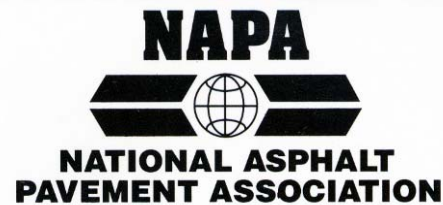


# Rubblization and Perpetual Pavement Save Money and Resources

National Symposium  
on  
HMA Energy & Recycling



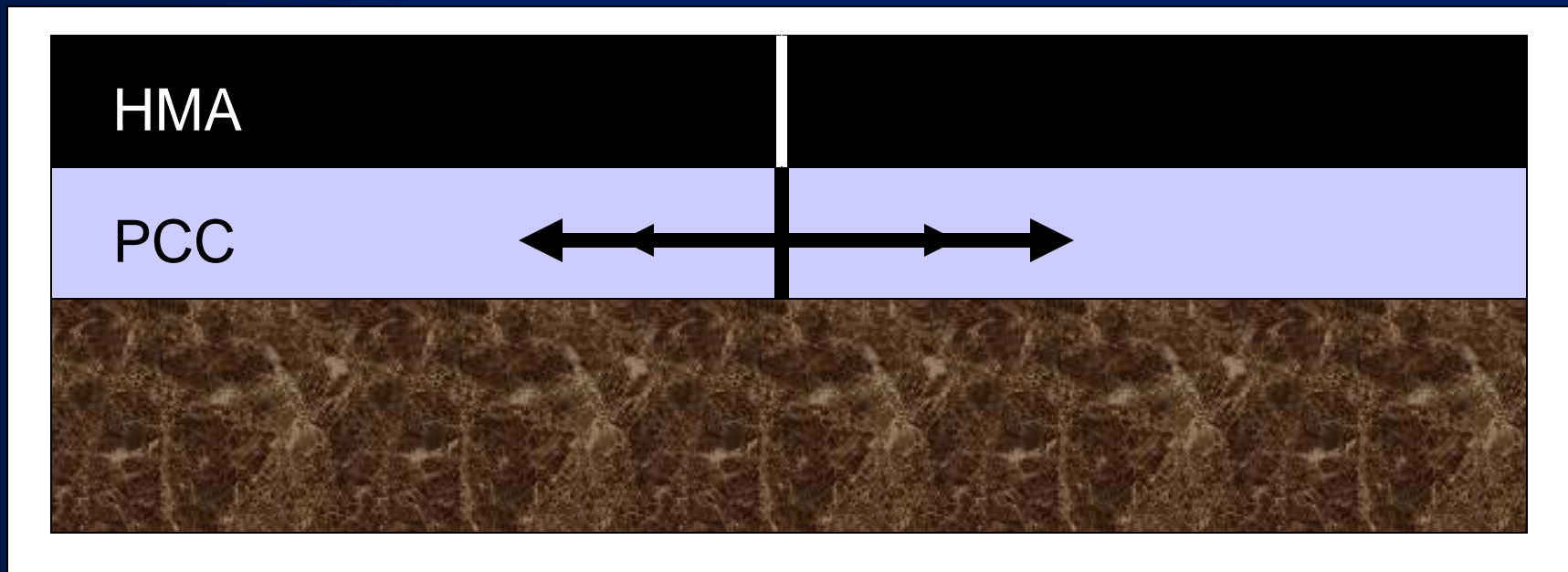
# HMA Overlay of PCC Pavement

- Surface Preparation
  - Cut & Patch with Saw & Seal
  - Crack & Seal
  - Break & Seat
  - Rubblization
- HMA Overlay
  - Thickness
  - Mix Type

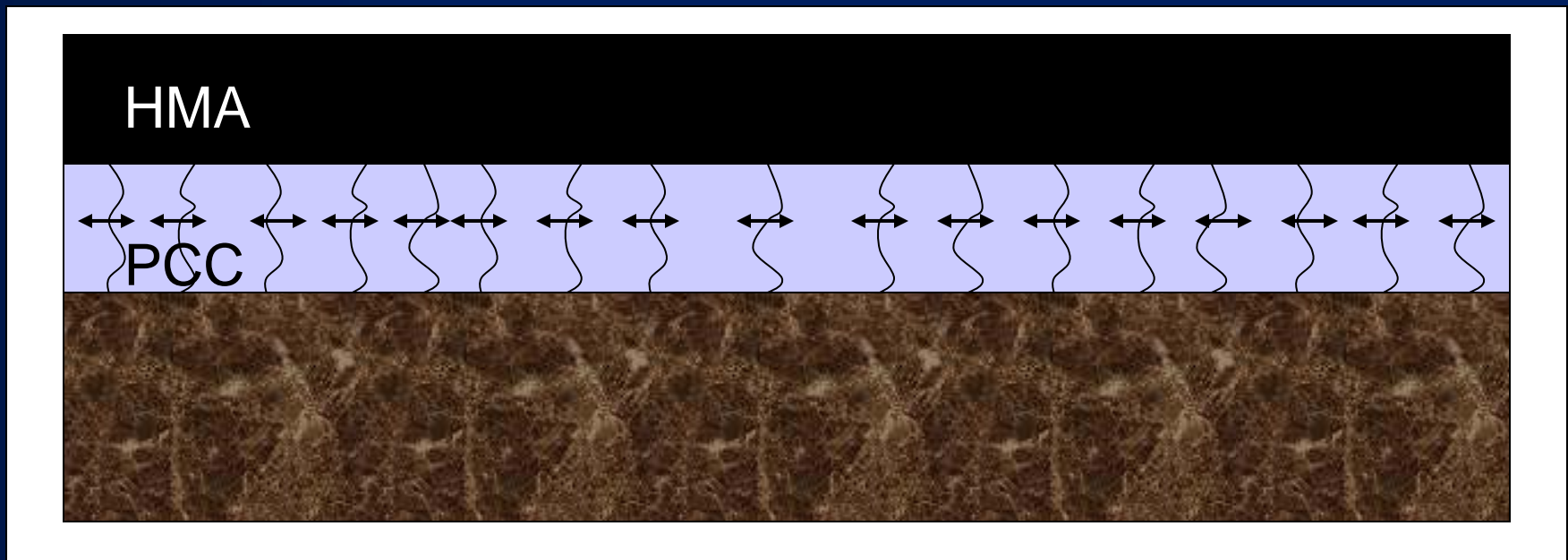
# Purposes for Overlaying PCC Pavements

- Improve ride quality
- Correct surface defects
  - improve surface drainage
  - increase surface friction
- Delay/prevent structural deterioration
- Strengthen pavement structure  
(rehabilitation)

# Larger Pieces = Larger Movement = Cracking



# Smaller Pieces = Smaller Movement = No Cracking



# Rubblization

- **Fracturing:**
  - **Eliminates slab action**
  - **Destroys bond between concrete and steel**
- **Rubblized base responds as a tightly keyed, interlocked high-density, unbound layer**
  - **Layer cannot crack; already fractured**

# Why Rubblize?

- Fracturing PCC to segments less than 9" precludes reflection of:
  - Joints
  - Cracks
  - Faults
- Production Rates up to 1 lane-mile/day

# Benefits

- Time savings
  - Choose work hours
  - High production rates
- Economic Savings
  - Reduce user delay costs
  - Reduce construction costs



# Benefits (continued)

- Environmentally friendly
  - Reduce landfill
  - Reduce fuel consumption/air pollution
- Smoothness
  - Eliminate reflection cracking/faulting

# Resonant Pavement Breaker





**Multi-Head Breaker (MHB)**

# Rolling



# Particle Size



- PCC fractured into 9 in.-minus pieces
- Most pieces are 1- 4 in. diameter
- Aggregate interlock maintained beneath surface
- Rolling knits together surface particles



# When to Rubblize

- Patching  $\geq$  10%.
- Severe D-cracking.
- Severe ASR or ACR cracking.
- Dowel bar locking
- Severe joint deterioration
- Persistent faulting.

# How Effective is Rubblization?

- Witczak and Rada, 1992
  - "Rubblization . . . is the preferred rehabilitation method for all types of PCC pavements."
- Thompson, 1999
  - Rubblization is a "viable and cost-effective rehabilitation option."

# How Effective is Rubblization?

- 39 States have had Rubblization projects
- Arkansas
  - 383 miles of rubblized and overlaid primary routes
- Performance Projections: Over 20 years before PCR = 70



# An Example of Economics

- Interstate Highway
  - 40,000 ADT
  - 4 Lanes
  - Existing Concrete Pavement
  - Condition Suitable for Rubblization or Replace
- 3 Alternatives
  - Rubblization and Overlay
  - Unbonded Concrete Overlay
  - Remove and Replace

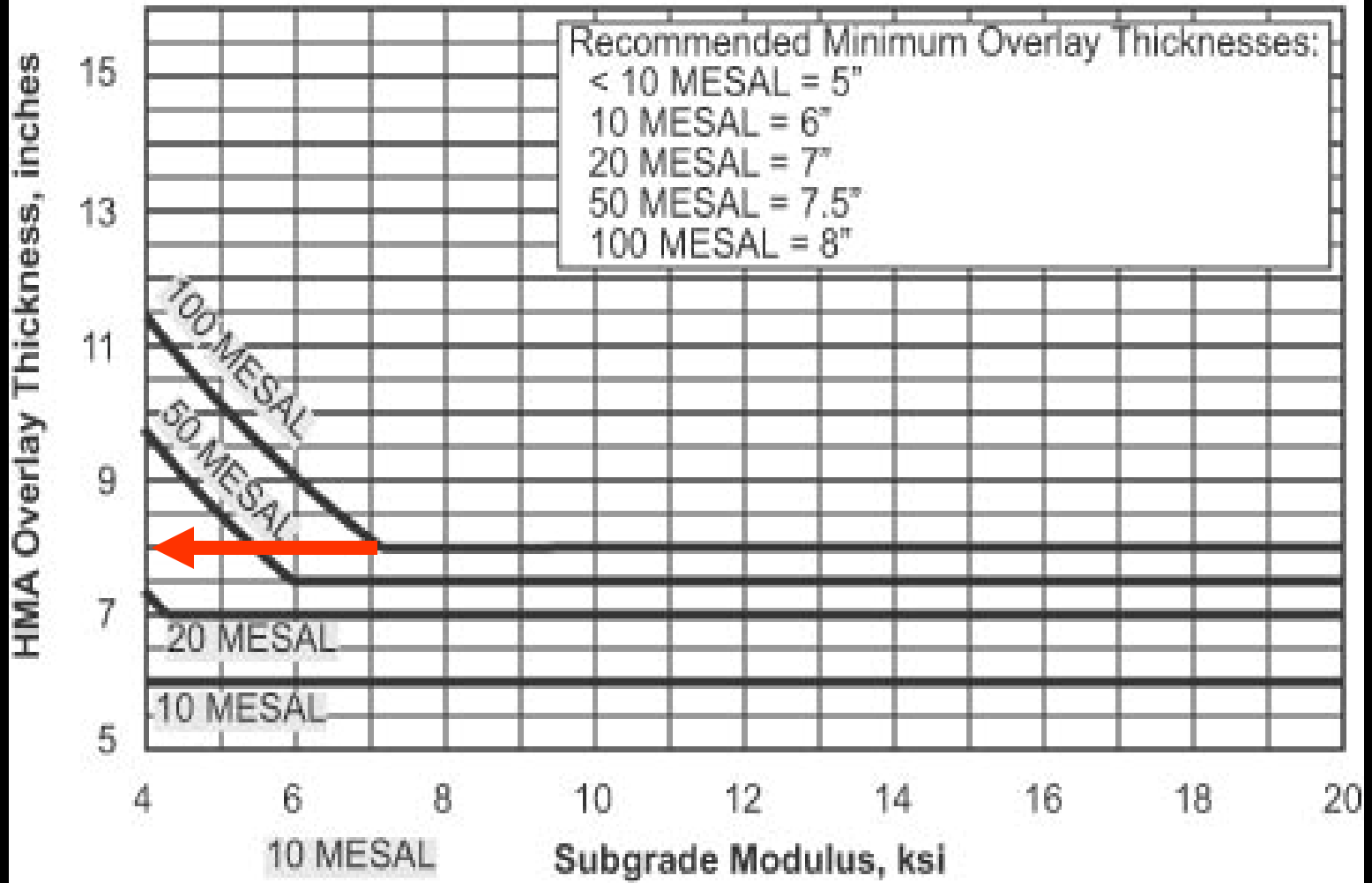
# Oklahoma Bid Prices

- HMA in place \$60/ton @ 145 lb/ft<sup>3</sup>
- PCC in place \$34.44/SY @11" thick and \$27.78/SY @ 8" thick
- PCC removal \$40/CY
- PCC Patch \$100/SY
- HMA milling \$2/SY-INCH
- Rubblization: ~ \$1.50/SY

# First Cost Comparisons

- One Lane-Mile (7040 SY)
- Case 1: Rubblization with Perpetual Pavement
- Case 2: Unbonded PCC Overlay
- Case 3: Remove PCC and Replace with PCC

HMA Overlay Thickness vs. Subgrade Modulus  
11" Rubblized PCC,  $SN_{sb} = 0.8$



# Case 1

- Perpetual Pavement with Rubblization
  - Rubblize 11” PCC
  - Overlay with 8” HMA
- Initial Cost:

Item	Unit Cost	Total
Edge Drains	4.00/lf	\$21,120
Rubblize	1.50/SY	\$10,560
HMA Overlay	60.00/ton	\$183,744
<b>TOTAL</b>		<b>\$215,424</b>

# Case 2

- Unbonded PCC Overlay
  - 10% Patching
  - Bond Breaker – 2" HMA
  - Overlay with 8" PCC
- Initial Cost:

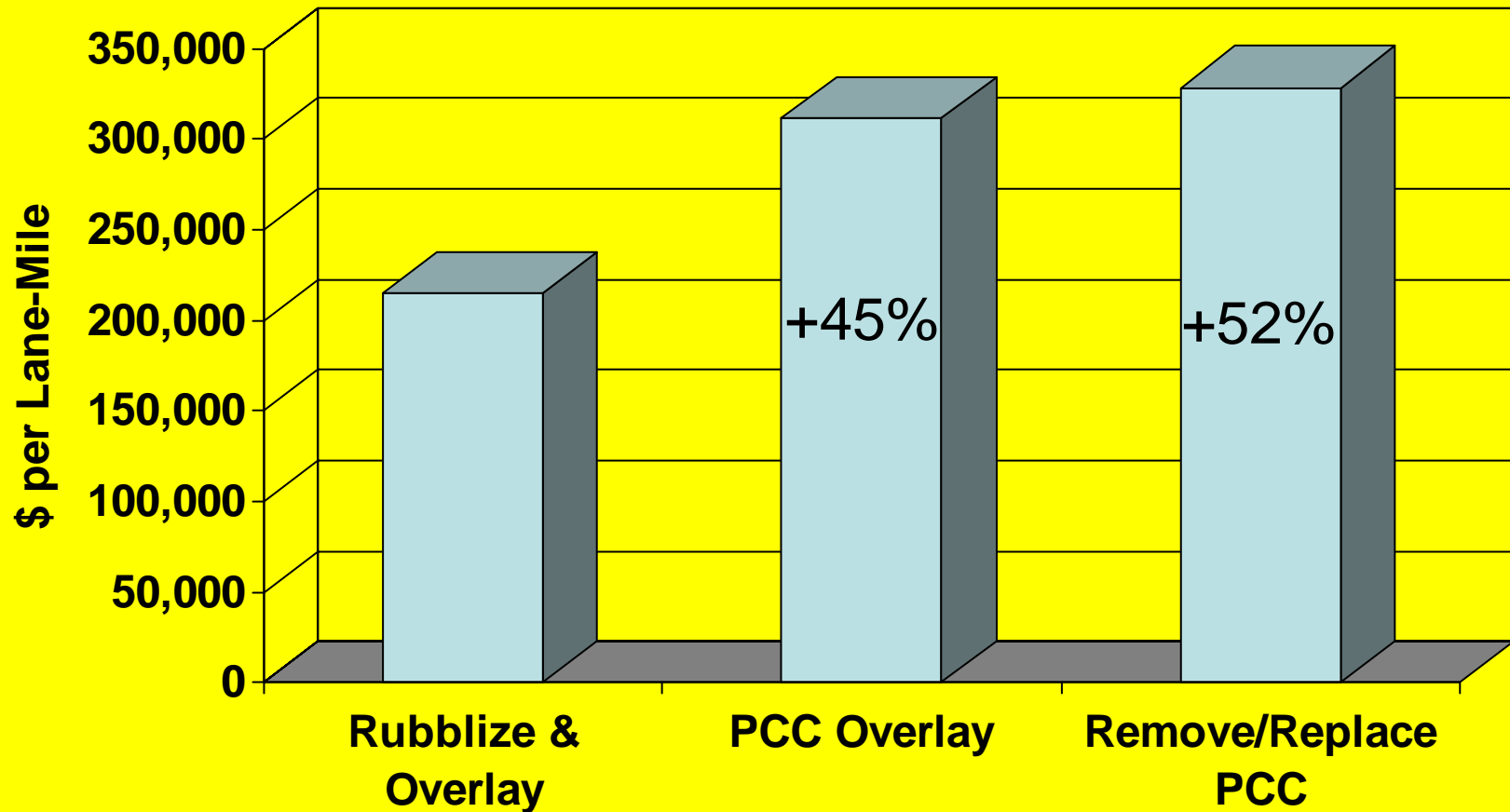
Item	Unit Cost	Total
Concrete Patching	100.00/SY	\$70,400
Bond Breaker	60.00/ton	\$45,936
PCC	27.78/SY	\$195,571
TOTAL		\$311,907

# Case 3

- Remove/Replace PCC
  - Remove PCC
  - Replace with 11" PCC
- Initial Cost:

Item	Unit Cost	Total
Remove PCC	40.00/CY	\$86,044
PCC Placement	34.44/SY	\$242,458
<b>TOTAL</b>		<b>\$328,502</b>

# Initial Cost Comparison





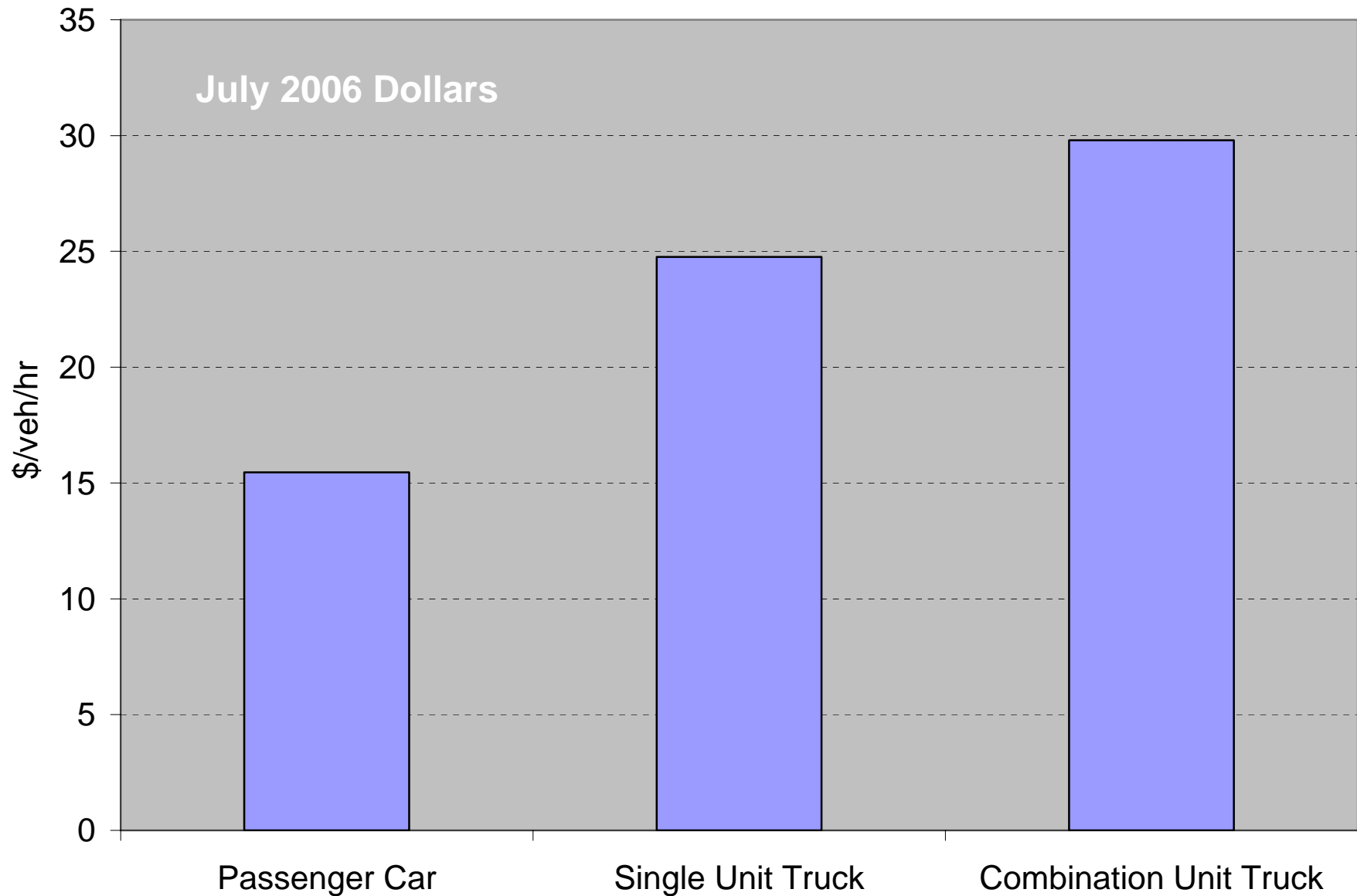
# General Experience

- First Cost: Rubblization ~ 1/3 the cost of remove/replace
- Speed of Construction: days vs. weeks
- Impact of User Costs?

# User Costs

- Use FHWA Guidelines for Life Cycle Cost Analysis
- Work Zone:
  - Speed Change – VOC
  - Speed Change – Delay
  - Speed Change – Reduced Speed
- Queuing
  - Stopping – VOC
  - Stopping – Delay
  - Idle Time
  - Added Travel Time

# Work Zone User Cost Rates



# Work Zone Assumptions

- 1 mile long
- 4 lanes
- One lane open each direction during work
- 40,000 ADT

# Case 1

- Rubblization: One lane-mile/day production
  - Paving: 2 lane-miles/day
  - Sequence
    - 3" bottom lift
    - 3" 2<sup>nd</sup> lift
    - 2.5" 3<sup>rd</sup> lift
    - 2.5" 4<sup>th</sup> lift
  - 24 hour closure until 2<sup>nd</sup> asphalt lift
  - 12 hour closure each for 3<sup>rd</sup> and 4<sup>th</sup>
- User Cost = \$138,714

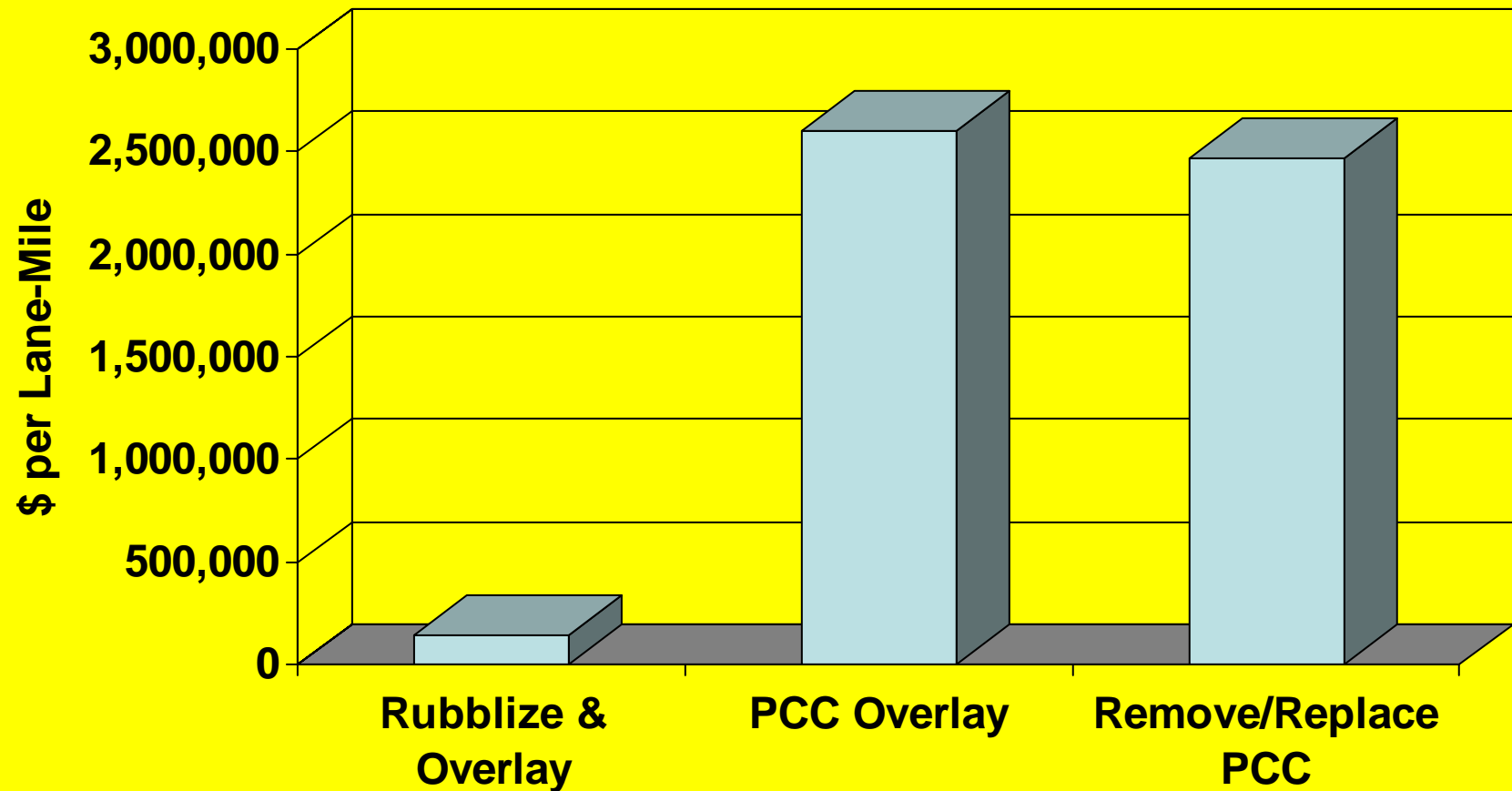
## Case 2

- Unbonded PCC Overlay
  - Patching: 350 SY/day ~ 2 days – 24 hr/day
  - Curing: 3 days – 24 hr/day
  - Bond Breaker: 2 lane-miles/day – 4 hr
  - Set Dowel Baskets: 1 mile/day – 8 hr
  - Paving: 0.75 mile/day – 11 hr
  - Curing: 14 days – 24 hr/day
- User Cost = \$2,601,161

# Case 3

- Remove/Replace PCC
  - Removal: 200 SY/day ~ 3.5 days – 24 hr/day
  - Trim Base: 1 mile/day – 8 hr
  - Set Dowel Baskets: 1 mile/day – 8 hr
  - Paving: 0.75 mile/day – 11 hr
  - Curing: 14 days – 24 hr/day
- User Cost = \$2,471,103

# User Costs





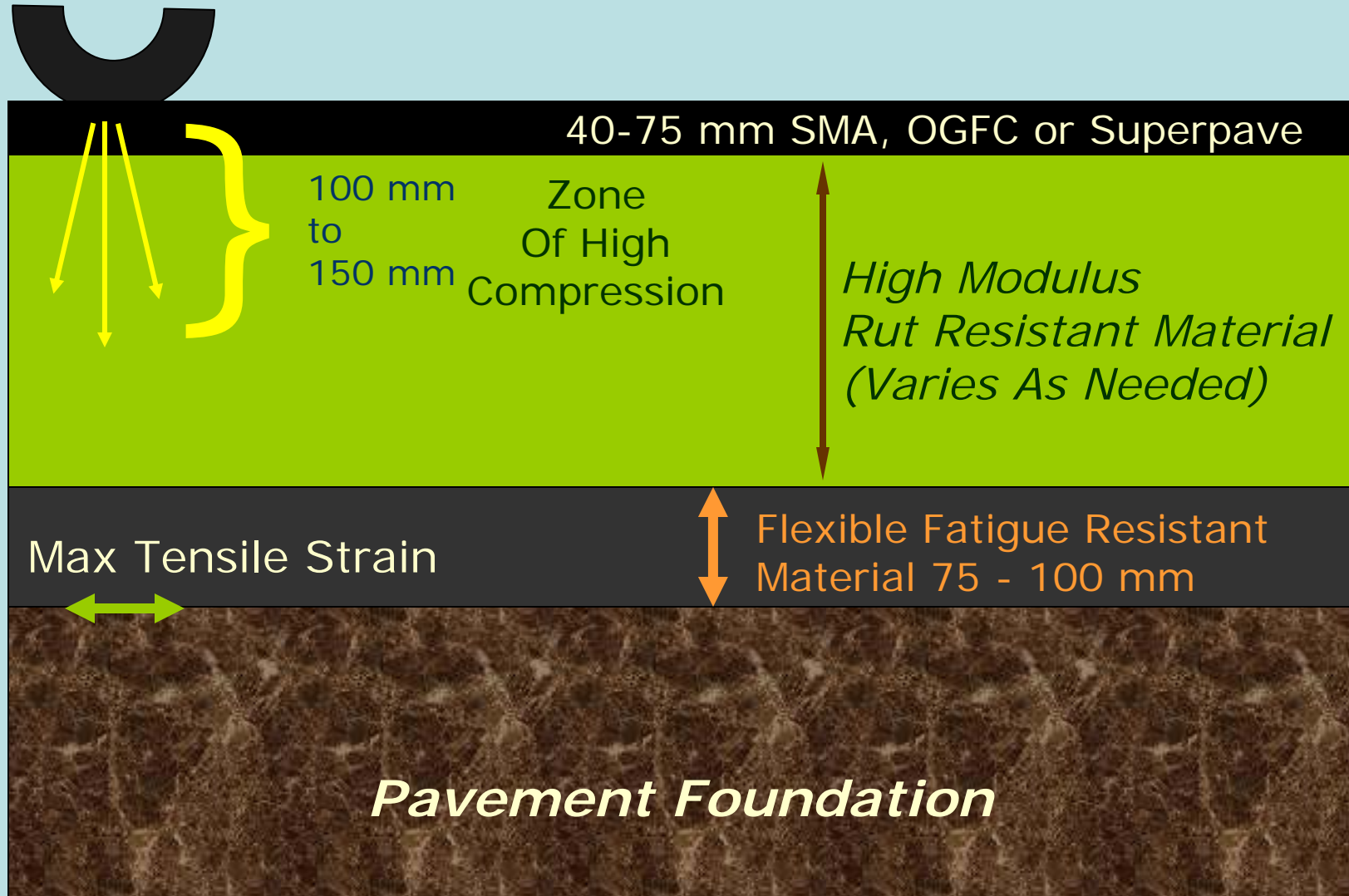
# References



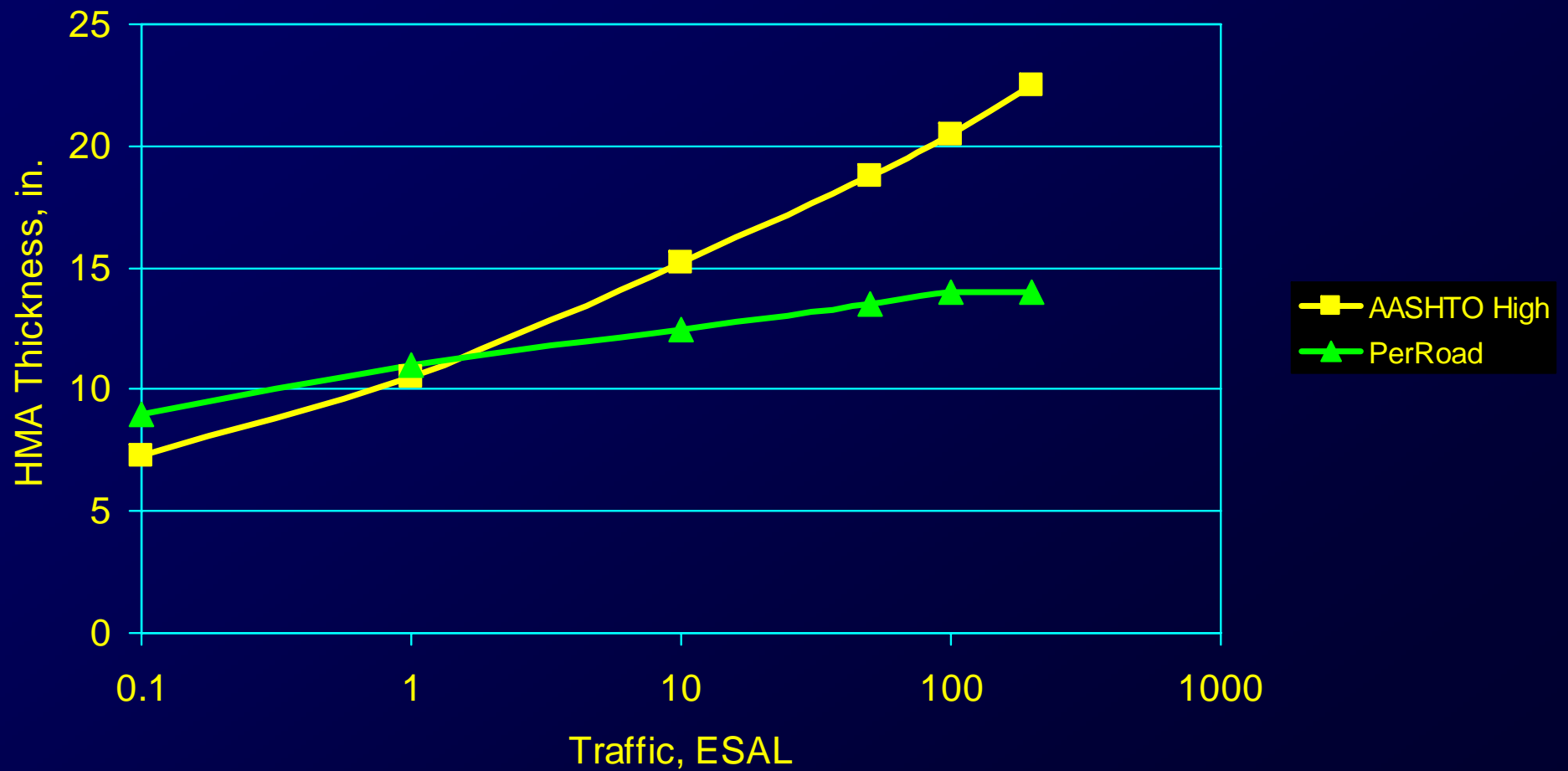
# Perpetual Pavements

- Save asphalt and aggregate over the long term. It's sustainable.
- Lower Life Cycle Cost
- Lower User Cost

# Concept



# Perpetual Pavement versus Conventional Design

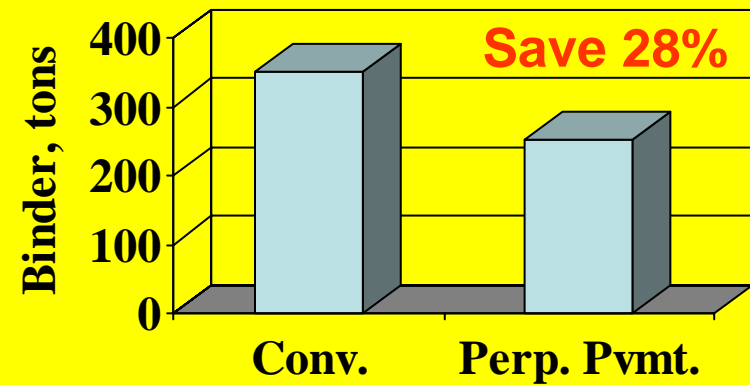
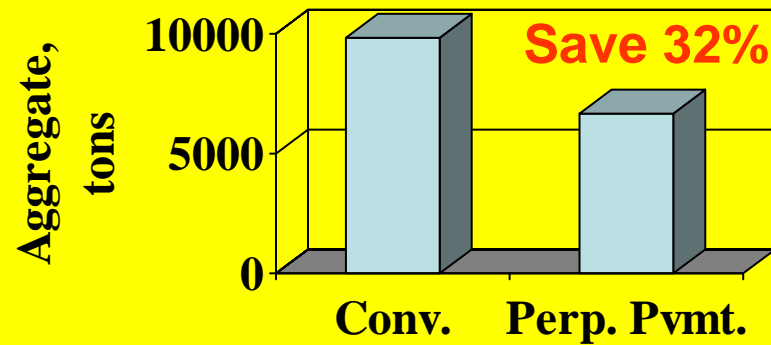
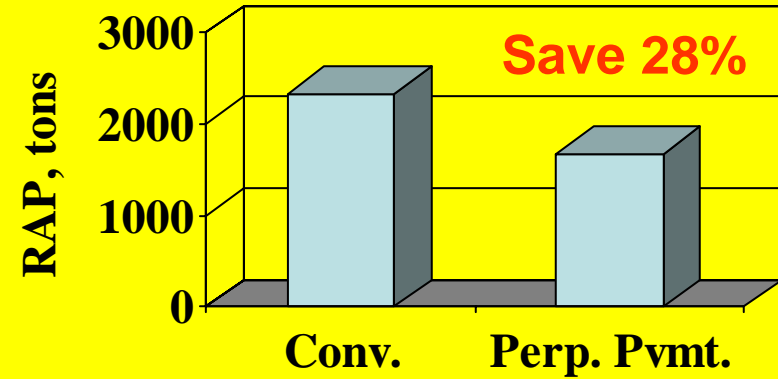
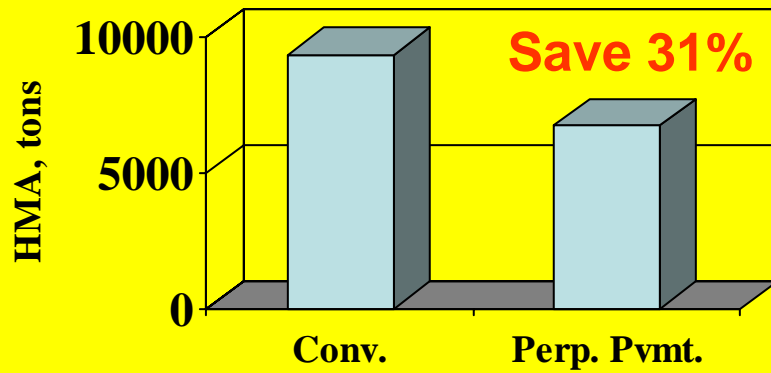


# Comparison of Structures

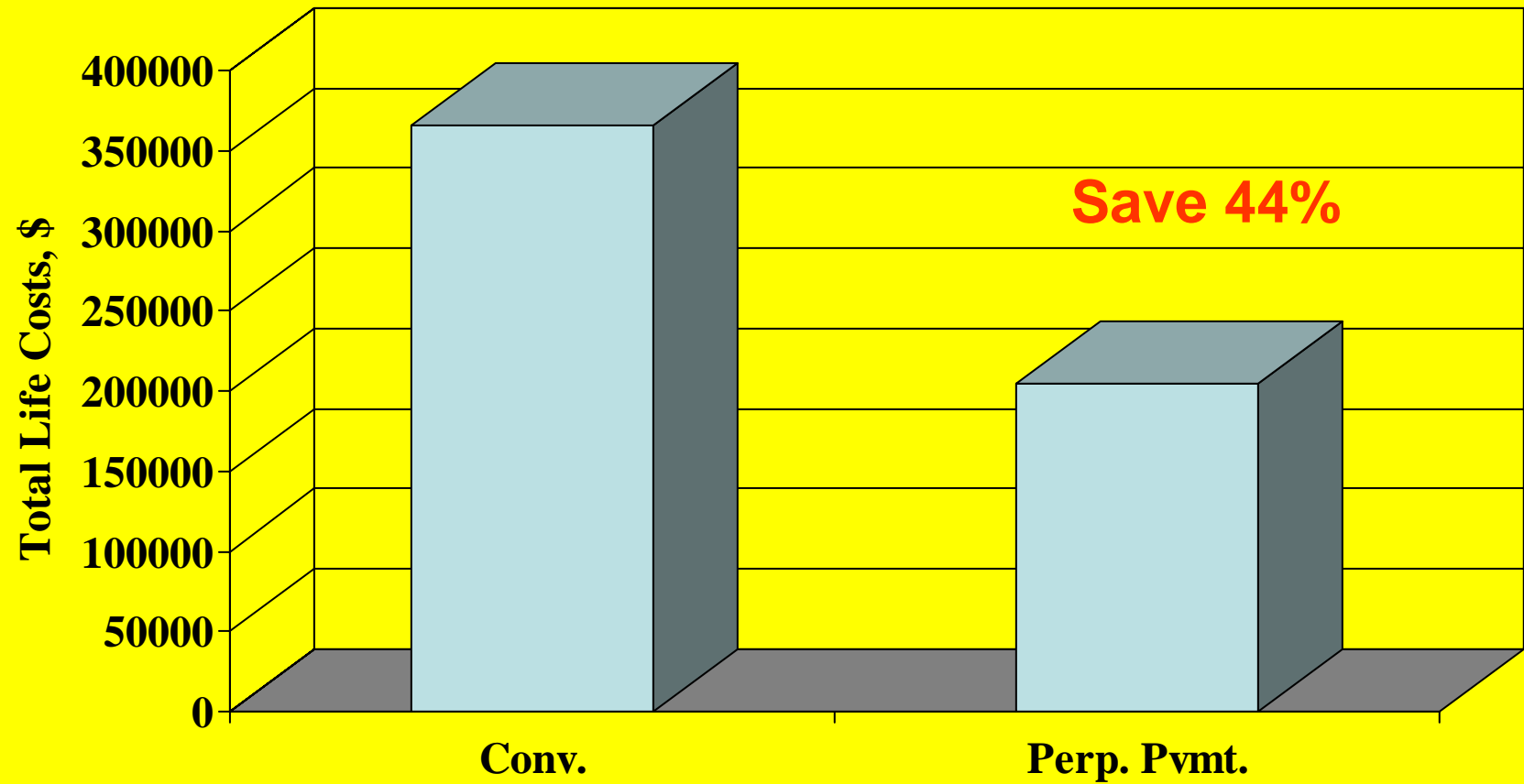
Conventional		Perpetual	
Year	Activity	Year	Activity
0	6" HMA/10" Base	0	11" HMA/6" Base
15	Mill 2"/Overlay 3"	18	Mill 2"/Overlay 2"
25	10% Patching + Mill 2"/Overlay 3"	33	Mill 2"/Overlay 2"
35	Reconstruct with 8" HMA	48	Mill 2"/Overlay 2"
50	Mill 2"/Overlay 3"	50	-----

Year	Conventional (tons/lane-mile)		Perpetual Pavement (tons/lane-mile)	
	HMA*	Gravel Base*	HMA*	Gravel Base*
0	2,376	3,168	4,356	1,901
15	1,188			
18			792	
25	1,426			
33			792	
35	3,168			
48			792	
50	1,188			
<b>Total</b>	<b>9,346</b>	<b>3,168</b>	<b>6,732</b>	<b>1,901</b>
RAP	2,337		1,683	
Aggregate	6,659	3,168	4,797	1,901
Asphalt Binder**	350		252	

# Material Usage



# Costs





# Summary

- Rubblization saves:
  - Time – especially for users
  - Money – about 50% for agencies, 17X less user costs
  - Materials
- Perpetual Pavements saves:
  - Asphalt
  - Aggregate
  - RAP
  - Money
- Need to apply proper solutions.
- Need to apply engineering principles.
- **DON'T SACRIFICE QUALITY!**

# Other Ideas

- Get Pavement considered as part of solution to road noise – Lower Noise Barriers by 3 ft by resurfacing with a low noise asphalt!