Utilization of MSM in HMA and Laboratory Performance

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Eastern Canada Region

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Background

- Potential benefits from the use of Scrap Manufactured Shingles in HMA include:
  - Improved resistance to pavement cracking
    - Due to reinforcement from fibers
  - Improved resistance to rutting
    - Due to fibers and increased stiffness of binder
  - Conservation of landfill space
    - Redirecting shingles from landfill and recycling
  - Studies ongoing at this time

Mallick Report (200)

- Manufactured roofing shingle waste can be incorporated successfully into HMA.
- Roofing shingle modified mixes show less temperature susceptibility than mixes without shingles.
- The use of shingles also lowered the tensile strength of mixes at 18C, thus, improving the resistance against low temperature cracking.
- The properties of HMA are affected mainly because of the presence of asphalt and fibers in the shingles.

Reference: Mallick, Rajib B., Teto, Mathew R., and Mogawar, Walaa. "Evaluation of Use of Manufactured Waste Asphalt Shingles in Hot Mix Asphalt." Technical Report #26. Chelsea Center for Recycling and Economic Development, 2000

Newcomb Report (1993)

- Compactability of mixtures generally increased with manufactured shingle waste content
- Use of manufactured shingle waste resulted in a less temperature susceptible asphalt mixture. The mixture stiffness were adversely decreased when the shingle content exceeded 5 % by weight of aggregate
- The manufactured shingle waste mixture for the SMA experiment had similar stiffness to that found for the commercial cellulose fibers

Newcomb Report (1993)

- Use of manufactured shingle waste did not significantly change the moisture susceptibility of the conventional dense-graded mixtures
- Samples containing reroof (post consumer tear-off) material had increased susceptibility to moisture damage
- Manufactured shingle waste seemed to actually improve the resistance to water damage in the SMA mixtures

Newcomb Report (1993)

- Tensile strengths at low temperatures decreased with increasing manufactured shingle waste content
- Mixtures made with reroof material showed a decrease in strain capacity with increased shingle content, implying that this material will be more brittle at cold temperatures
- The field mixture obtained from Wright County behaved similarly to the laboratory mixture containing 5% manufactured shingle waste.

Newcomb D., Stroup-Gardiner M., Weikle B., Drescher A., "Influence of Roofing Shingles on Asphalt Concrete Mixture Properties." Report MN/RC-93/09, University of Minnesota, Dept. of Civil and Mineral Engineering, June 1993

Ross (1997)

- The addition of scrap manufactured shingle to HMA can produce equal or better properties than the conventional HMA mixtures
- Scrap manufactured shingle can be used to produce SMA mixtures
- The asphalt from shingles can cause significant increase in the stiffness of the recycled asphalt binder. Five percent shingles is sufficient to increase the PG grade of the recycled asphalt binder by one grade
- The use of scrap manufactured shingles in HMA mixtures will generally improve the rutting resistance of the mix

Ross, B.,"An Evaluation of The Use of Hot Mixed Asphalt Pavements Containing Roofing Shingle Material in North Carolina", presented to the North Carolina Department of Environment, Health and Natural Resources, Raleigh, North Carolina, 1997

Manufactured vs Post Consumer

- Manufactured
  - More uniform in content
  - Asphalt is softer and more functional in a paving mixture
- Post Consumer
  - Contaminated with mails, wood and other deleterious material
  - Asphalt is hardened from oxidation and the volatilization of the lighter organic compounds

What is MSM?

- MSM is Manufactured Shingle Modifier
- It is produced by shredding up virgin shingle material direct from the manufacturer – not used post consumer tear-off material.
- It is typically produced to ½" to 3/8" minus material

Typical MSM Production

- Clean and Consistent


MSM Fiber Feed Stock

MSM COMPONENTS
TYPICAL

- 25% Low Penetration Asphalt Cement
- 58% Minus 2.36 mm Crushed Aggregate
- 17% Cellulose Fiber

Each component is used in HMA

Mix Design Criteria

- Treat as an enhanced asphalt fiber modifier
- Use between 3 to 5% by wt. of mix
- Can be used with or w/o RAP
- Typically will see a total AC increase of 0.3 to 0.5% over conventional mixes
- Increases Marshall air voids
- Increases Marshall stabilities

Production

- Require recycle bin
- Can be pre-mixed with RAP in proper ratio
- Batch plant - can be introduced in weigh hopper or boot of hot elevator (desirable)
- Drum plant – recycle collar
- Monitor moisture – keep dry
- Increase hot aggregate temperature to get desired HMA temperature

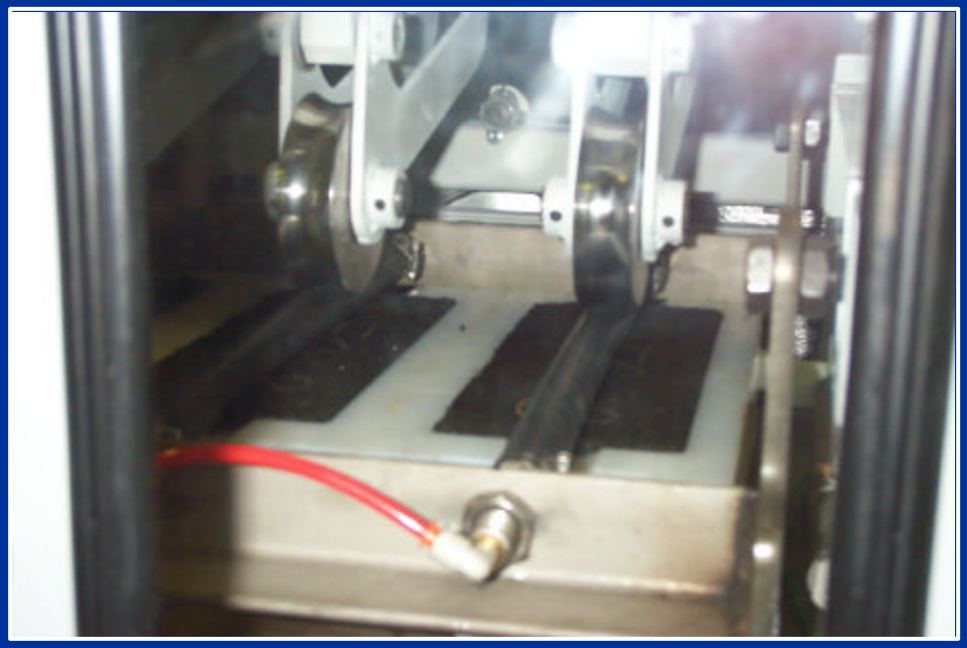

HAZARD
MATERIAL

Construction

- Use conventional paving equipment
- Keep rubber tire wheels hot

Performance

- Rutting testing – Asphalt Pavement Analyzer



Performance Testing

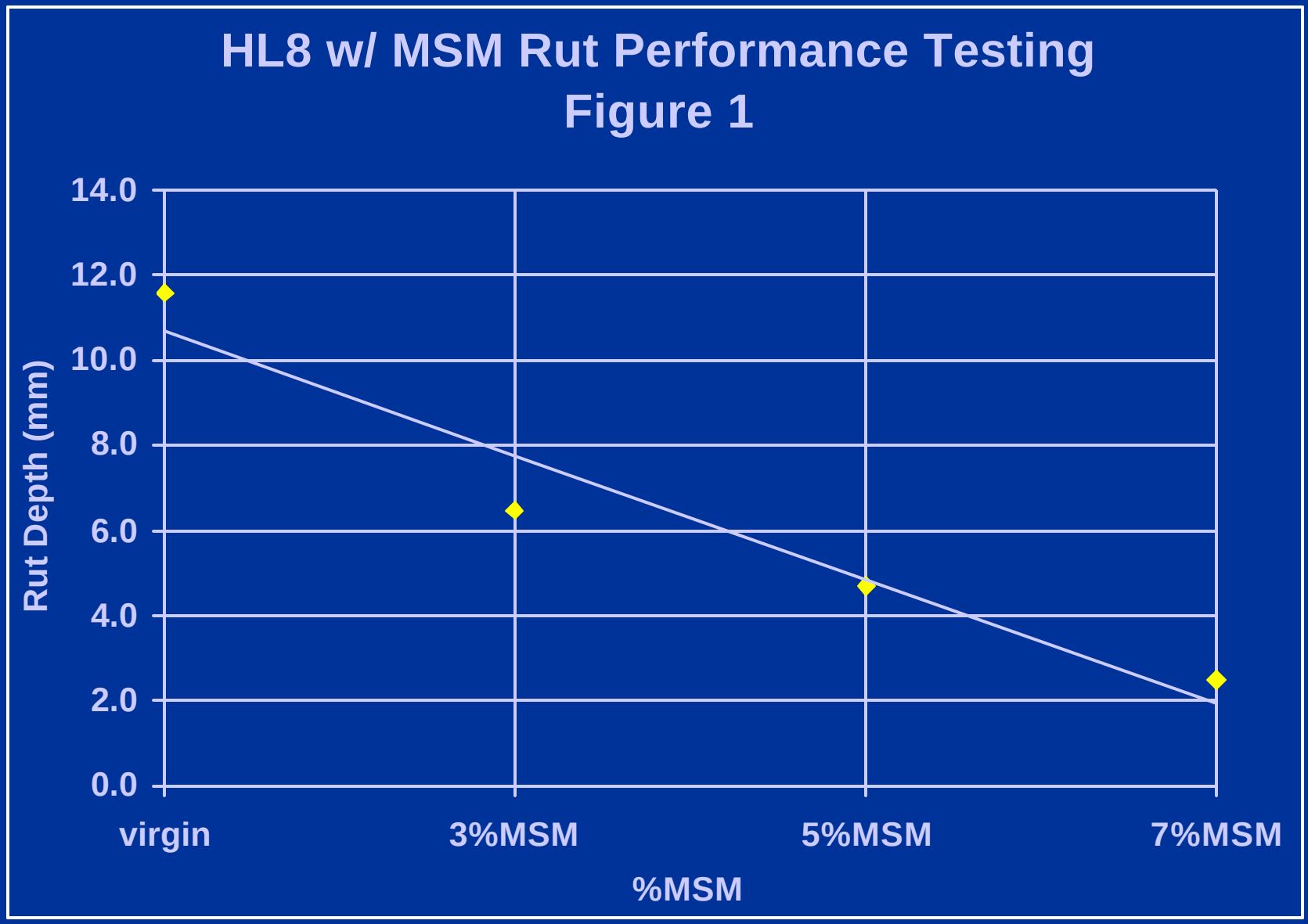
- Using OPSS HL 8 mix (virgin, MSM and MSM/RAP blends) and HL 3 mix (virgin & MSM)
- CA was quarried limestone, FA 1 – natural sand, FA 2 – limestone screenings
- Targeted 4% Marshall air voids and met PGAC guidelines for recycle content
- Use of RAP up to 20% utilized a PG 58-28
- RAP contents greater than 20% utilized a softer PG 52-34 AC
- Rut tests
  - Beams cured for a maximum 6 hours at 58C
  - Beams subjected to 100 lbs loading at 58C for 8000 cycles

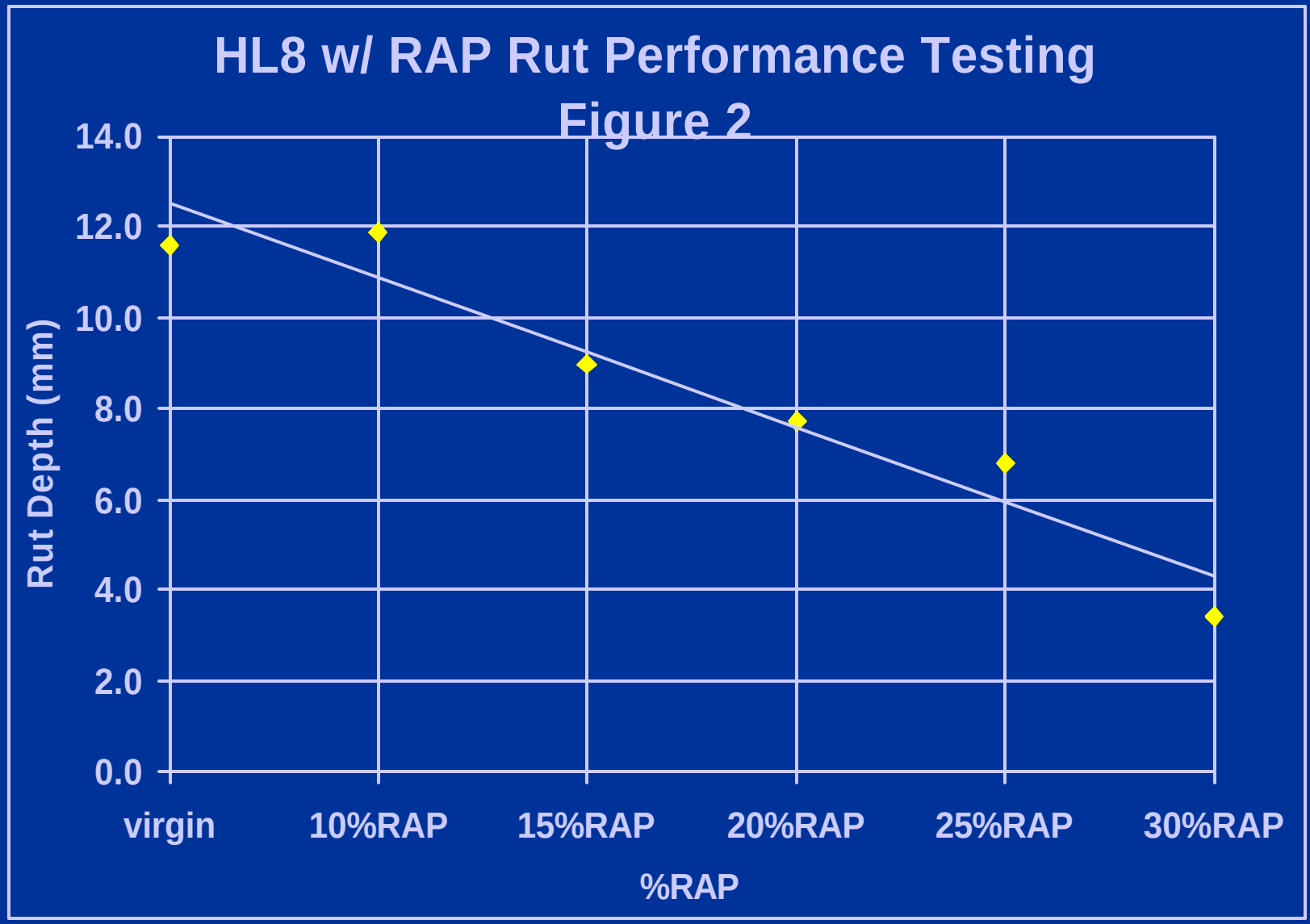
Table 1

Summary of HL 8 Mix APA Rut Test Results

Mix No.	Description	Rut	Rut Depth
		Air Voids (%)	(mm)
1	virgin	6.3	11.6
2	3%MSM	6.6	6.5
3	5%MSM	7.9	4.7
4	7%MSM	7.8	2.5
5	10%RAP	6.5	11.9
6	15%RAP	6.8	9
7	20%RAP	5.6	7.7
8	25%RAP	6	6.8
9	30%RAP	6.5	3.4
10	5%MSM/5%RAP	6.4	6.5
11	5%MSM/10%RAP	5.7	6
12	5%MSM/15%RAP	8.7	5.8
13	5%MSM/20%RAP	7.1	3.3
14	5%MSM/25%RAP	7.8	1.9

HL8 w/ MSM Rut Performance Testing
Figure 1




HL8 w/ RAP Rut Performance Testing
Figure 2
Rut Depth (mm)
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
virgin
10%RAP
15%RAP
20%RAP
25%RAP
30%RAP
%RAP

HL8 w/ MSM & RAP Rut Performance Testing
Figure 3

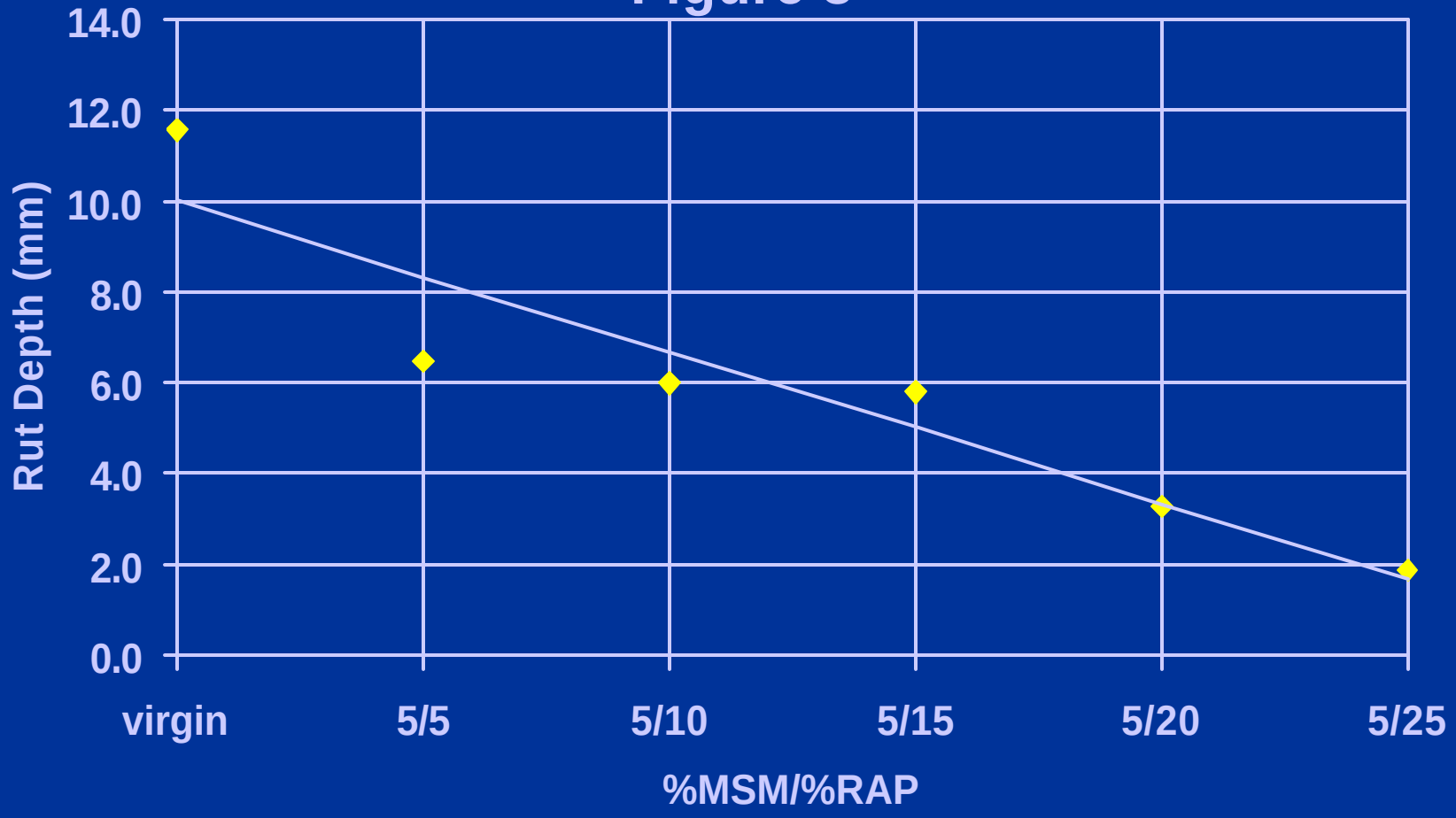
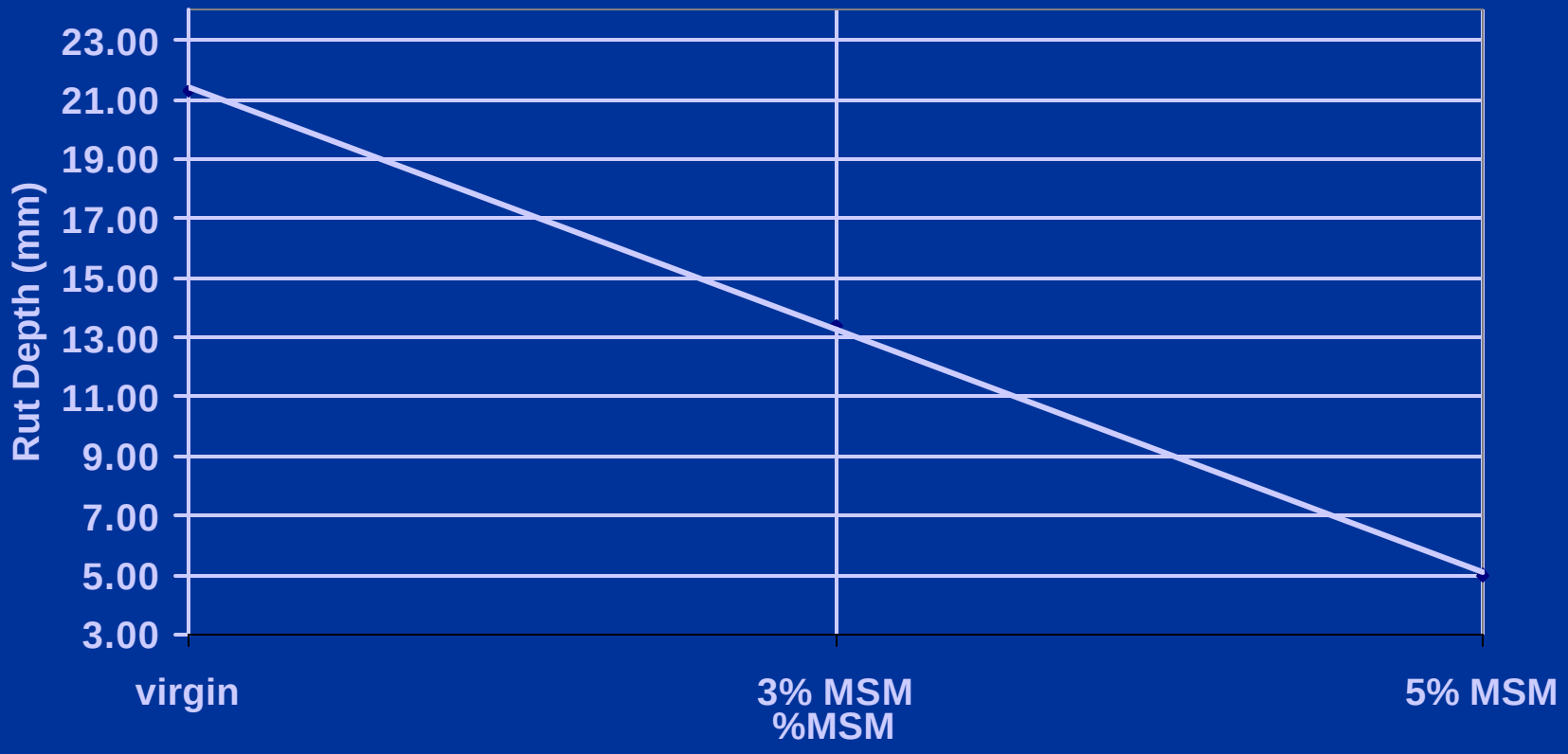


Table 2			
Summary of HL 3 Mix APA Rut Test Results			
Mix No.	Description	Rut	Rut Depth
		Air Voids (%)	(mm)
1	virgin	8.8	21.3
2	3%MSM	7.6	13.4
3	5%MSM	8.6	5.0

HL 3 Mix w/ MSM Rut Performance Testing
Figure 7



Performance Testing

- Using MTO HDBC and DFC (virgin and MSM blends, PG 64-28)
- Targeted 4% and 3.5% Marshall air voids, respectively)
- Rut tests
  - Beams cured for a maximum 6 hours at 58C
  - Beams subjected to 100 lbs loading at 58C for 8000 cycles

Table 3

Summary of DFC APA Rut Test Results

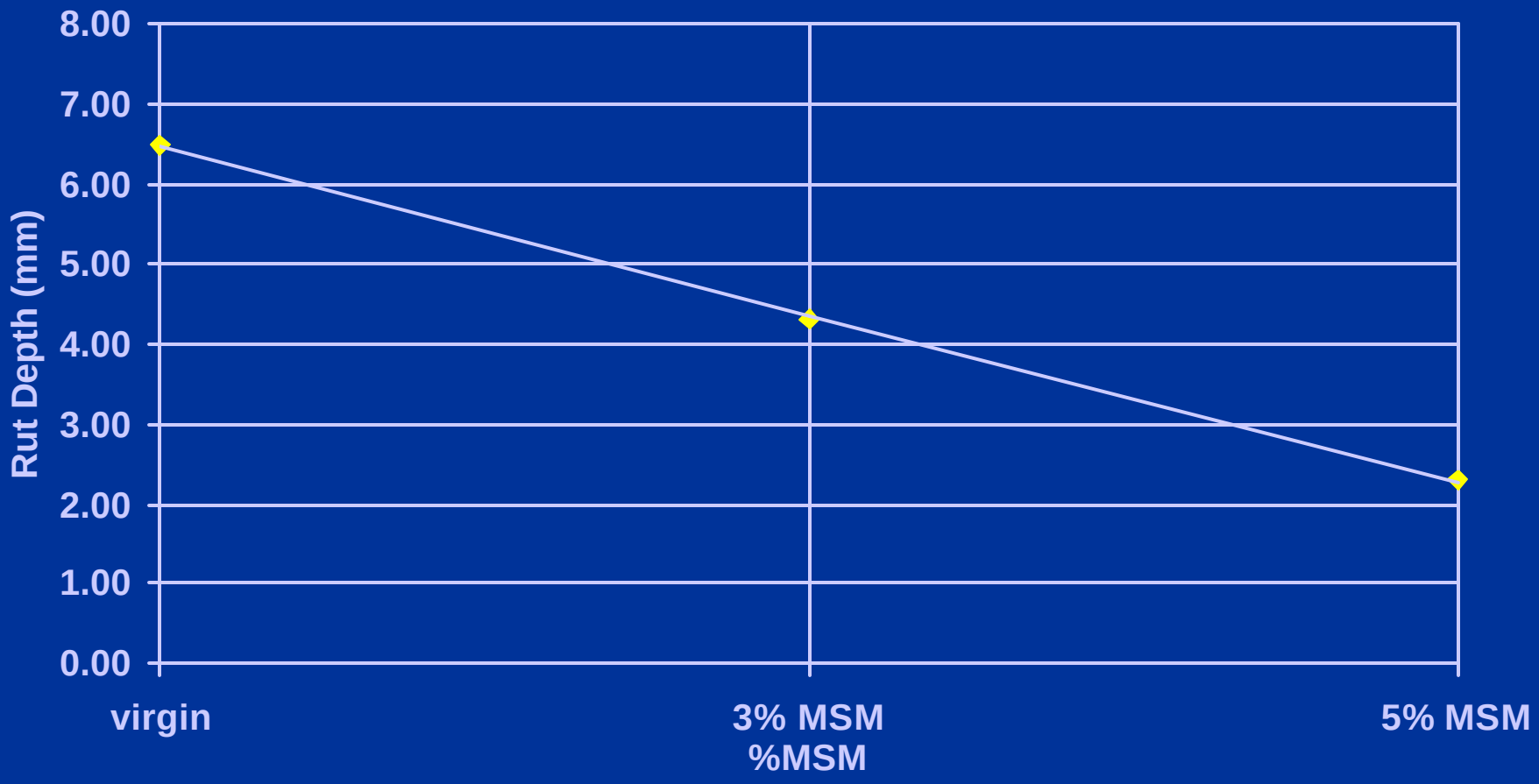
Mix No.	Description	Rut	Rut Depth	
		Air Voids (%)	(mm)	
1	virgin	6.1	6.5	
2	3%MSM	6.5	4.3	
3	5%MSM	6.3	2.3	

Table 4

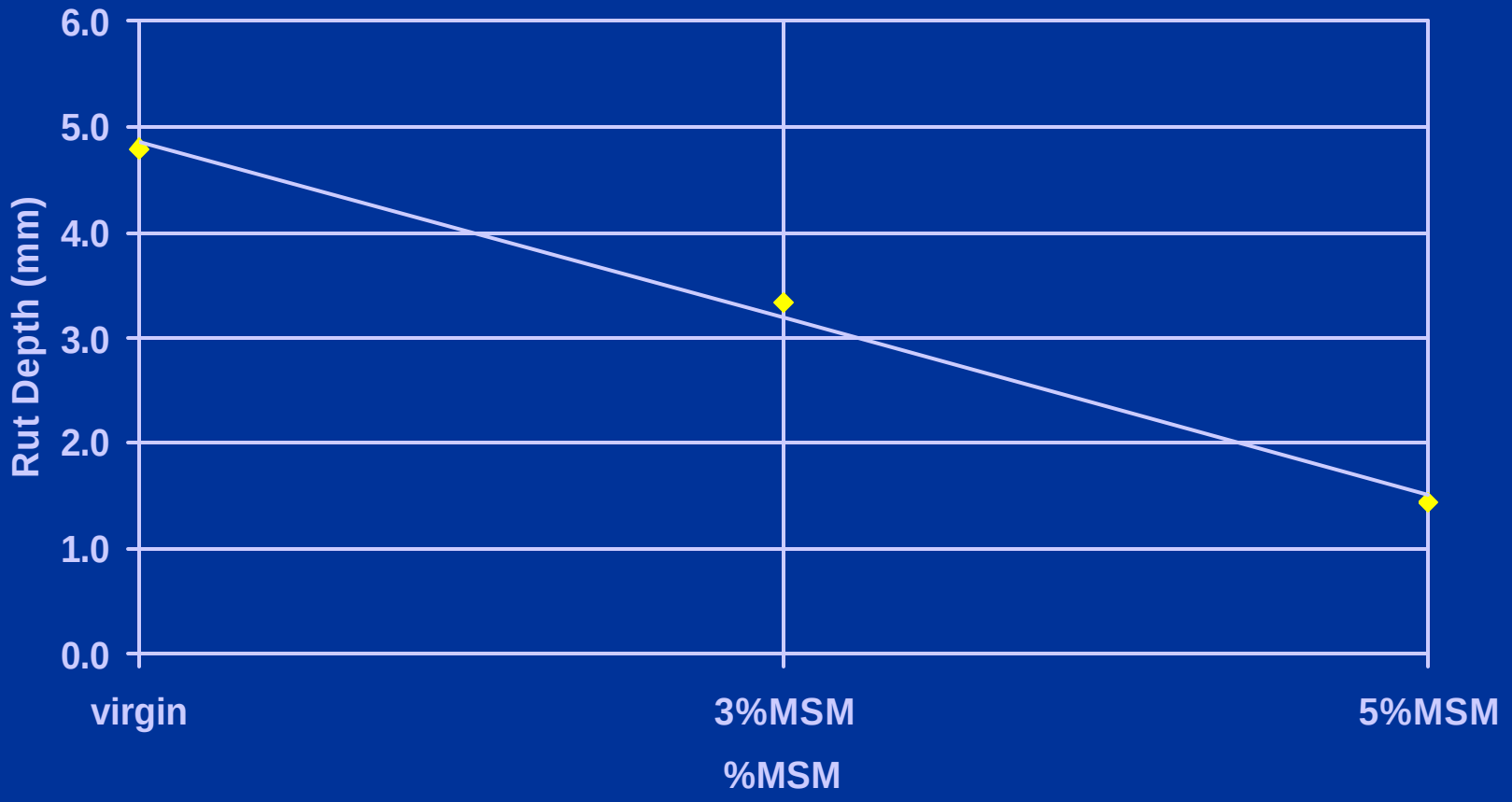
Summary of HDBC APA Rut Test Results

Mix No.	Description	Rut	Rut Depth	
		Air Voids (%)	(mm)	
1	virgin	8.0	4.8	
2	3%MSM	7.8	3.3	
3	5%MSM	7.8	1.4	

DFC w/ MSM Rut Performance Testing
Figure 8



HDBC w/ MSM Rut Performance Testing
Figure 10



Special Projects

- July 1995, MTO Trial Project with 3% MSM in HL 1, HL 4 and MDBC on Hwy. 86 SBL north of Northfield Dr.
- 4000 t of MSM Modified mixes using 150-200 pen grade (PG 52-28)
- To-date (2001) no low temperature transverse or longitudinal cracks, ravelling, fatigue cracking or rutting in the modified surface section.
- Excellent performance

Perth County

- Designed an HL 2 Modified Mix incorporating 5% MSM with overall higher AC content (~6.5%)
- Constructed ¾" to 1" thick on prepared granular grade
- Replacement for single and double surface treatment
- Cost effective and good performance
- Continual use since 1996

Benefits

- Use as an enhanced asphalt fiber modifier – easier to introduce at asphalt plant
- Increases Marshall stabilities
- Improves rutting resistance
- Improves fatigue resistance and flexural strength
- Increases AC content and film thickness
- Improves overall HMA durability
- Proven performance in Ontario

Customers

- Counties of Middlesex, Perth, Brant
- Cities of London, Stratford, Kitchener, Waterloo, Cambridge, Paris, Brantford, Hamilton, Burlington, Oakville, Mississauga, Brampton, Toronto, Peterborough, Ottawa
- Ministry of Transportation

Approved By

- Ontario Provincial Standards Materials Committee, a branch of OPSS Main Committee
- Accepted and allowed for use by Ontario owner/agency on the Road Authority website, www.roadauthority.com

Thank You, Questions?