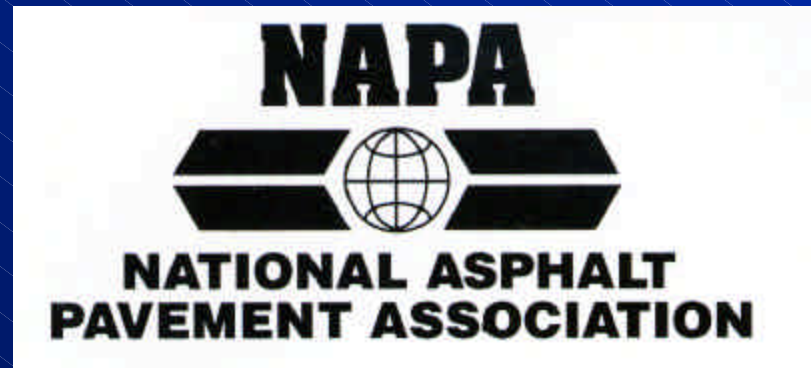


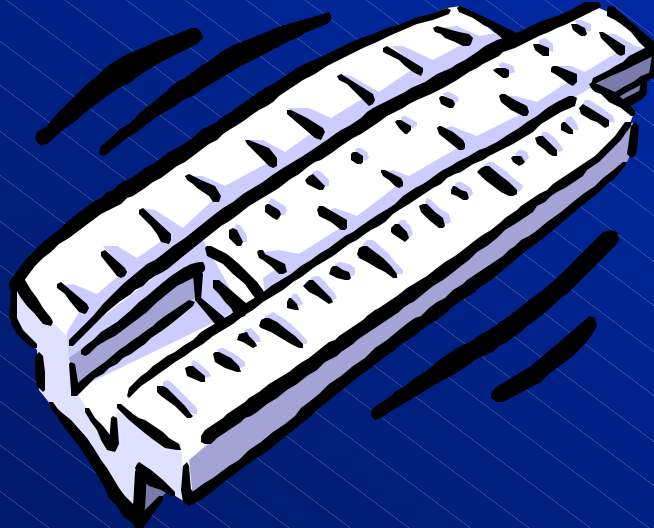
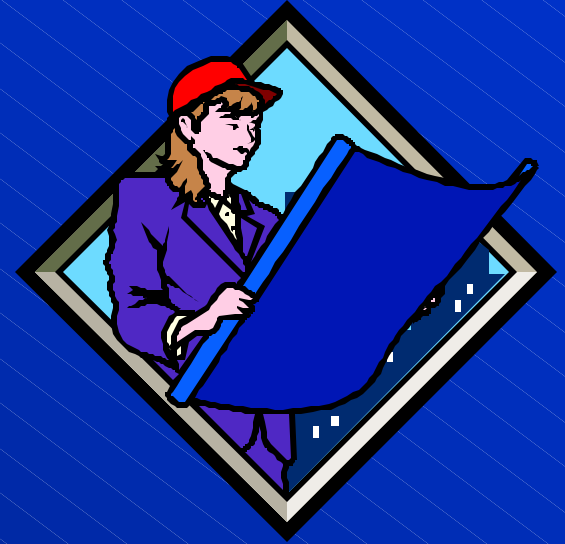
# Roofing Shingles in Hot Mix Asphalt

Second Asphalt Shingles  
Recycling Forum



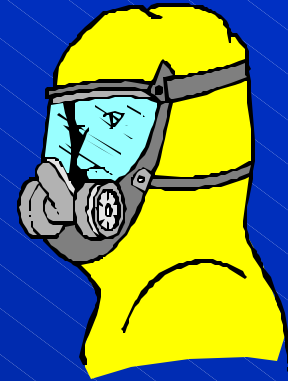
# 3E's for Waste Utilization

- Engineering
  - Handling and Processing
  - Consistency and Quality
  - Performance



# 3E's for Waste Utilization

- Environmental
  - Worker Safety and Health
  - Future Reuse
  - Impact



# 3E's for Waste Utilization

- Economics
  - Equipment
  - Recyclability
  - Incentives for Use
  - Cost of Disposal



# Types of Waste Tried in HMA

- RAP - Great success story
- Fly ash
- Incinerator ash
- Glass
- Carpet fibers
- etc.
- Roofing Shingles!



# Description

- Type of Waste

- Re-roofing
- Manufacturing
- Waste

- Composition

- Polymer Modified Asphalt: 25 - 35%
- Ceramic Granular Material: 60 - 70%
- Felt or Fiber-Glass Fibers: 5 -15%



# Mn/DOT Research at University of Minnesota

- Newcomb, Stroup-Gardiner, Weikle, and Drescher - MN/RC-93/09
- Supported by Mn/DOT and Office of Waste Management
- Study Period: 1991 - 1993
  - Pre-Superpave



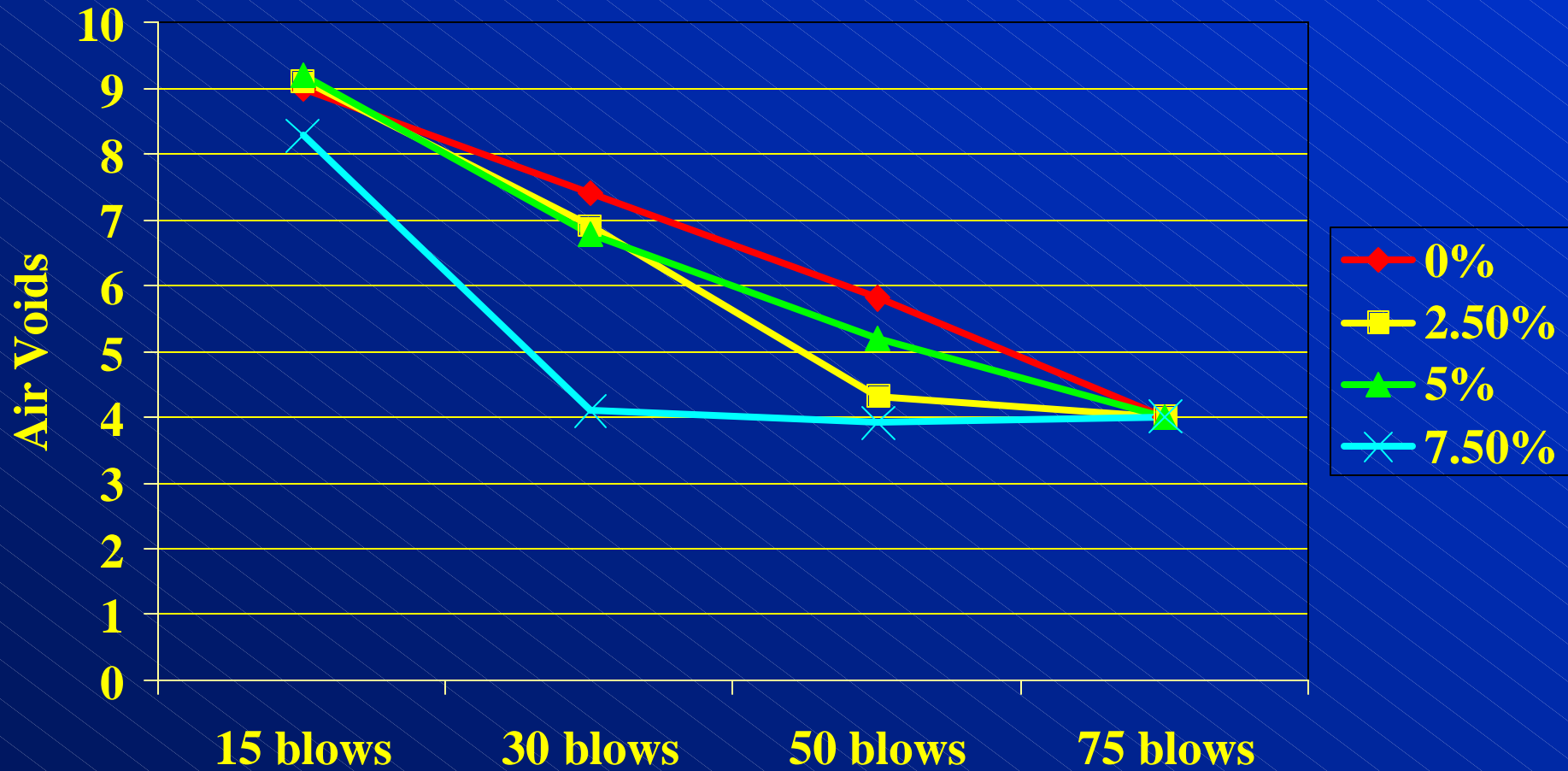
# Scope

- Types of Shingles
  - Felt-backed
  - Fiberglass-backed
  - Reroof tear-off
- Types of Mixtures
  - Dense-graded
  - SMA
- Virgin AC
  - 85/100 pen (~PG 58-28)
  - 120/150 pen (~PG 52-34)



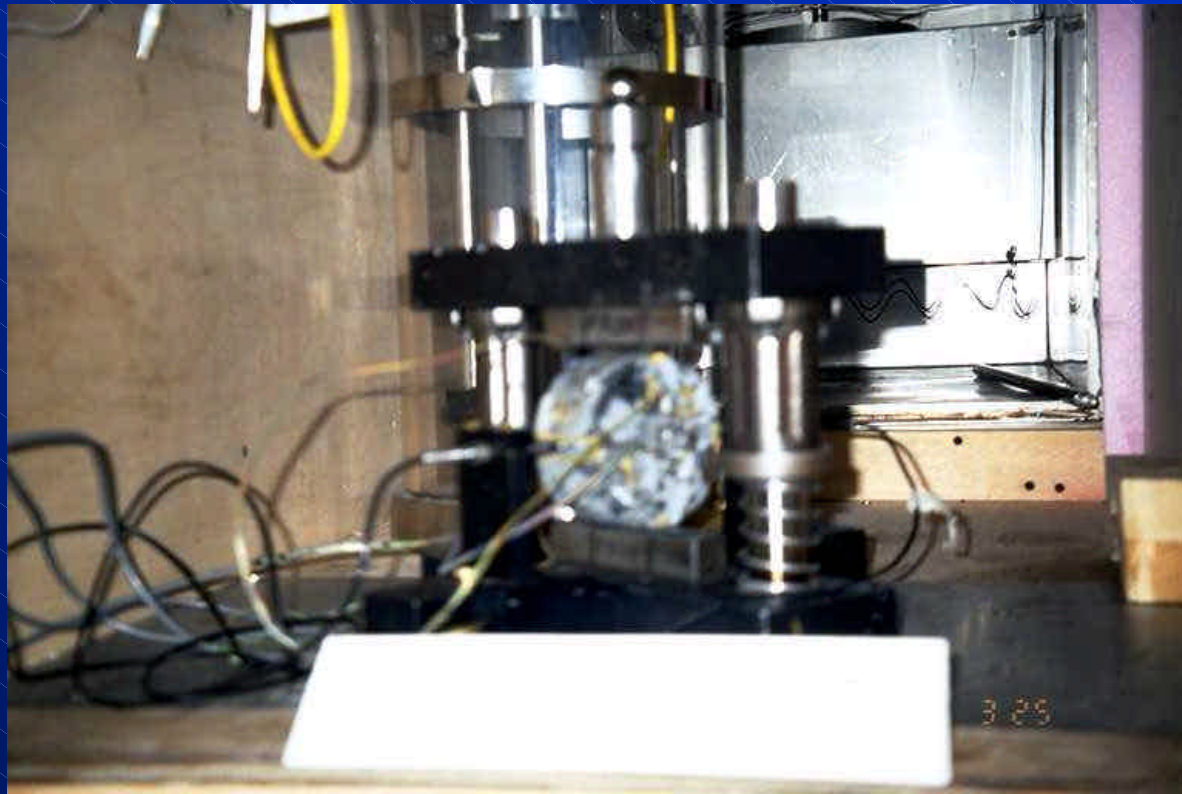


# Influence of Roofing Shingles on Compaction



# Resilient Modulus Testing

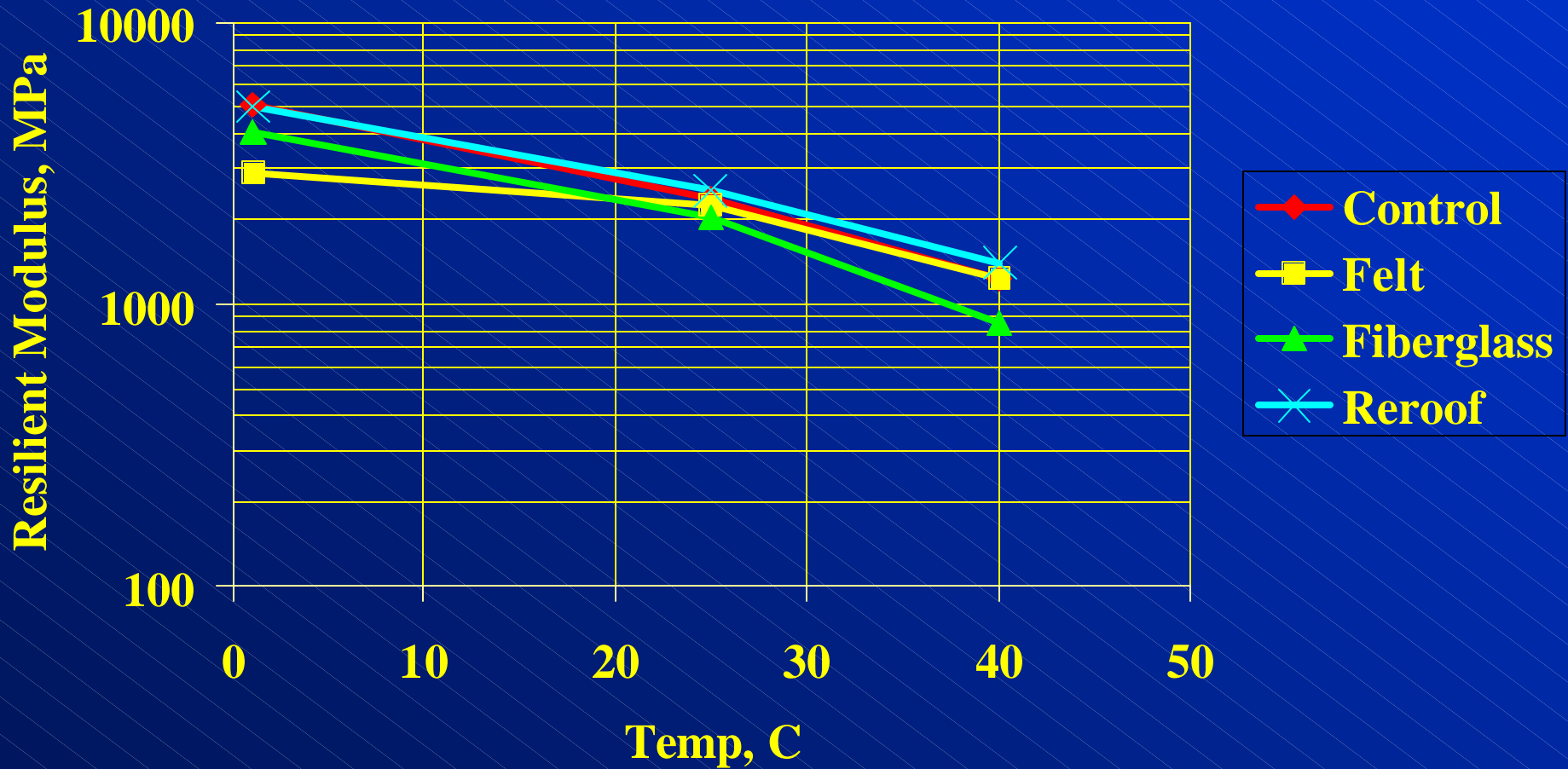
- Diametral
- 1, 25, and 40°C



# Resilient Modulus - Temp

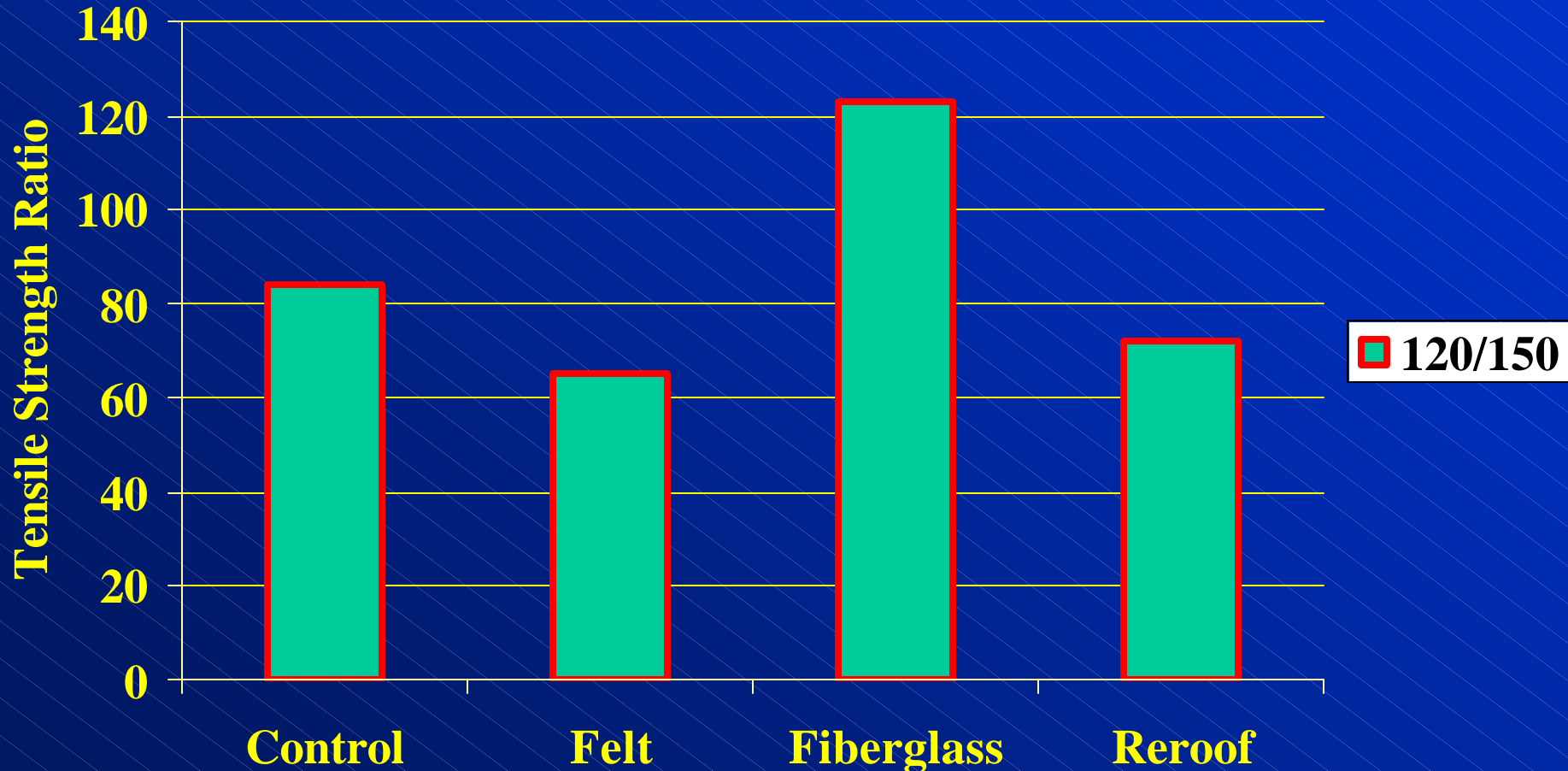
5% Shingles

120/150 Asphalt



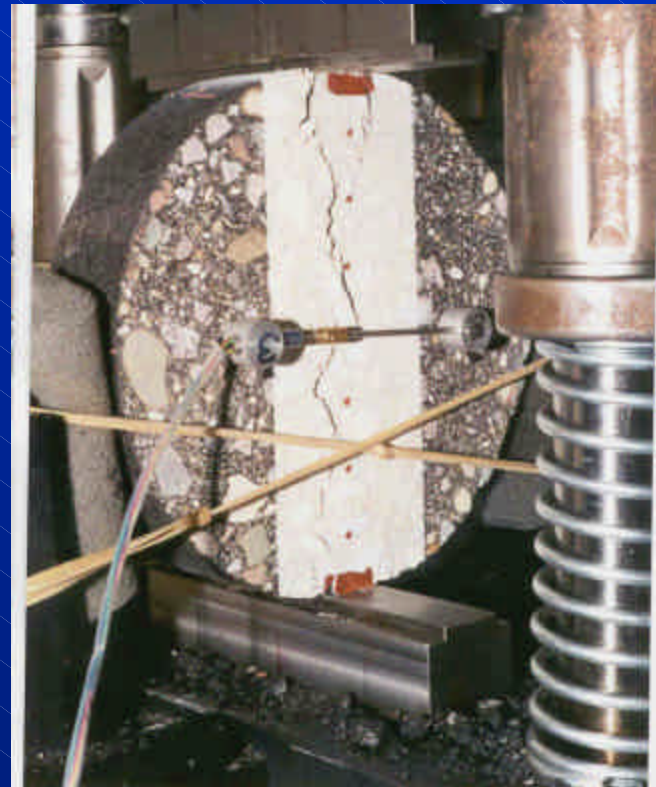
# Moisture Susceptibility

5% Shingles



# Low Temp Tensile Strength

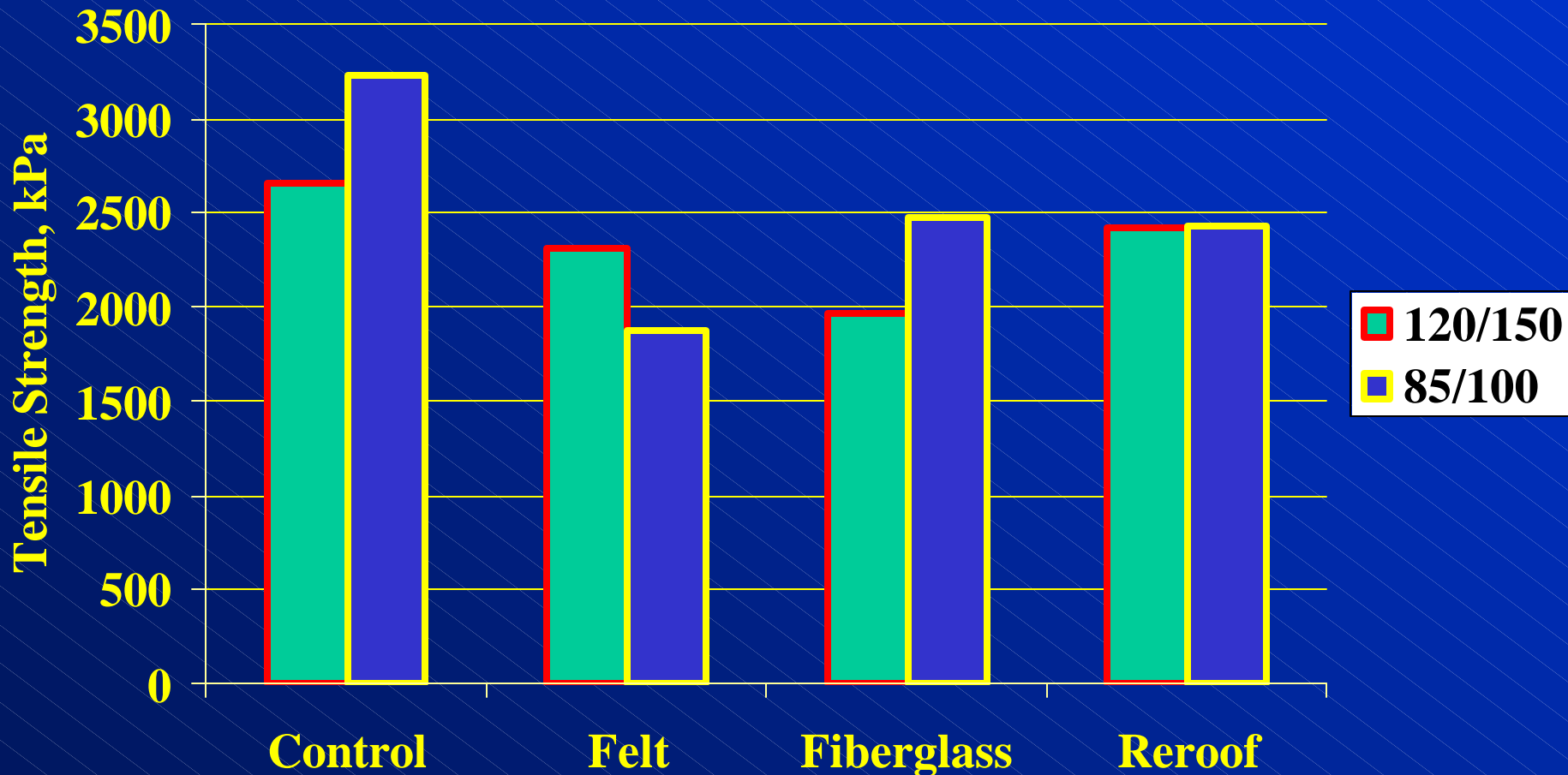
- Diametral
- Stress vs. Strain
- $-18^{\circ}\text{C}$ , 0.25 mm/min



# Low Temp Tensile Strength

5% Shingles

Test Temp: -18°C

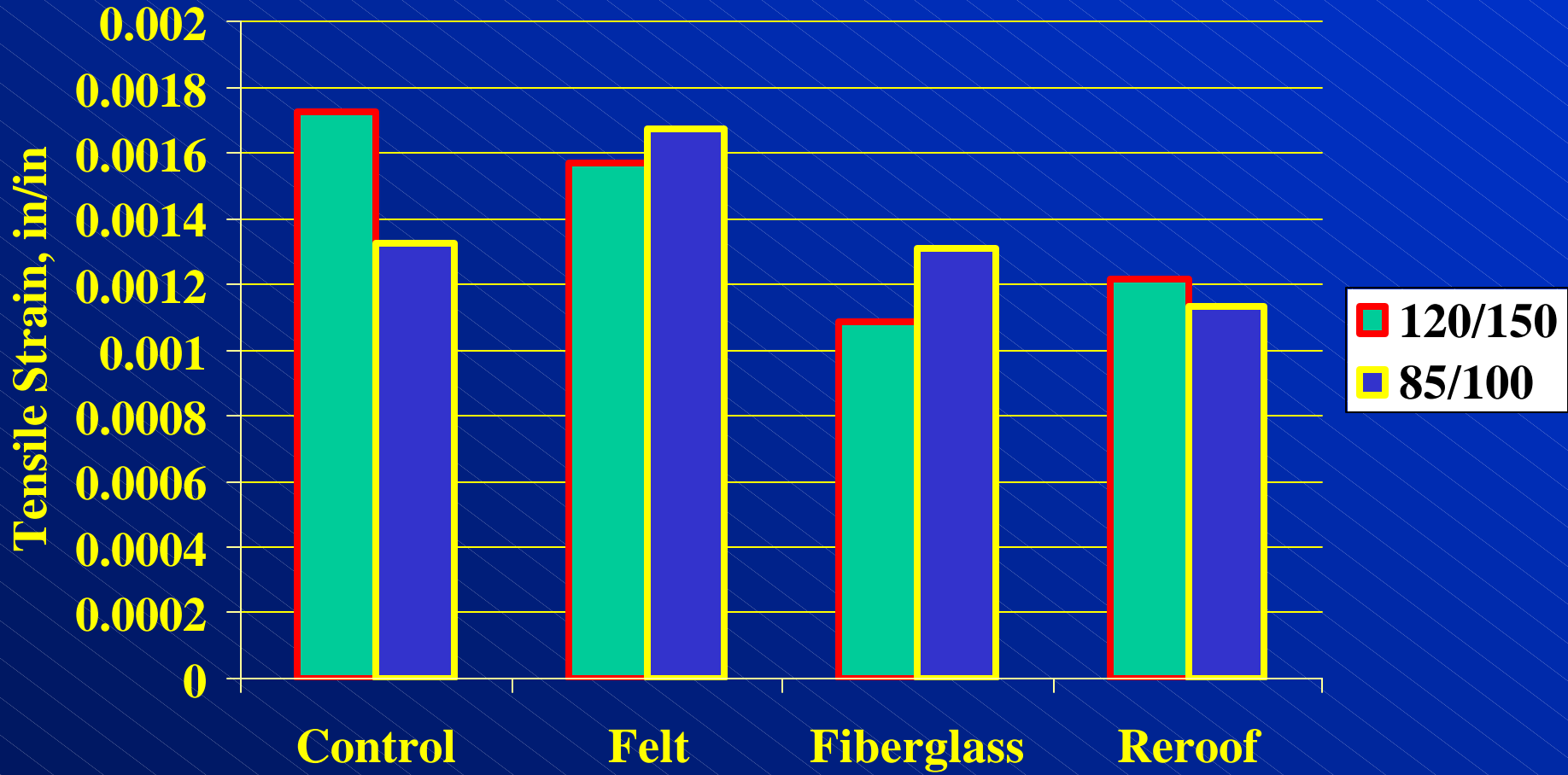




# Tensile Strain at Peak Stress

5% Shingles

Test Temp: -18°C



# High Temp Deformation

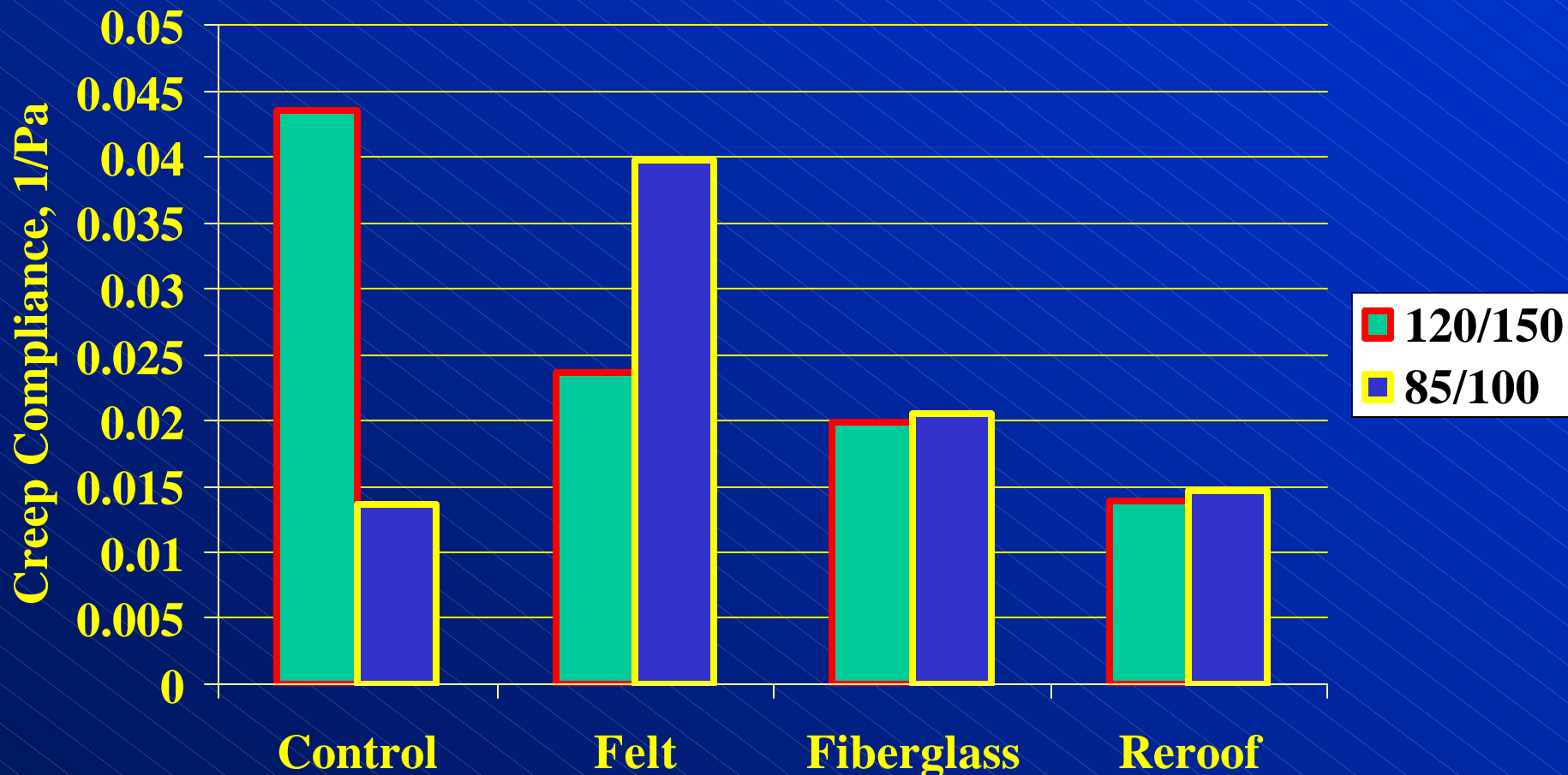
- Uniaxial Compression
- Marshall Samples Tacked Together
- 100 kPa for 30 min.



# Creep Compliance

5% Shingles

Test Temp: 40°C



# Field Trial

- Wright County, MN
- Roofing Waste
  - Source: Certainteed
  - Processor: Oman Bros.
  - ~95% Felt
  - ~5% Fiberglass
- Mix Design by Braun Intertec
  - 6% AC by 50-blow Marshall

# Field Trial Results

- Results similar to those for felt-backed in lab study.
- Cold temp  $M_R$  lower, and warm temp  $M_R$  about the same.
- Moisture sensitivity results inconclusive.
- Field material was more brittle at low temp than lab material.

# Conclusions

- Reduction in optimum asphalt content.
- Increased compactibility.
- Reduced temp susceptibility.
- No effect on moisture sensitivity.
- Cracking at cold temp may be reduced.
- Perm deformation at high temp may be improved.



# Recommendations

- Should allow permissive spec - 5% for manufactured shingles.
- No facilities at that time for reroof processing.
- Performance needs to be monitored.
- Should try gap-graded mix.
- Reduce moisture in production.

