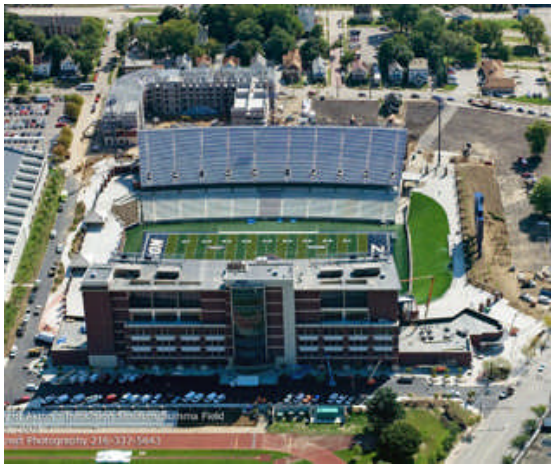

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