Illinois Asphalt Pavement Assn.

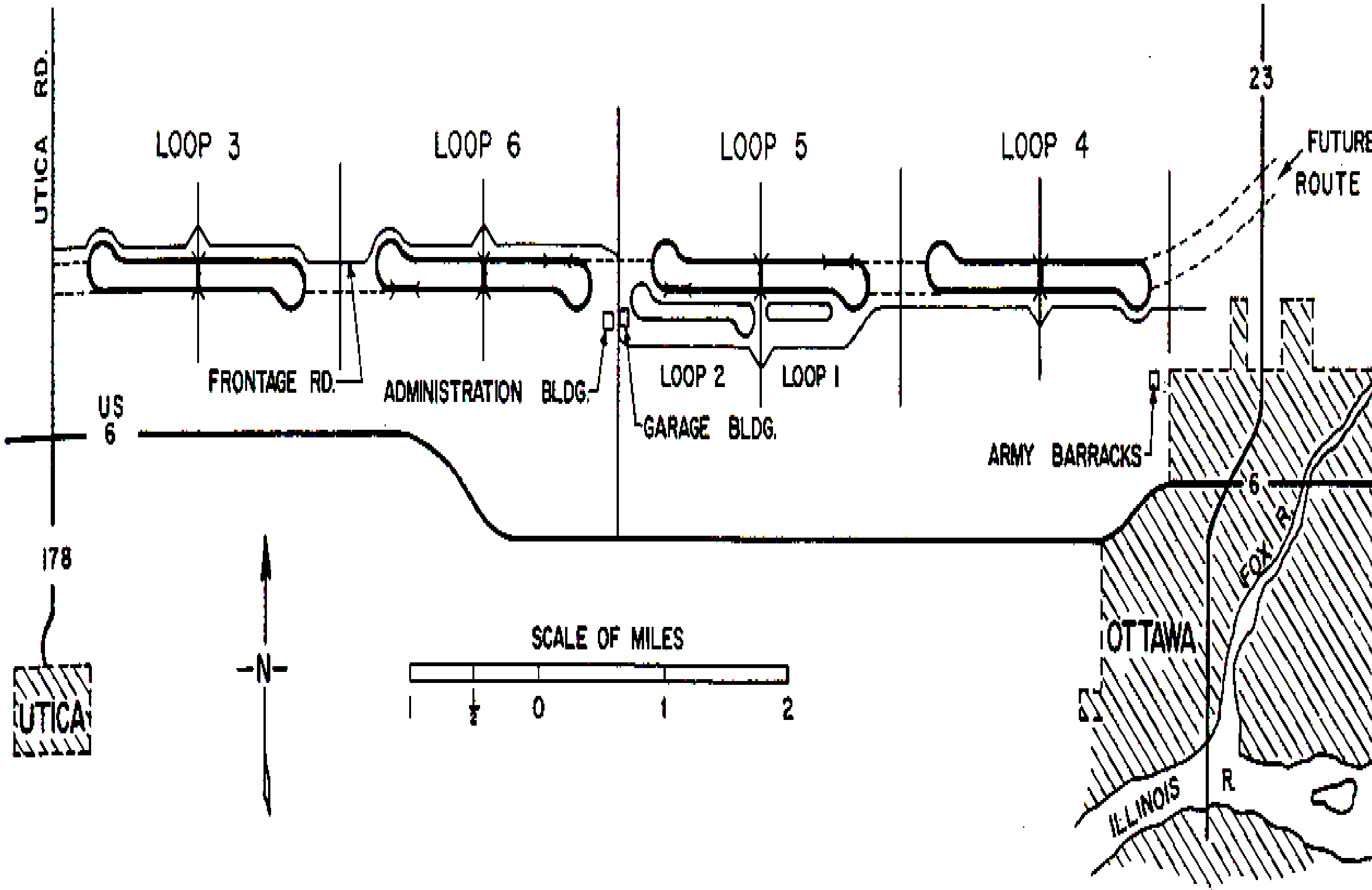
iapa

**Marvin Traylor**

# PERPETUAL PAVEMENT

## And Selected Short Subjects

# "AASHO Road Test"



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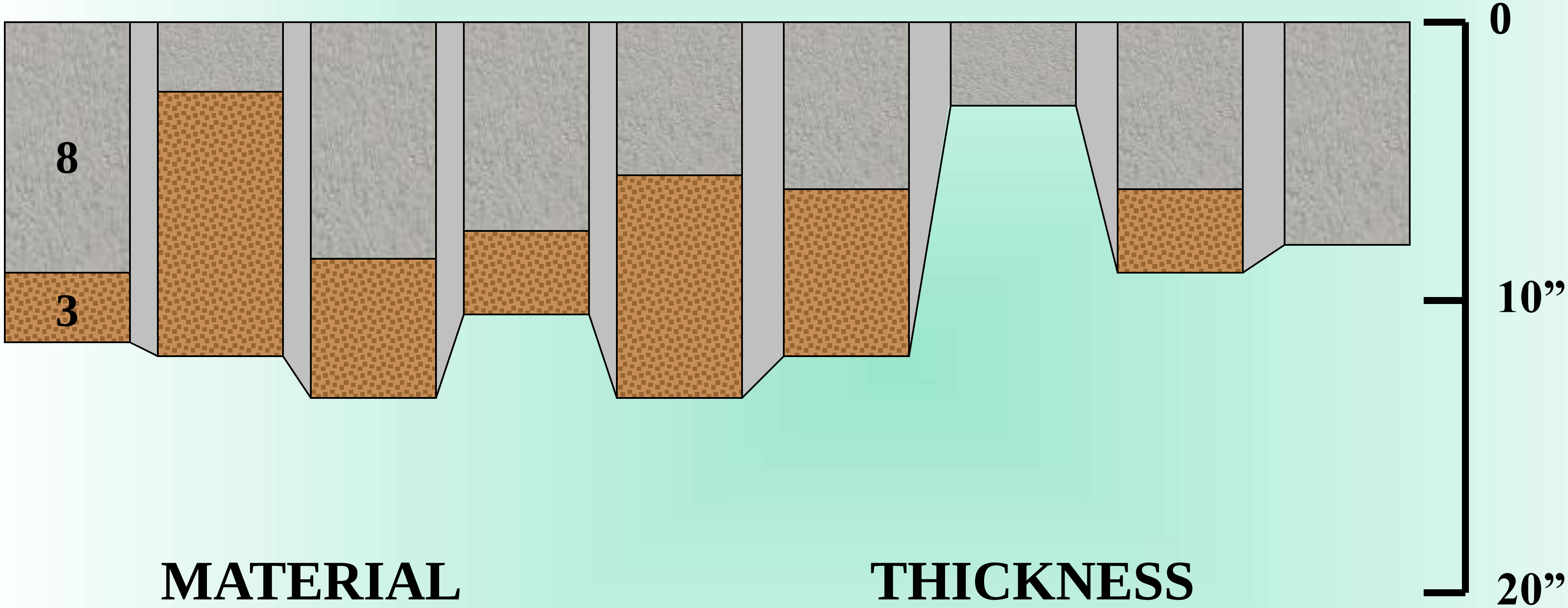
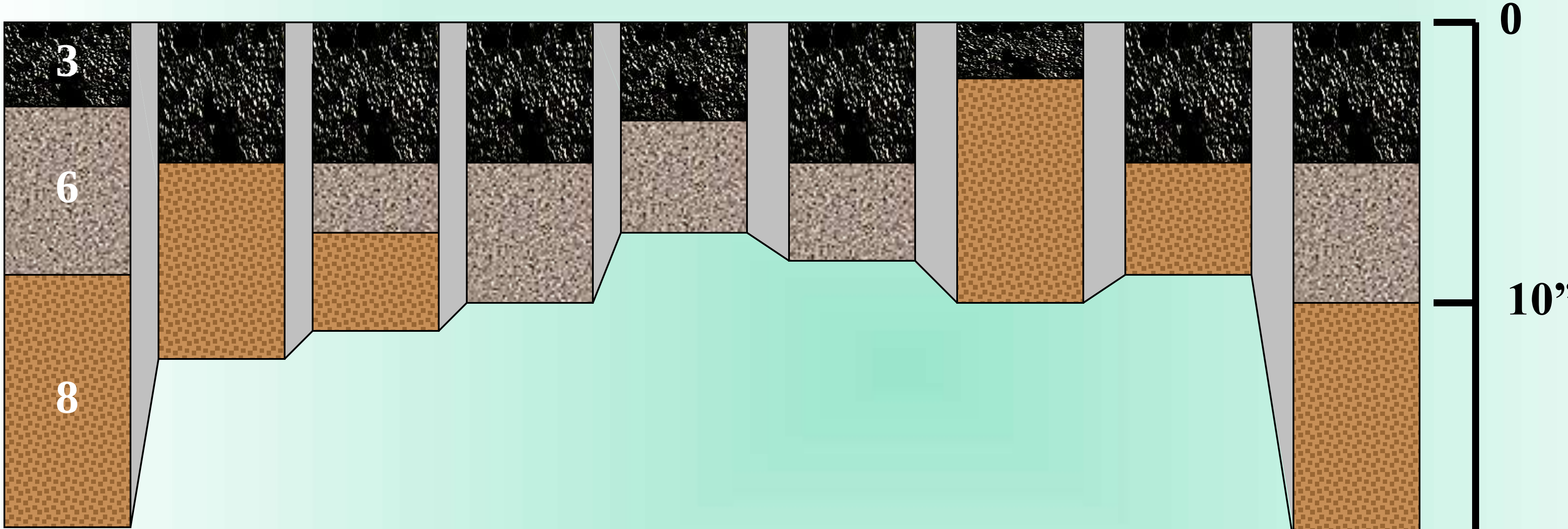
# Rigid Profile




| MATERIAL | THICKNESS |
|---|---|
| PCC | 3½ 5 6½ 8 9½ 11 12½ |
| SANDY GRAVEL subbase | 0 3 6 9 |

# Flexible Profile




| MATERIAL | THICKNESS | | | | |
|---|---|---|---|---|---|
| ASPHALT surface | 2 | 3 | 4 | 5 | 6 |
| CRUSHED STONE base | 0 | 3 | 6 | 9 | |
| SANDY GRAVEL subbase | 0 | 4 | 8 | 12 | 16 |

# Loading



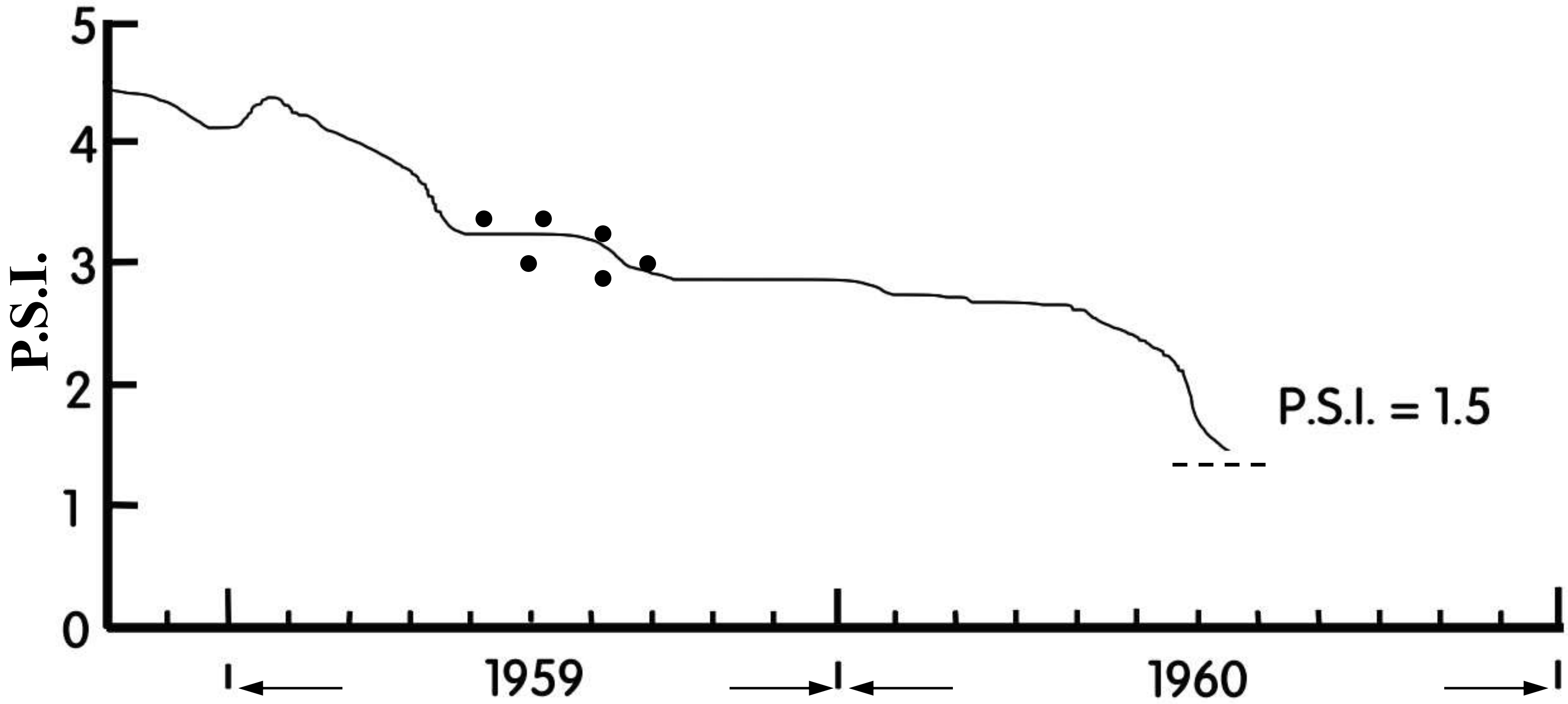
LOOP

| | | | |
|---|---|---|---|
| 3 | 4 | 12 | 12 |
| 4 | 6 | 18 | 18 |
| 5 | 6 | 22 | 22 |
| 6 | 9 | 30 | 30 |

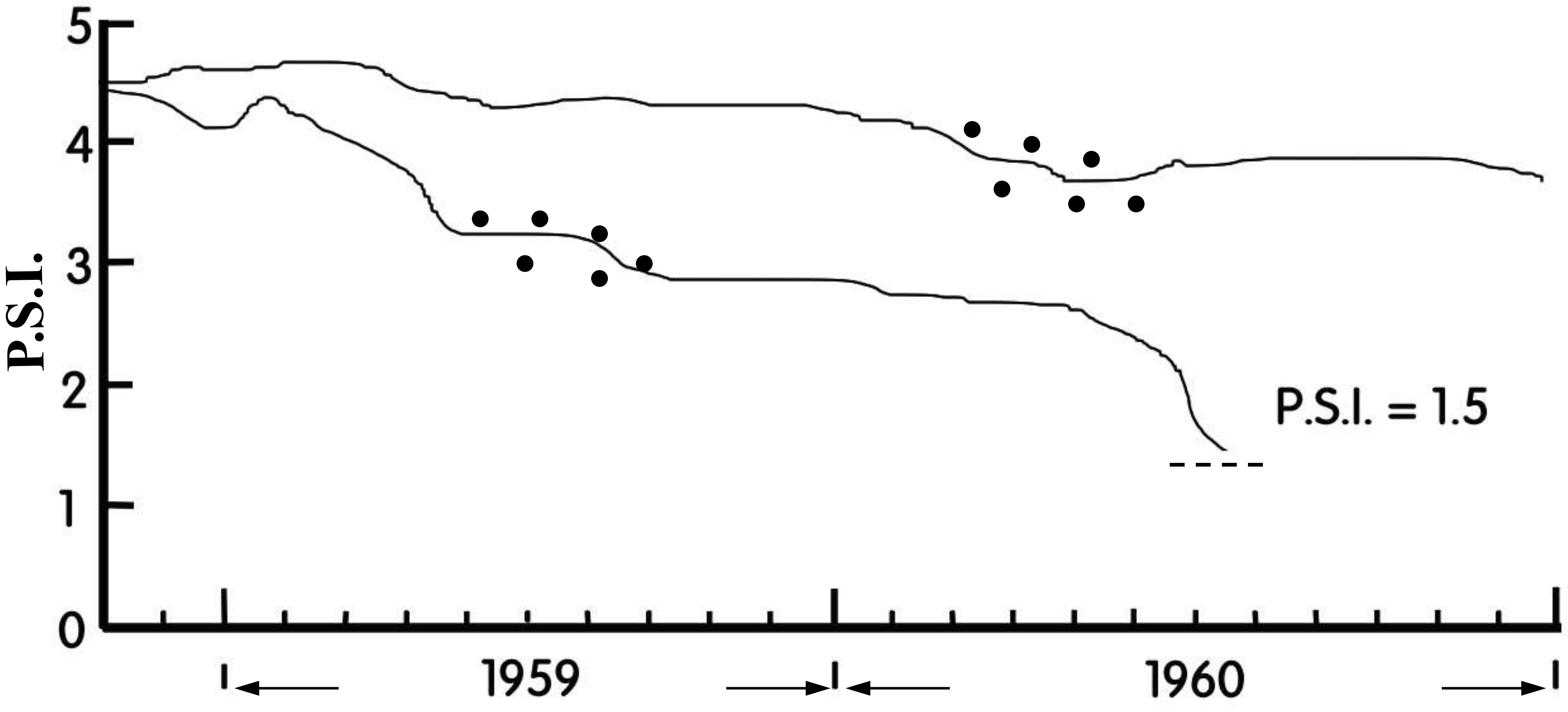
| | | | |
|---|---|---|---|
| | 6 | 24 | 24 |
| | 9 | 32 | 32 |
| | 9 | 40 | 40 |
| | 12 | 48 | 48 |

2 Years = 1.1 Million Axle Loads

# Pavement Performance



# Pavement Performance

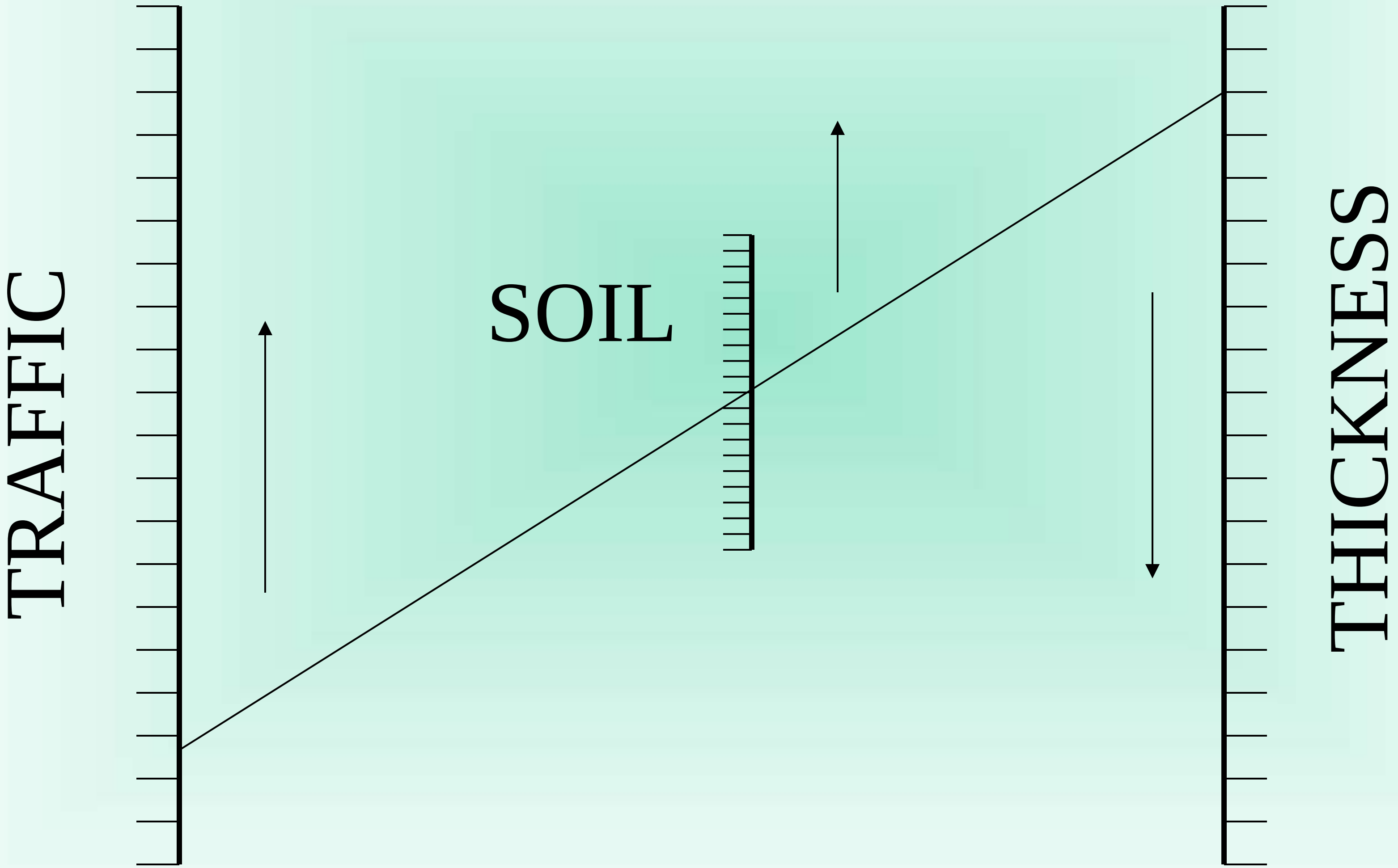


# Rigid Findings

Subbase Necessary to

Prevent Pumping

# Rigid Nomograph



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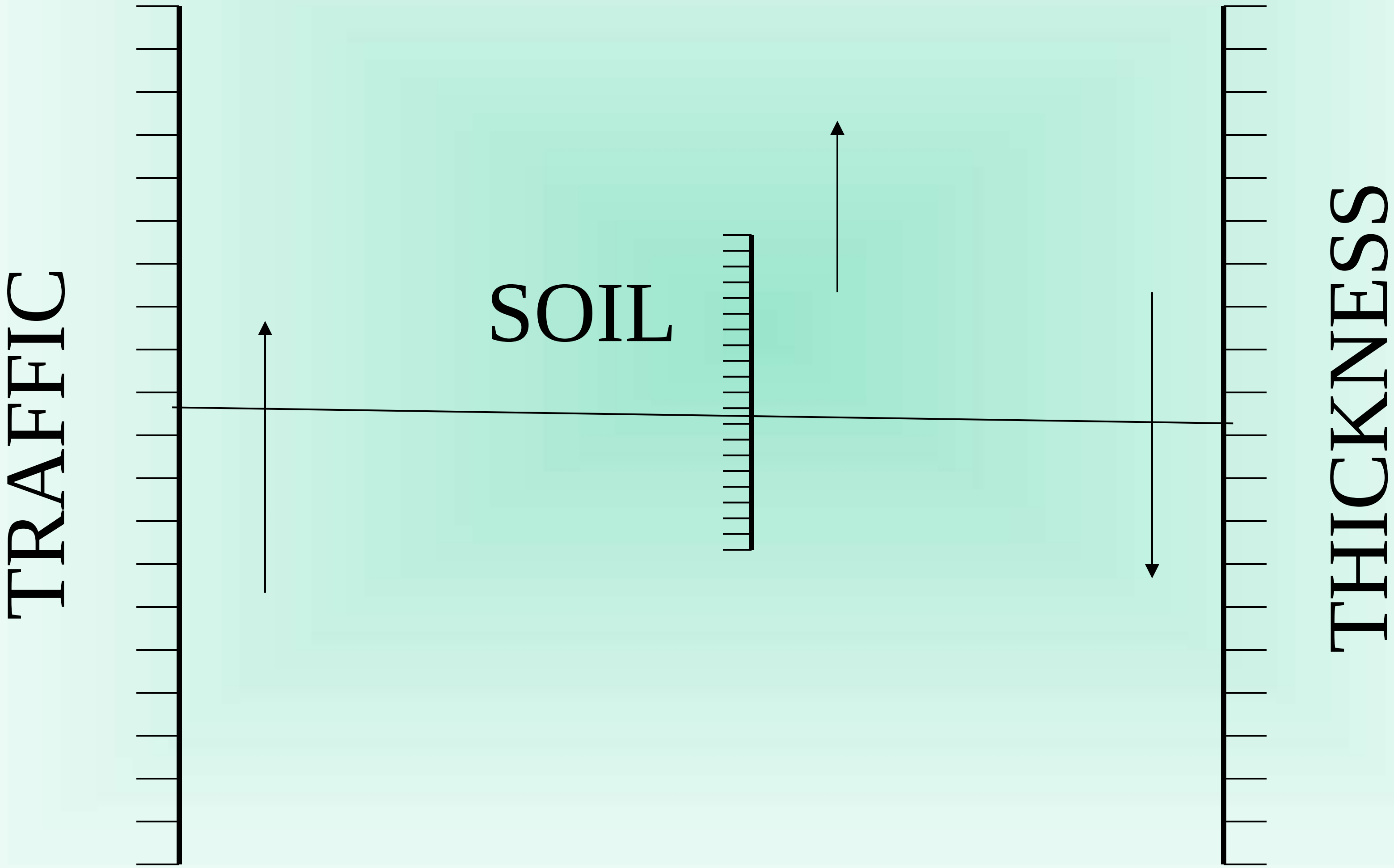

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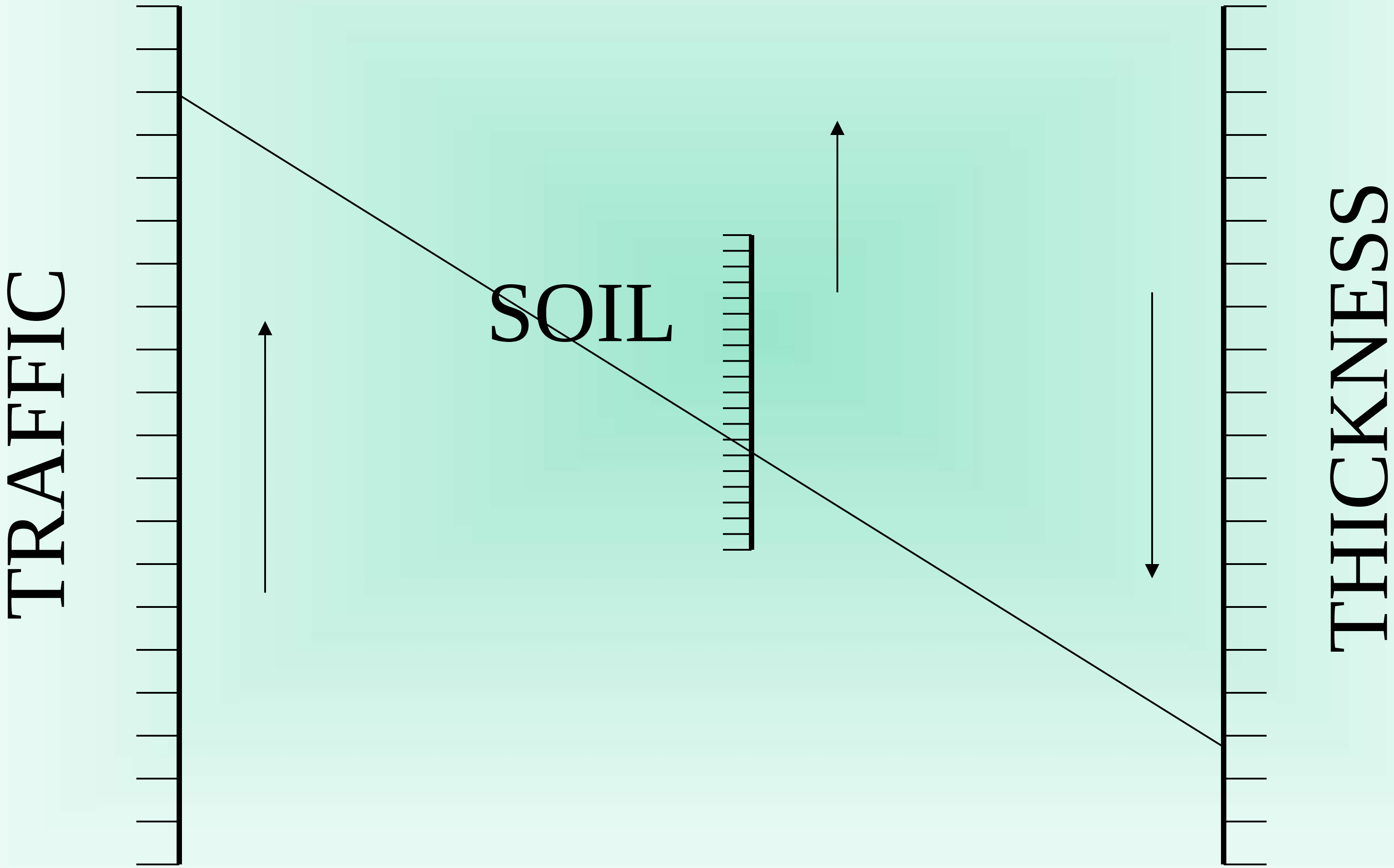
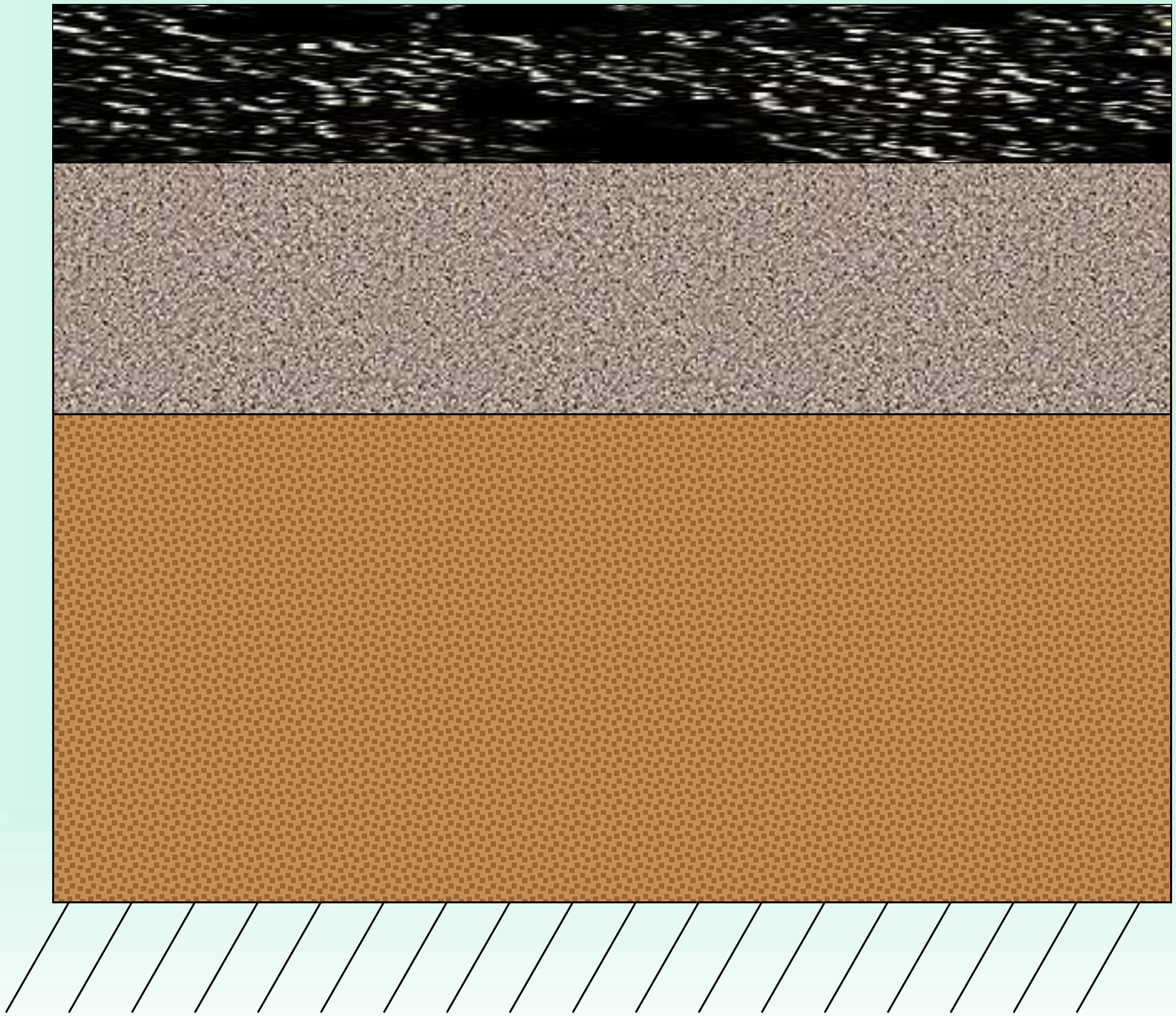
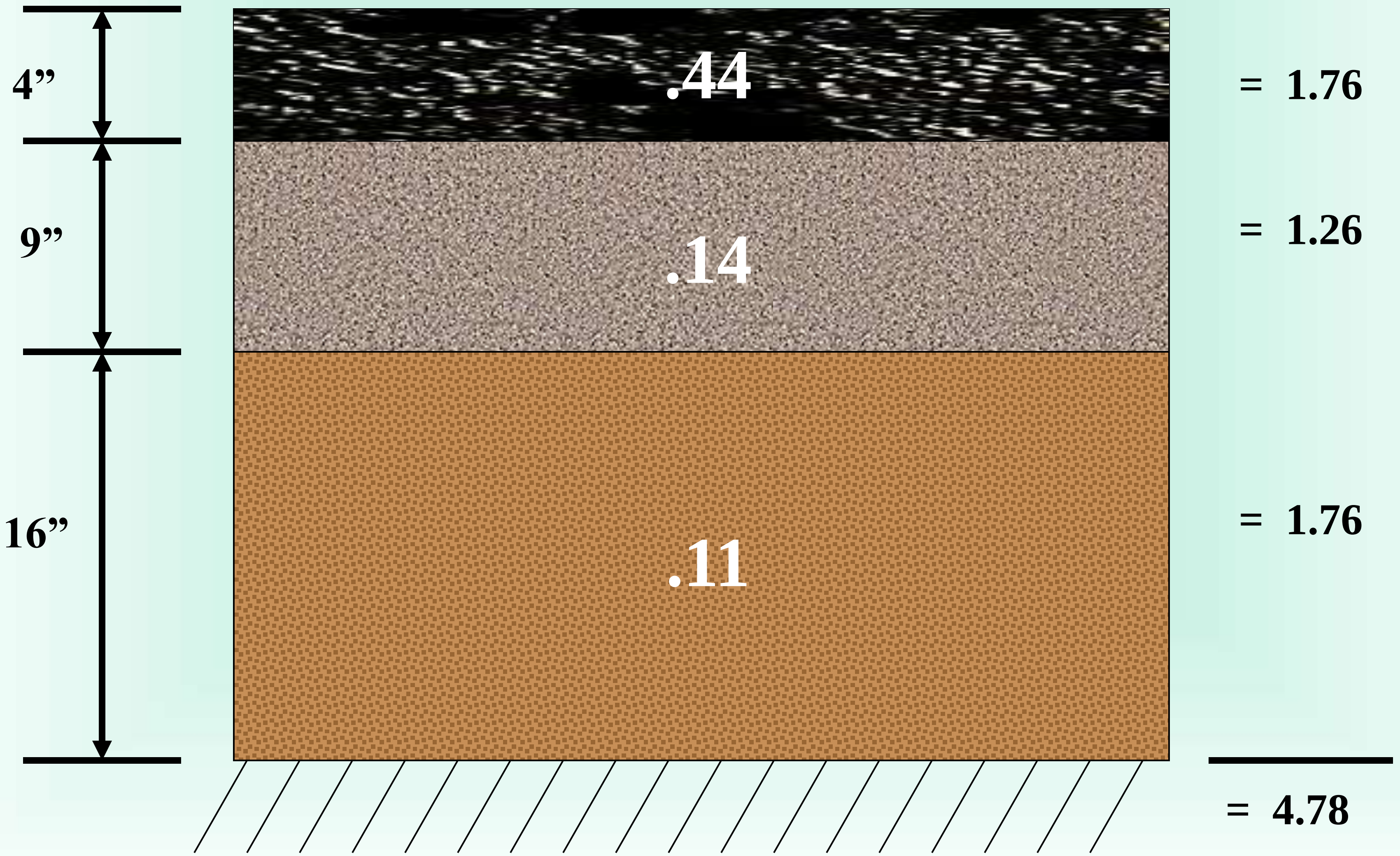


# Flexible Findings



# Structural Number Concept



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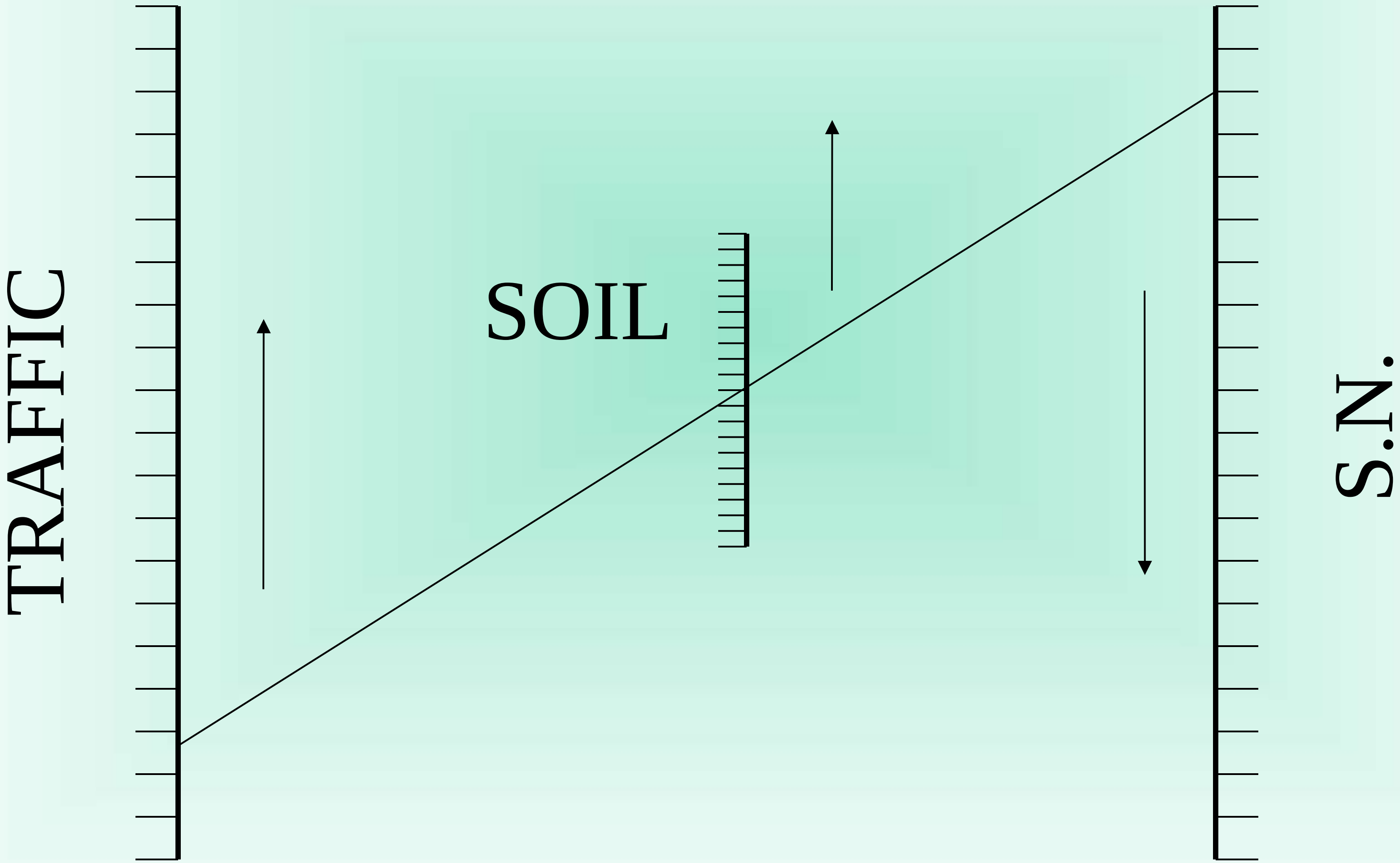

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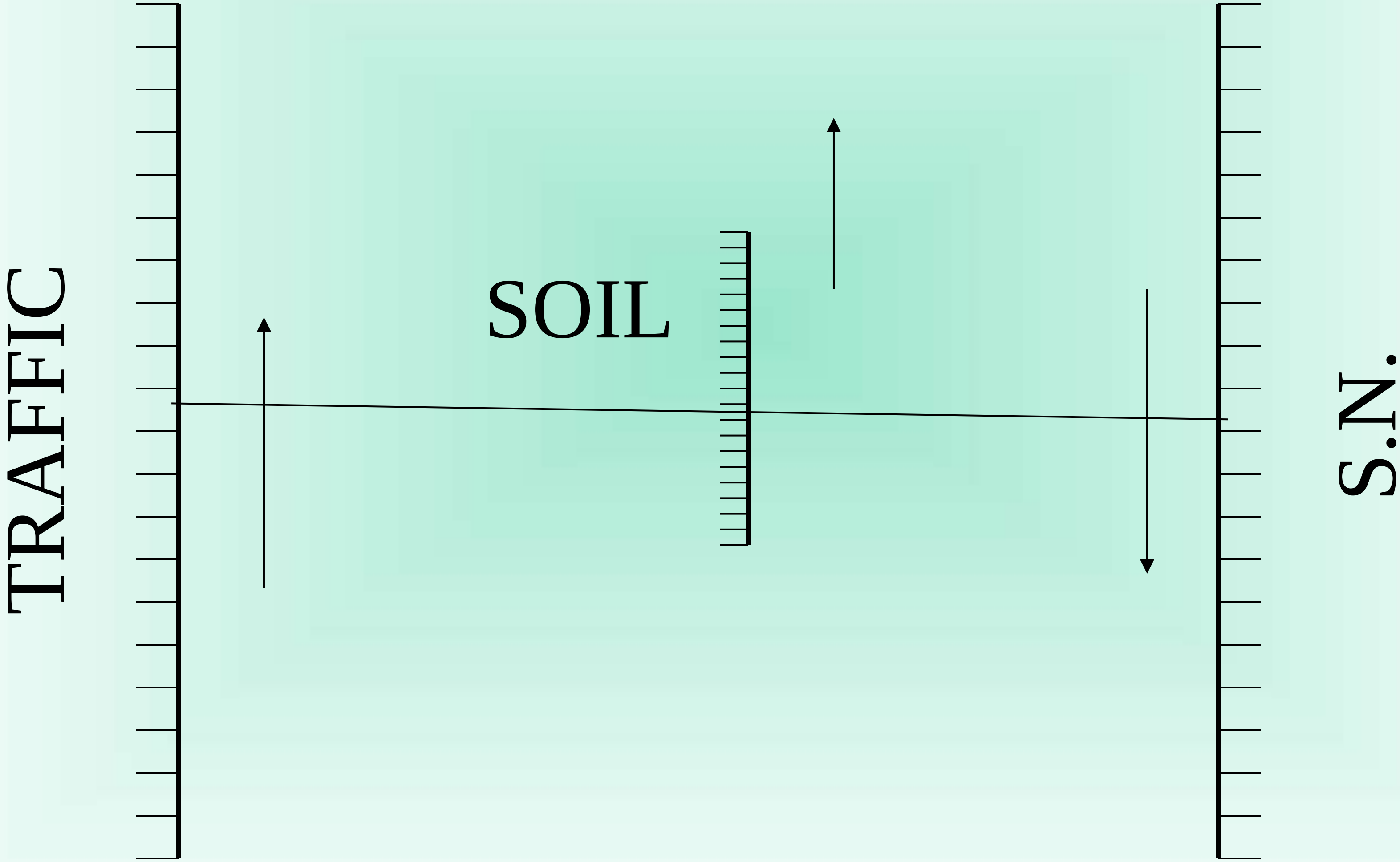

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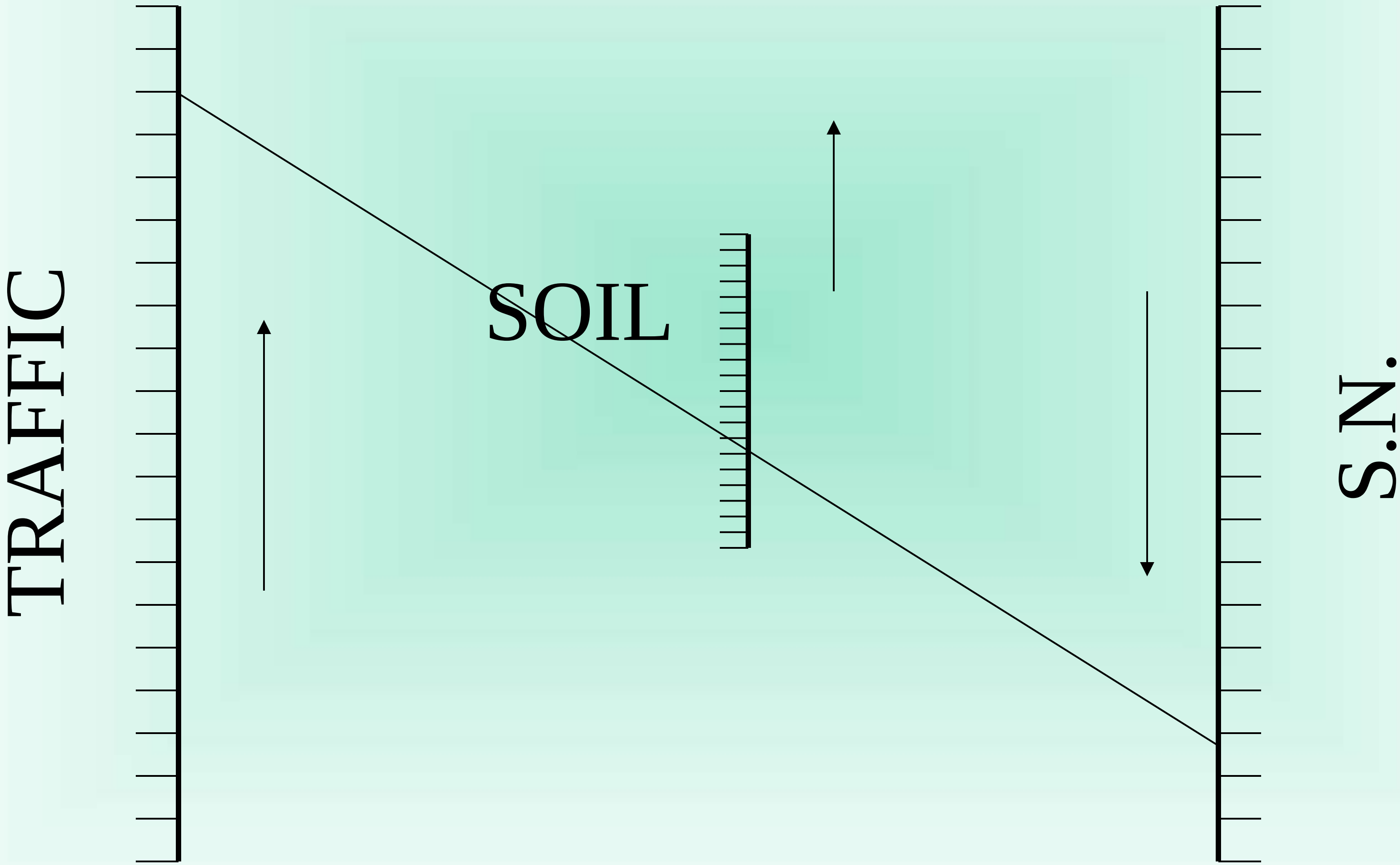


# AASHO Advances

- Equivalent $18^K$ Single Axle Loads (ESALs)
- Thickness Designs for both B & W
- “Equivalent” Pavements

# AASHO Limitations

- One Set of Materials
- Two Years of Weathering
- 1.1 Million Axles
- No Full Depth
- Totally Empirical

# Mechanistic Design

Mechanistic -

"Concerning the Relationships Between Applied Forces and Material Responses."

# Mechanistic Design

Mechanistic -

"Concerning the Relationships Between Applied Forces and Material Responses."

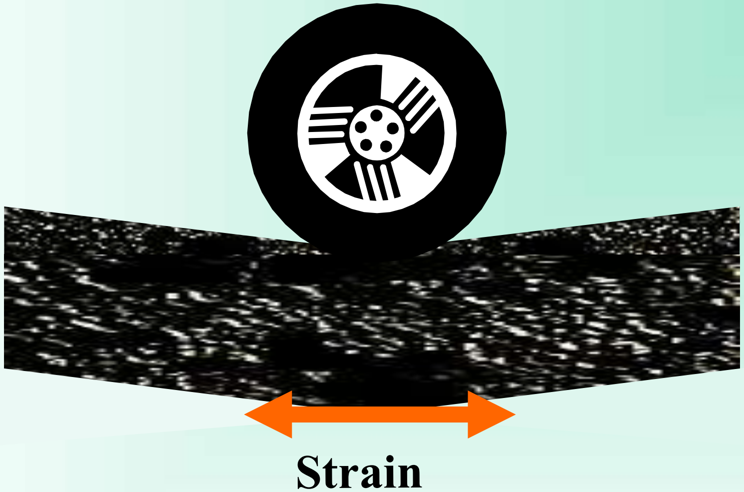
Basic Premise -

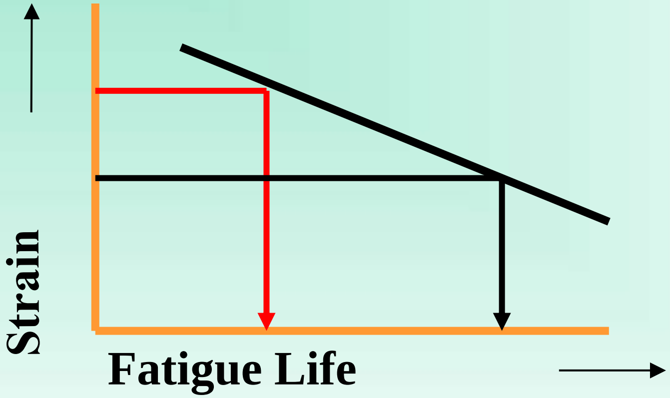
Low Deflections = Long Life

# Fatigue Theory

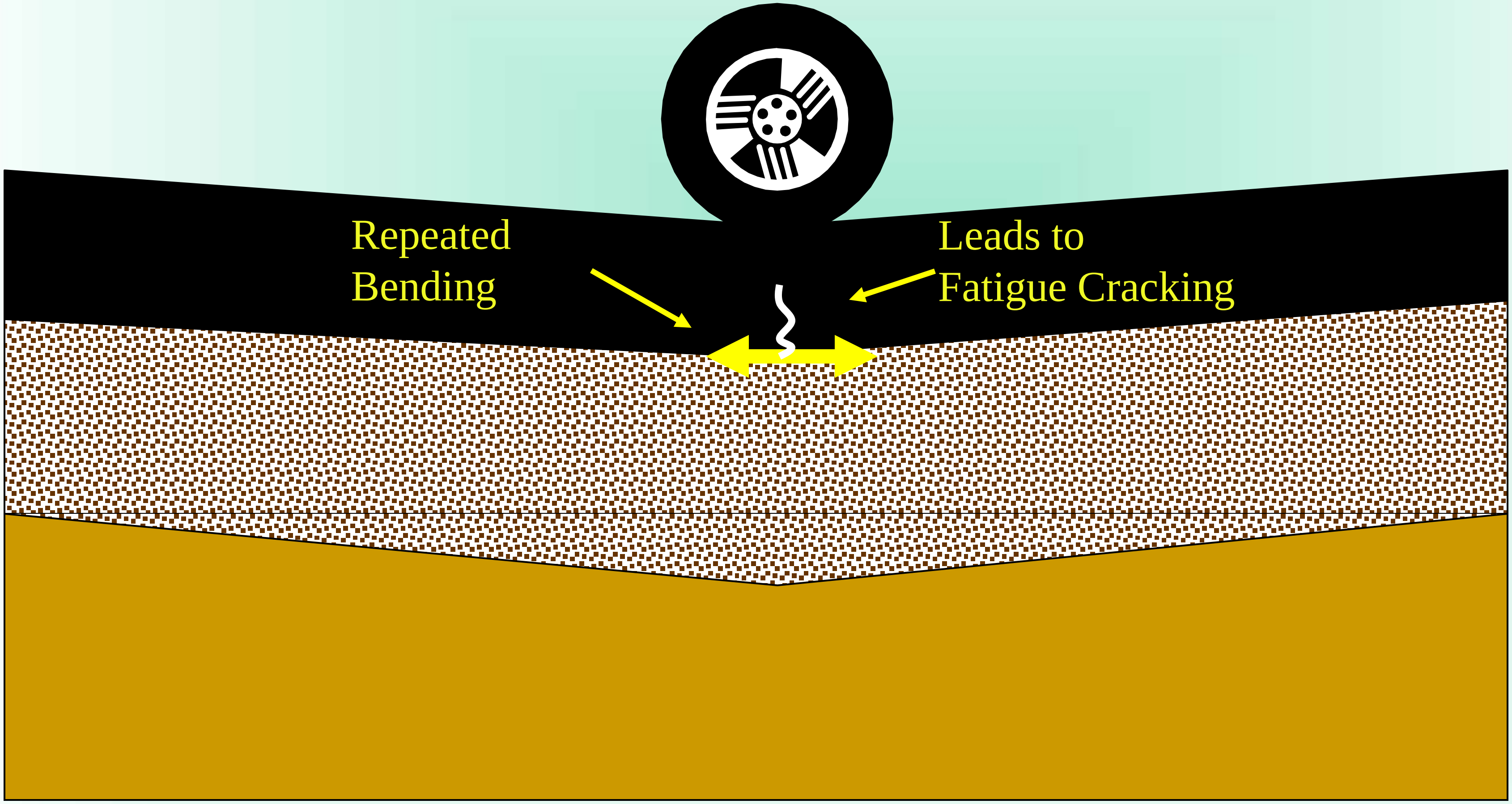
High Strain = Short Life

Low Strain = Long Life

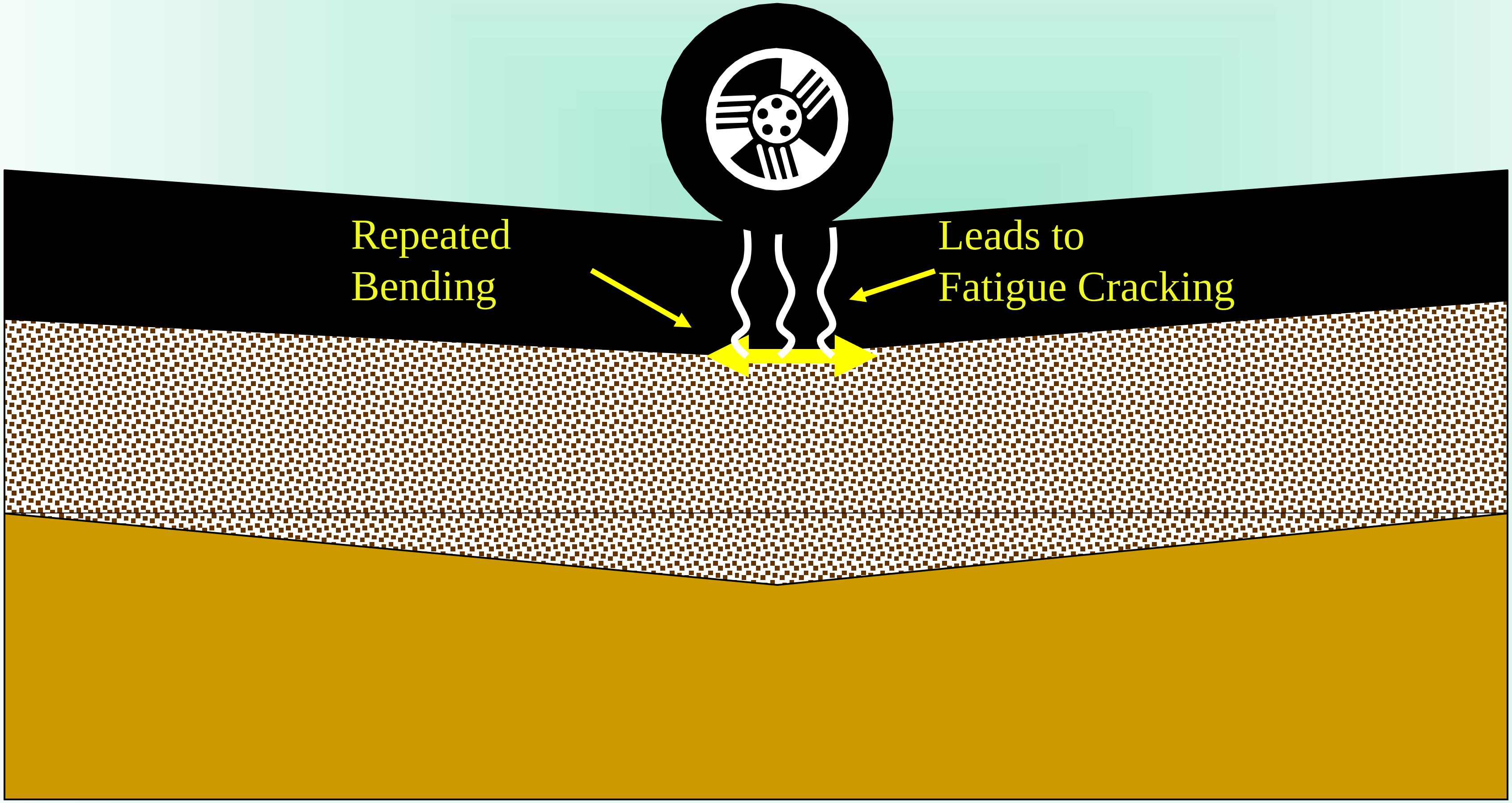


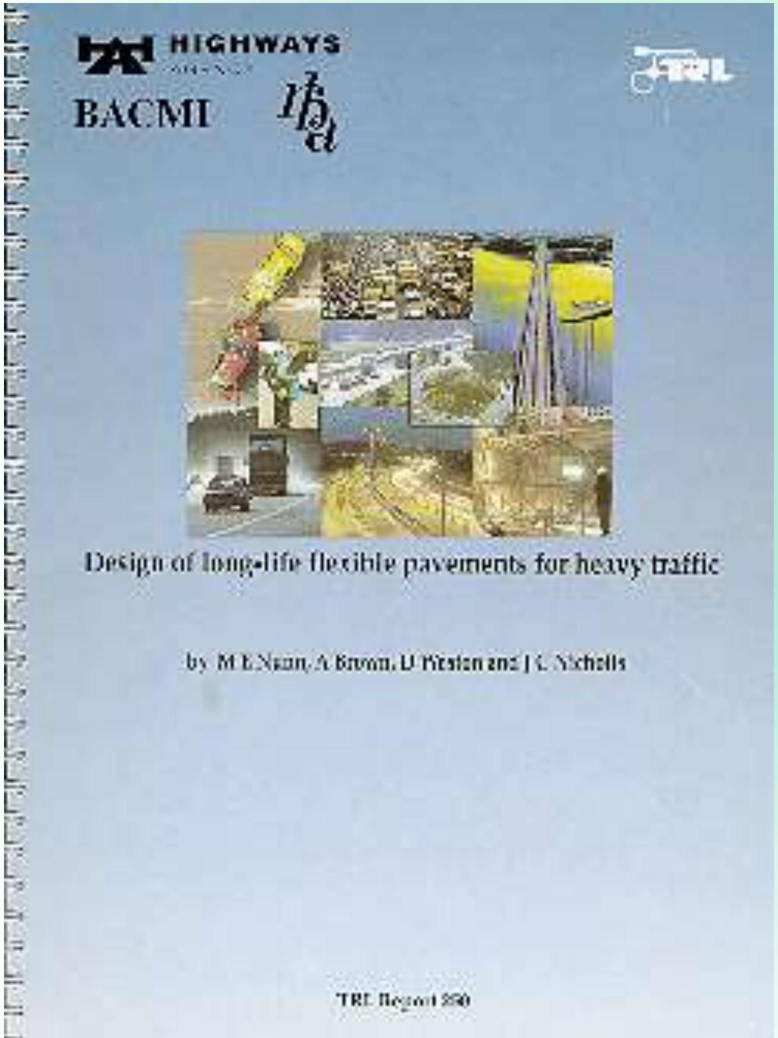



# Fatigue Cracking



# Fatigue Cracking

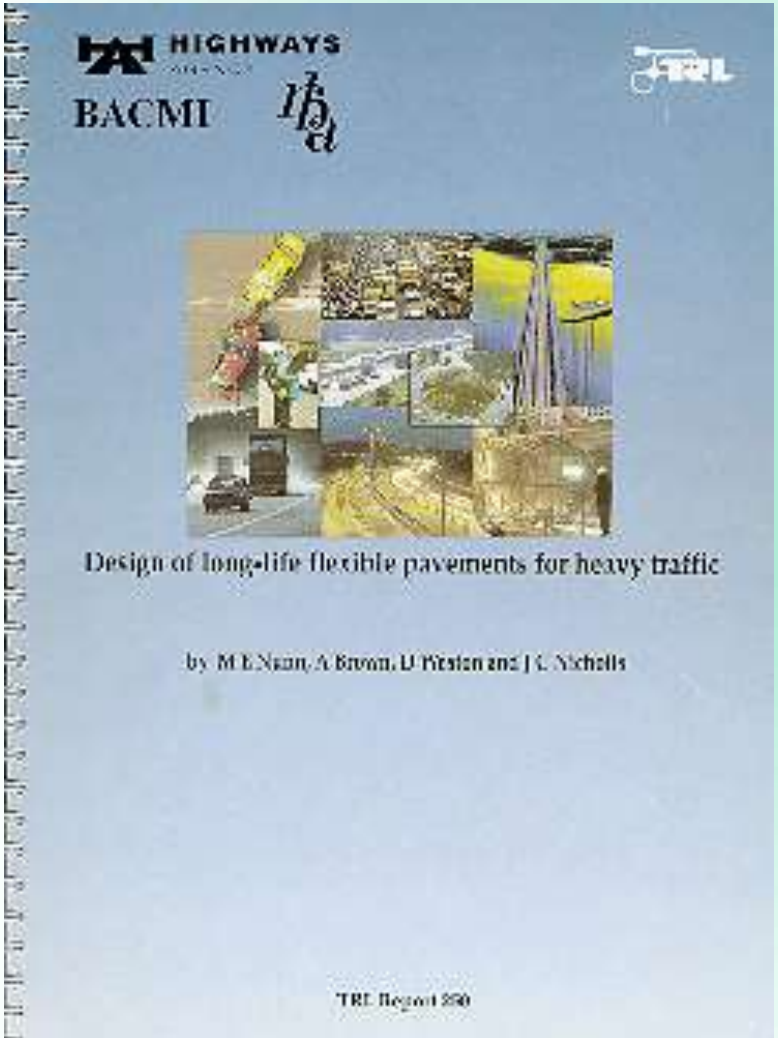





TRL Report 250
Nunn, Brown, Weston
& Nicholls

Design of Long-Life Flexible Pavements for Heavy Traffic

http:\\www.trl.co.uk

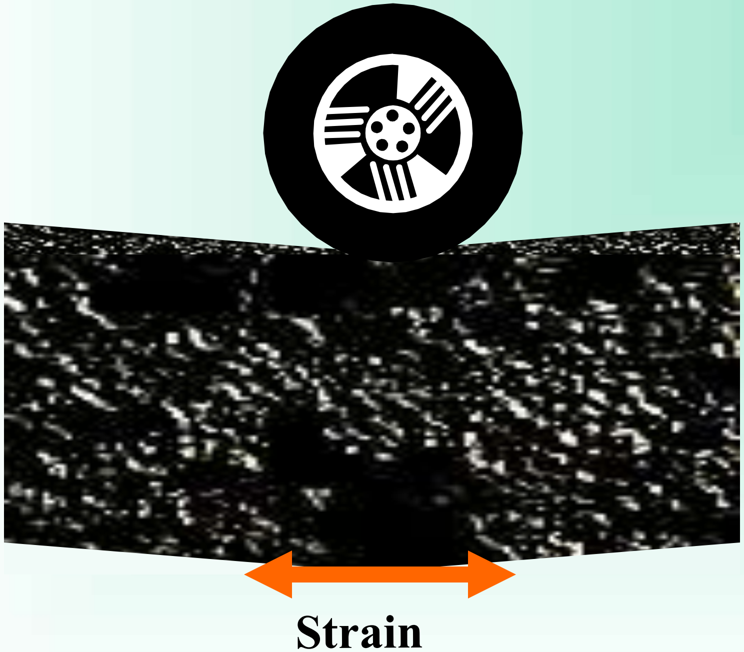


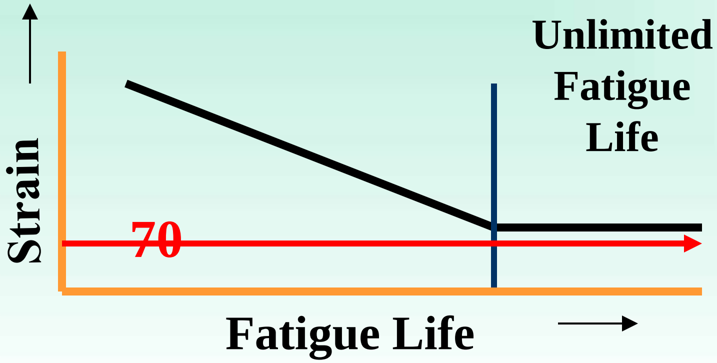

"The deterioration of thick, well constructed, fully flexible pavements is not structural, but occurs at the surface as cracking and rutting."

# Fatigue Theory for Thick Pavements

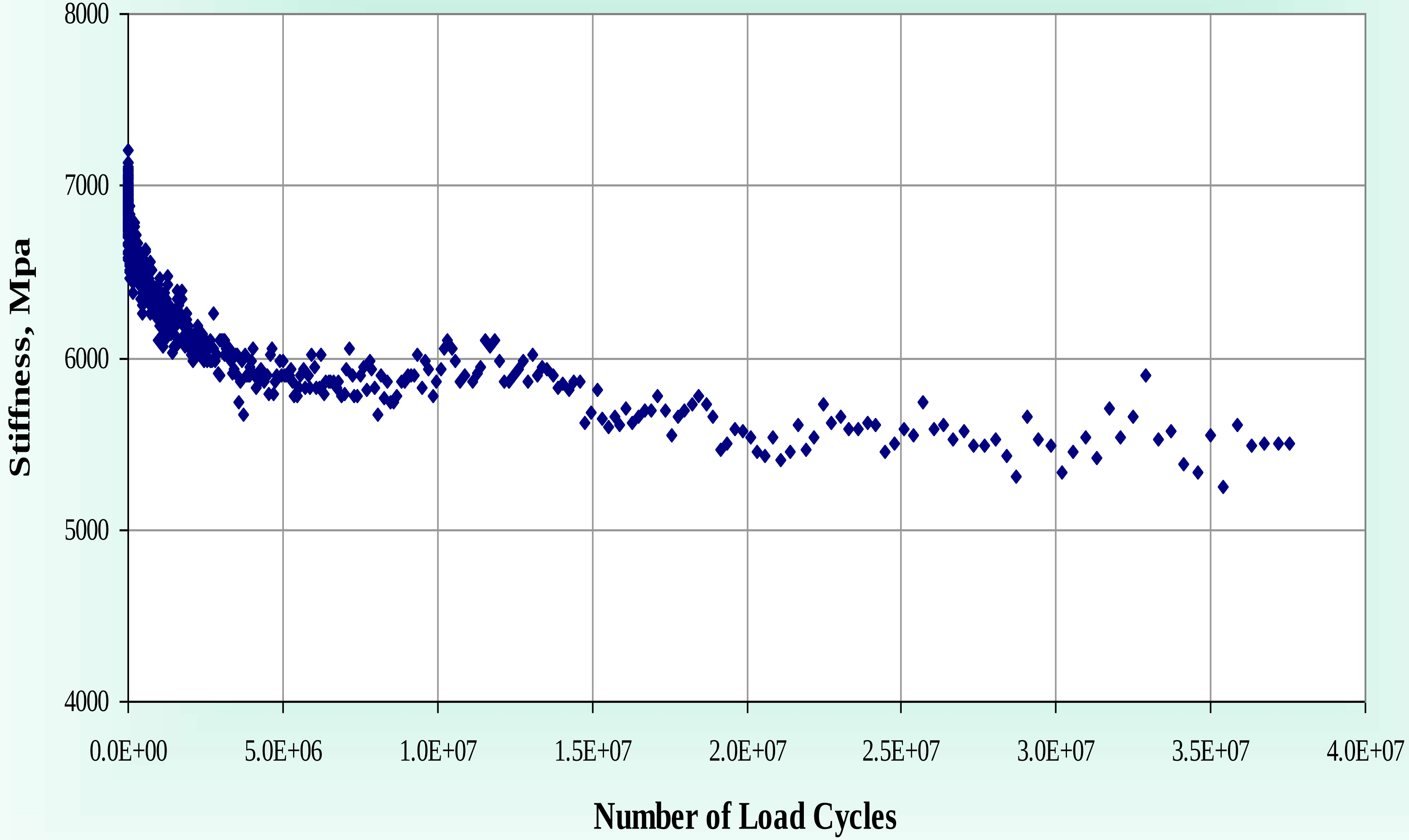
High Strain = Short Life

Low Strain = Unlimited Life

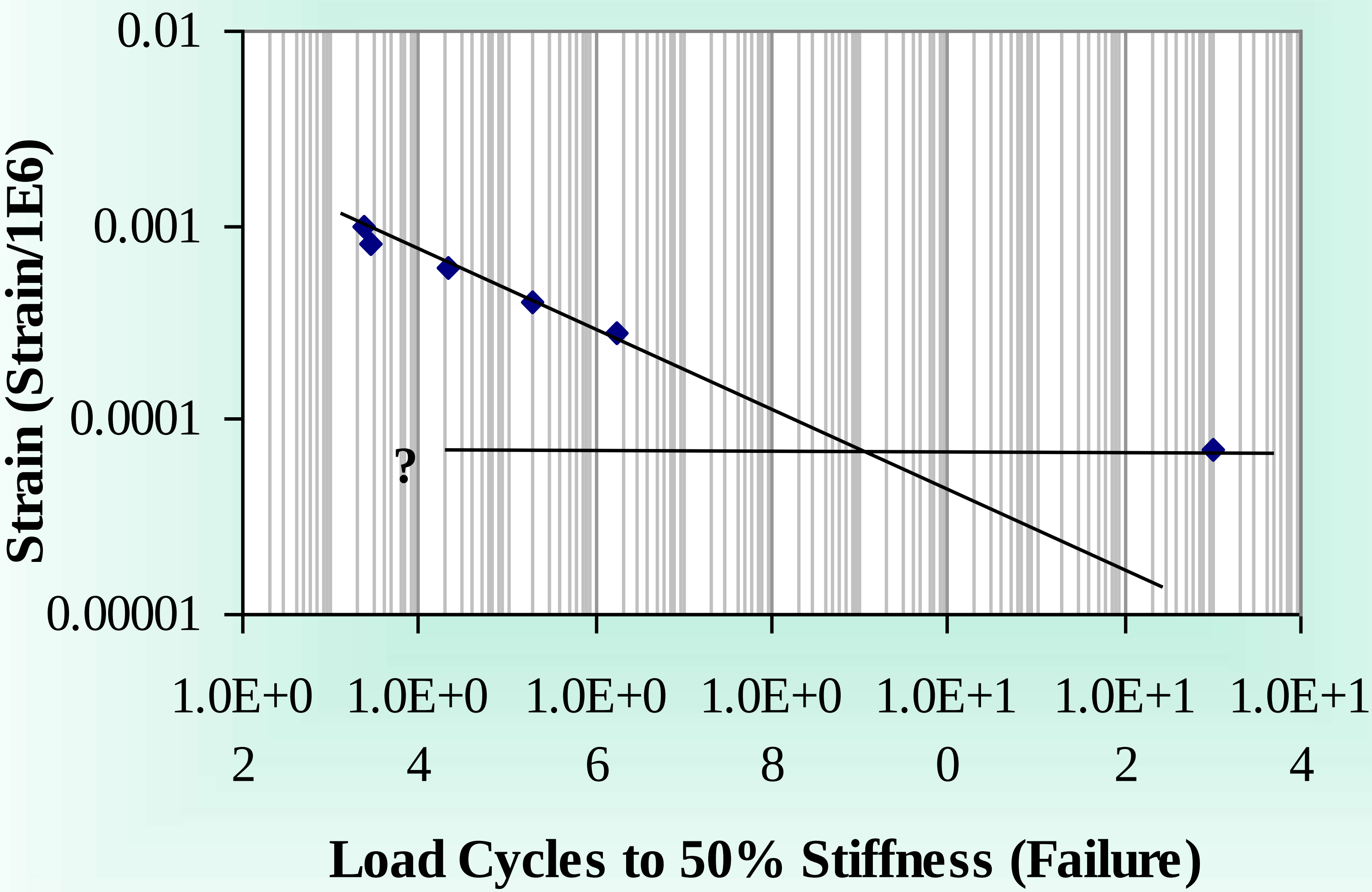


# 70 Micro Strain Test



# Traditional Fatigue Plot



# Fatigue

## (20 Year Mechanistic Thickness Design)

| TF | Microstrain | Thickness |
|---|---|---|
| 1 | 100 | 10.5 |
| 2 | 80 | 12.5 |
| 3 | 70 | 13.5 |
| 5 | 60 | 14.5 |
| 10 | 50 | 16.5 |
| 15 | 45 | 18.0 |
| 20 | 40 | 19.0 |
| 30 | 35 | 22.0 |

TF1 = 200 Trucks/Day

# Fatigue

## (20 Year Mechanistic Thickness Design)

| TF | Microstrain | Thickness |
|---|---|---|
| 1 | 100 | 10.5 |
| 2 | 80 | 12.5 |
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| 15 | 45 | 18.0 |
| 20 | 40 | 19.0 |
| 30 | 35 | 22.0 |

TF1 = 200 Trucks/Day

# Perpetual Pavement

# Advantages

- Thinner Sections
- No Full-Depth Patching
- Rapid/Inexpensive Rehab
- Permanent Elevations

# Dollars & Days

# Dollars & Days

## 30 Year Concrete

| Year | Activity | $ (millions) | Days |
|---|---|---|---|
| 0 | New Construction | 4.0 | 60 |
| 10 | | | |
| 20 | | | |
| 30 | Patch/Overlay | 0.4 | 60 |
| 40 | Patch/Overlay | 0.4 | 60 |
| 50 | Reconstruction | 4.0 | 60 |
| 60 | | | |
| 70 | | | |
| 80 | Patch/Overlay | 0.4 | 60 |
| 90 | Patch/Overlay | 0.4 | 60 |
| 100 | Reconstruction | 4.0 | 60 |
| | TOTAL | $13.6 | 420 |

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# Dollars & Days

## 30 Year Concrete

| Year | Activity | $ (millions) | Days |
|---|---|---|---|
| 0 | New Construction | 4.0 | 60 |
| 10 | | | |
| 20 | | | |
| 30 | Patch/Overlay | 0.4 | 60 |
| 40 | Patch/Overlay | 0.4 | 60 |
| 50 | Reconstruction | 4.0 | 60 |
| 60 | | | |
| 70 | | | |
| 80 | Patch/Overlay | 0.4 | 60 |
| 90 | Patch/Overlay | 0.4 | 60 |
| 100 | Reconstruction | 4.0 | 60 |
| | TOTAL | $13.6 | 420 |

## Perpetual Pavement

| Year | Activity | $ (millions) | Days |
|---|---|---|---|
| 0 | New Construction | 3.0 | 30 |
| 10 | | | |
| 20 | Mill/Overlay | 0.3 | 15 |
| 30 | | | |
| 40 | Mill/Overlay | 0.3 | 15 |
| 50 | | | |
| 60 | Mill/Overlay | 0.3 | 15 |
| 70 | | | |
| 80 | Mill/Overlay | 0.3 | 15 |
| 90 | | | |
| 100 | Mill/Overlay | 0.3 | 15 |
| | TOTAL | $4.8 | 105 |

# Rubblizing

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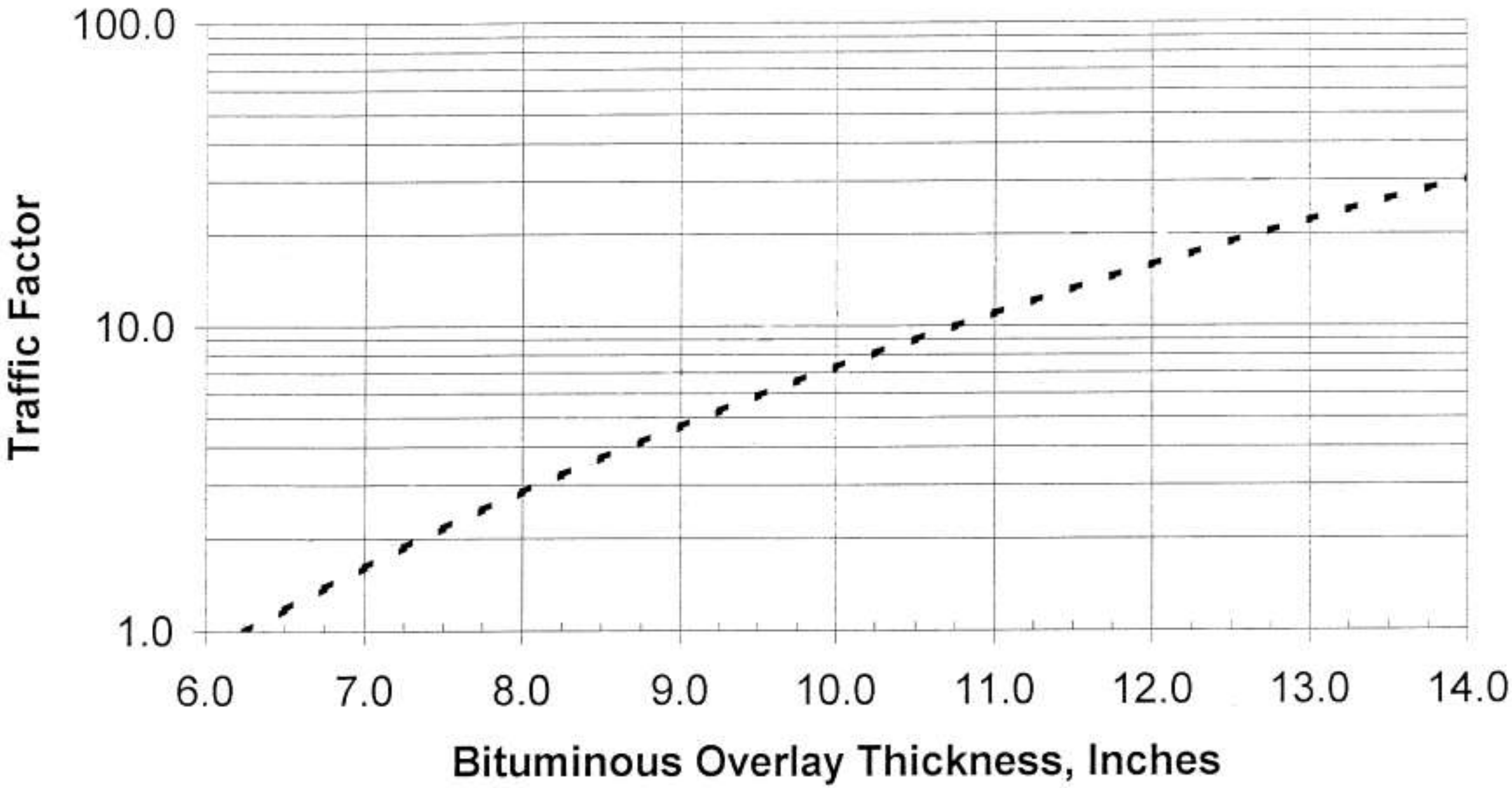
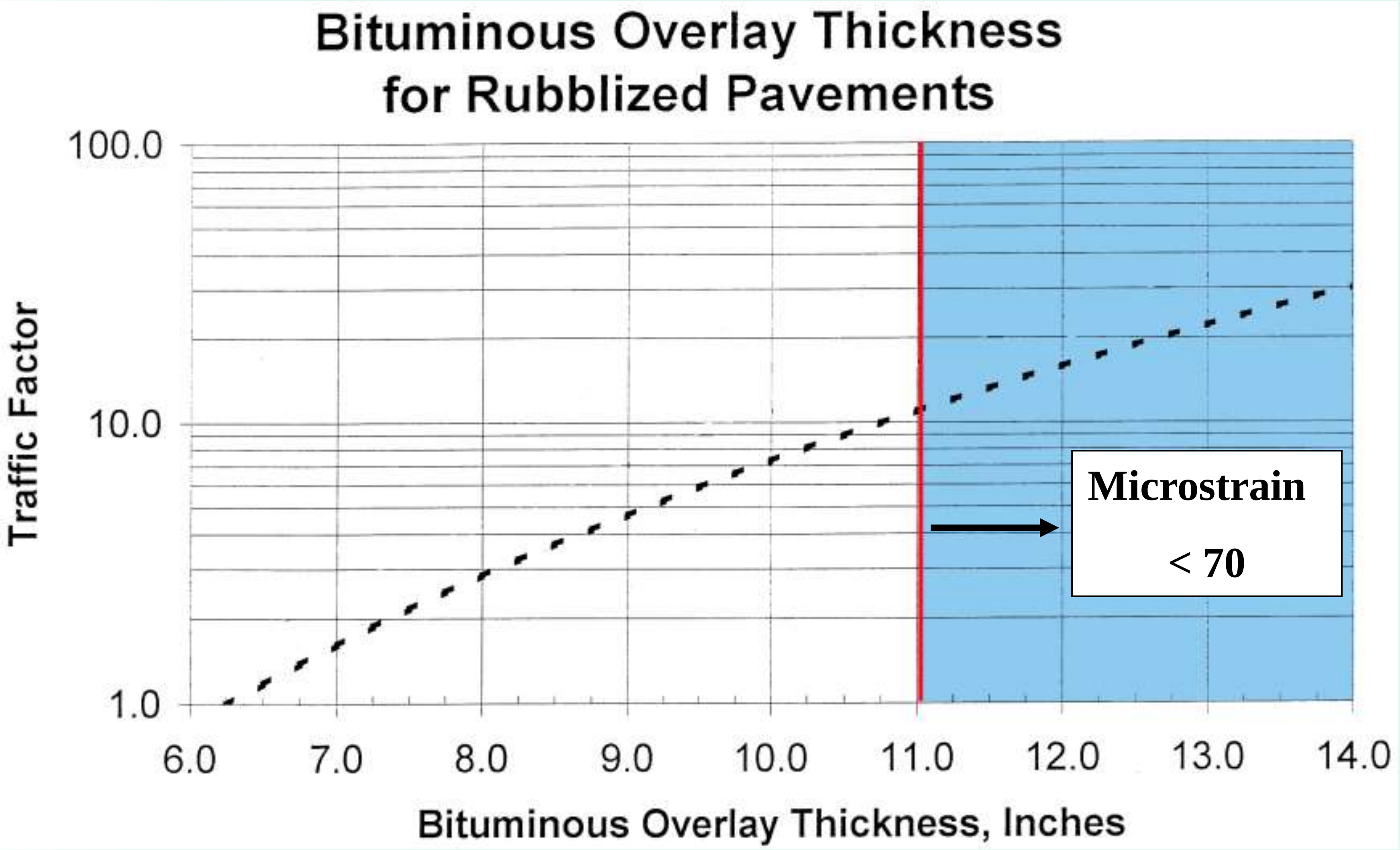
# Bituminous Overlay Thickness for Rubblized Pavements




Bituminous Overlay Thickness
for Rubblized Pavements
Traffic Factor
100.0
10.0
1.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
Bituminous Overlay Thickness, Inches
Microstrain
< 70

# Dollars & Days*

| | Rubblize | 20 Yr. PCC | 30 Yr. PCC |
|---|---|---|---|
| $ | 1.9 | 3.5 | 3.9 |
| Days | 55 | 90 | 105 |

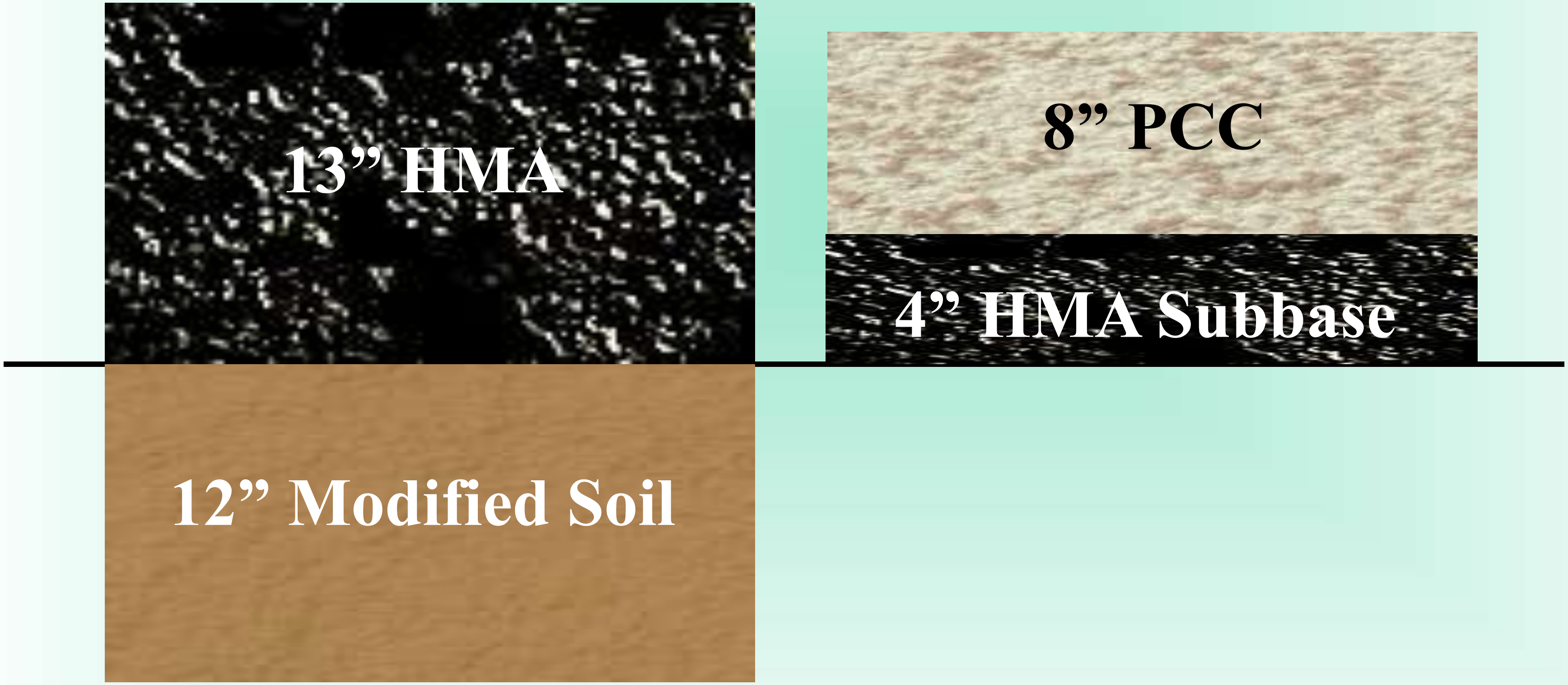
* All figures for One Mile of 4-Lane Divided Pavement

# Alternate Bids

# Stanford Avenue
## Springfield, Illinois

- 4-Lane Urban Section
- New Alignment
- Length of Project:  4673 feet
- Design Traffic:  28,000 ADT (8% trucks)
- Letting Date - 1999

# Alternate Pavements



# Engineer's Estimate (Total Project)

| WHITE | BLACK |
|---|---|
| $2,445,407 | $2,331,134 |

5% Difference

# Actual Bids (Total Project)

| | WHITE | BLACK |
|---|---|---|
| FREESEN | $2,114,322 | $1,599,532 |
| FLATT | | $1,599,992 |
| SANKEY | | $1,772,477 |
| MERRILL | | $1,779,209 |
| CALHOUN | $2,343,458 | |

## 32% Difference

# Engineer's Estimate (Pavement Section Only)

| WHITE | BLACK |
|---|---|
| $1,297,013 | $1,127,797 |

15% Difference

# Actual Bids
# (Pavement Section Only)

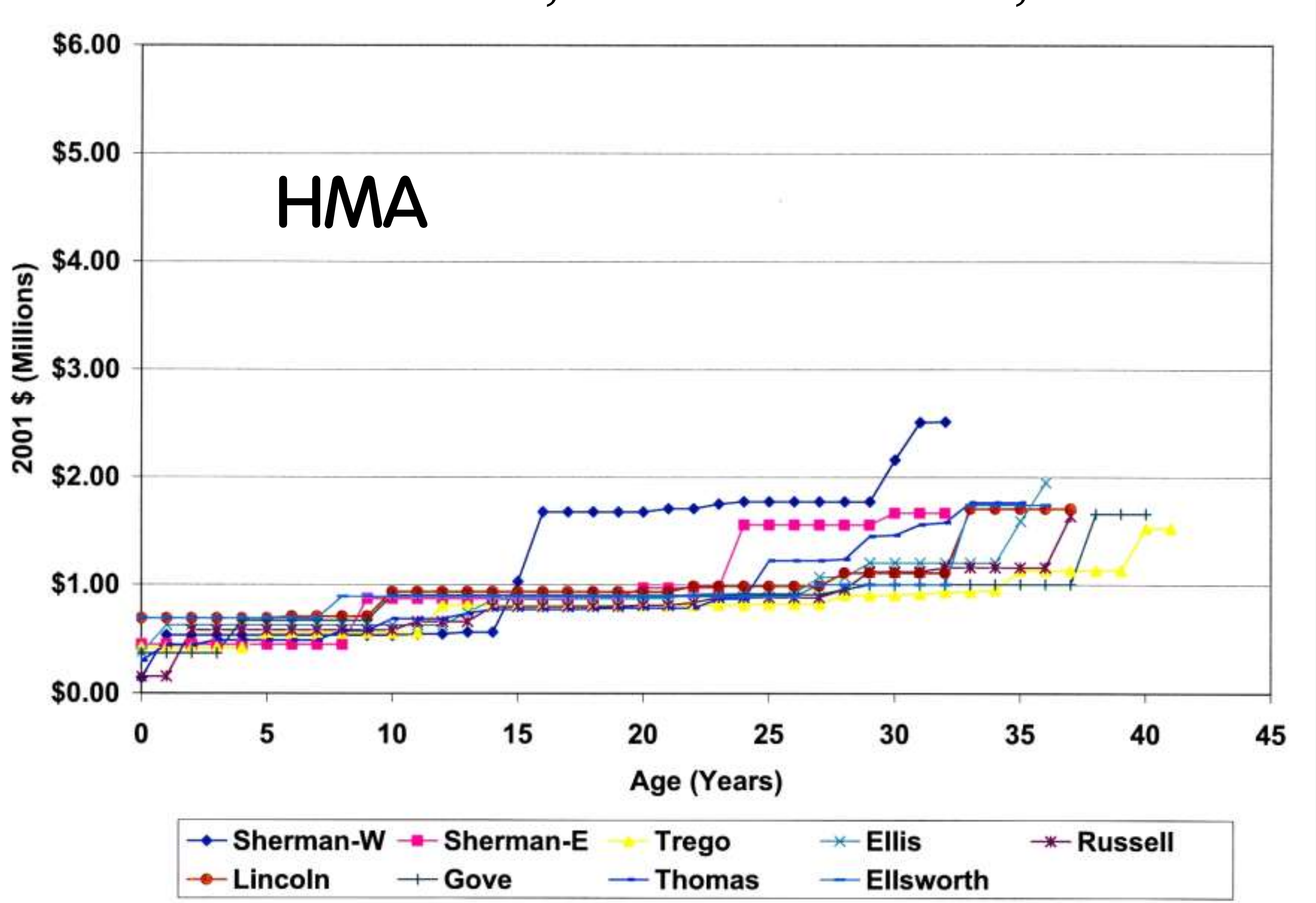
| WHITE | BLACK |
|---|---|
| $1,180,232 | $ 660,754 |

79% Difference

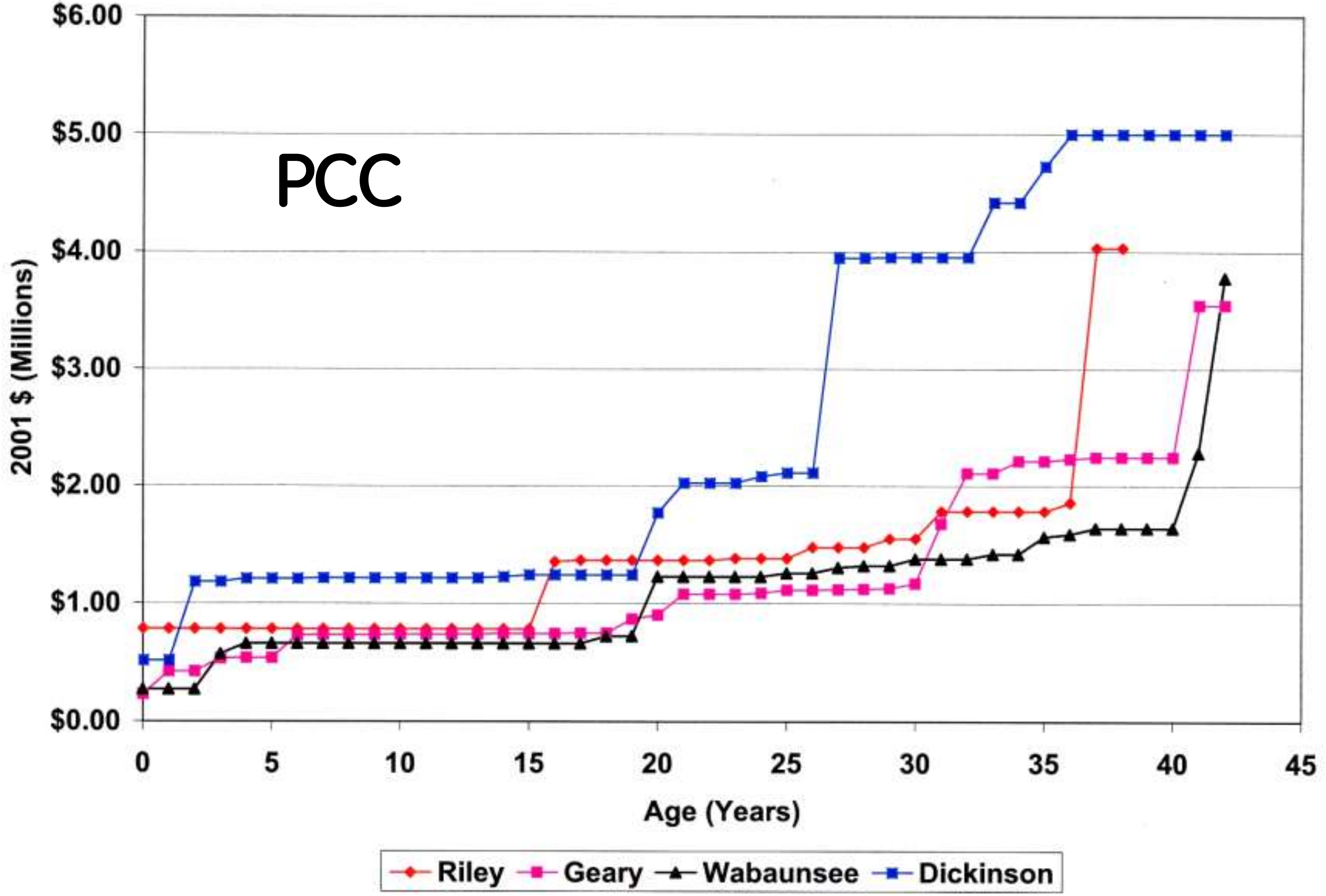
# Kansas Interstate Study

| TYPE | MILES |
|---|---|
| PCC | 184 |
| HMA | 244 |
| TOTAL | 428 |

# Total Expenditures Per 4-Lane Mile Per Year, HMA Pavements, I-70



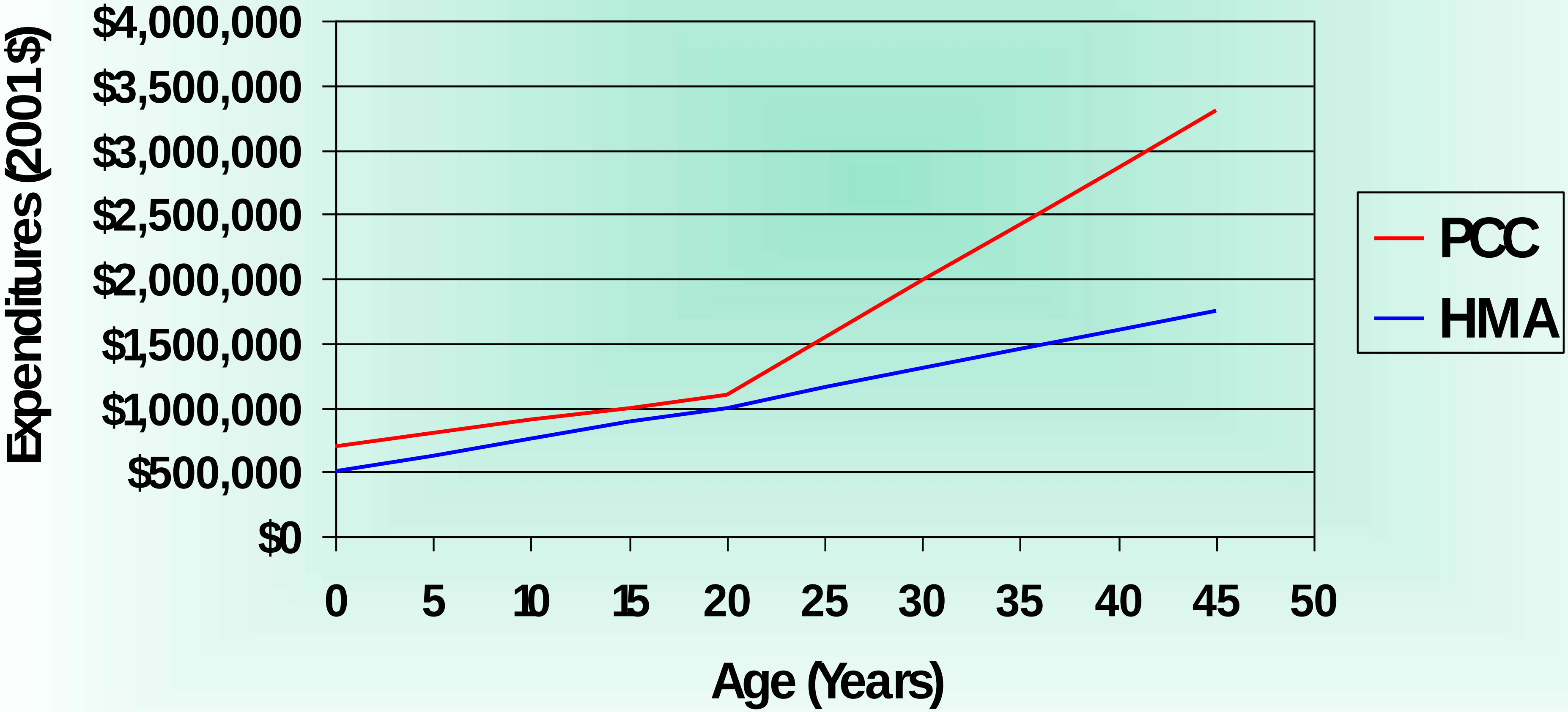
# Total Expenditures Per 4-Lane Mile Per Year, PCC Pavements, I-70



# Expenditures per 4-Lane Mile, 2001 $

| Pavement Type | Original Construction | Average Cost Per Year 0-20 Years | Average Cost Per Year >20 Years |
|---|---|---|---|
| PCC | $823,872 | $19,578 | $94,632 |
| HMA | $613,388 | $23,358 | $33,794 |

# Average Expenditures per 4-Lane Mile for Kansas Interstate Pavements



# Pavement Selection

| State | % of Pavements Constructed with Asphalt | State | % of Pavements Constructed with Asphalt |
|---|---|---|---|
| 1. Alaska | 100% | 26. Tennessee | 72% |
| 2. Vermont | 99% | 27. Texas | 67% |
| 3. Maine | 98% | 28. Arkansas | 64% |
| 4. Montana | 95% | 29. South Carolina | 63% |
| 5. New Hampshire | 94% | 30. California | 59% |
| 6. New Mexico | 93% | 31. Oklahoma | 55% |
| 7. Arizona | 93% | 32. Kentucky | 52% |
| 8. Florida | 92% | 33. West Virginia | 52% |
| 9. Hawaii | 92% | 34. Mississippi | 50% |
| 10. Idaho | 92% | 35. South Dakota | 49% |
| 11. Nevada | 91% | 36. Nebraska | 42% |
| 12. Utah | 91% | 37. New Jersey | 40% |
| 13. Maryland | 91% | 38. Minnesota | 37% |
| 14. Alabama | 90% | 39. Connecticut | 31% |
| 15. Oregon | 90% | 40. Ohio | 29% |
| 16. Wyoming | 89% | 41. Wisconsin | 28% |
| 17. Massachusetts | 88% | 42. Louisiana | 25% |
| 18. Rhode Island | 85% | 43. New York | 24% |
| 19. Washington | 85% | 44. Pennsylvania | 18% |
| 20. Georgia | 84% | 45. Michigan | 18% |
| 21. Colorado | 84% | 46. Indiana | 17% |
| 22. North Carolina | 81% | 47. Missouri | 12% |
| 23. Kansas | 79% | 48. Iowa | 9% |
| 24. Virginia | 78% | *49. Illinois* **** | *3%* |
| 25. North Dakota | 74% | 50. Delaware | 1% |

*Source: The Federal Highway Administration; Highway Statistics 1997; Table HM-31; Page V-18*

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| 1. Alaska | 100% | 26. Tennessee | 72% |
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| 3. Maine | 98% | 28. Arkansas | 64% |
| 4. Montana | 95% | 29. South Carolina | 63% |
| 5. New Hampshire | 94% | 30. California | 59% |
| 6. New Mexico | 93% | 31. Oklahoma | 55% |
| 7. Arizona | 93% | 32. Kentucky | 52% |
| 8. Florida | 92% | 33. West Virginia | 52% |
| 9. Hawaii | 92% | 34. Mississippi | 50% |
| 10. Idaho | 92% | 35. South Dakota | 49% |
| 11. Nevada | 91% | 36. Nebraska | 42% |
| 12. Utah | 91% | 37. New Jersey | 40% |
| 13. Maryland | 91% | 38. Minnesota | 37% |
| 14. Alabama | 90% | 39. Connecticut | 31% |
| 15. Oregon | 90% | 40. Ohio | 29% |
| 16. Wyoming | 89% | 41. Wisconsin | 28% |
| 17. Massachusetts | 88% | 42. Louisiana | 25% |
| 18. Rhode Island | 85% | 43. New York | 24% |
| 19. Washington | 85% | 44. Pennsylvania | 18% |
| 20. Georgia | 84% | 45. Michigan | 18% |
| 21. Colorado | 84% | 46. Indiana | 17% |
| 22. North Carolina | 81% | 47. Missouri | 12% |
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| 25. North Dakota | 74% | 50. Delaware | 1% |

*Source: The Federal Highway Administration; Highway Statistics 1997; Table HM-31; Page V-18*

# IDOT'S 40 Year Analysis

- New Construction
- 0-20 Year Maintenance
- 20 Year Rehab
- 20-40 Year Maintenance

**NO USER DELAY COSTS!**

# A Modern Life Cycle Cost Analysis

- Initial Costs
- Out Year Costs
- User Delay Costs

# Good Government Suggestions

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- Don’t reconstruct if you can rubblize

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- Don’t reconstruct if you can rubblize
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- Recognize the absence of thermal cracks
- Recognize the lack of full-depth patching

# Good Government Suggestions

- Don’t reconstruct if you can rubblize
- Incorporate the limiting strain criteria
- Recognize SuperPave rut resistance
- Recognize the absence of thermal cracks
- Recognize the lack of full-depth patching
- Recognize the cost of user delays

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**Marvin Traylor**