Geosynthetics
Subgrade Stabilization and Base Reinforcement

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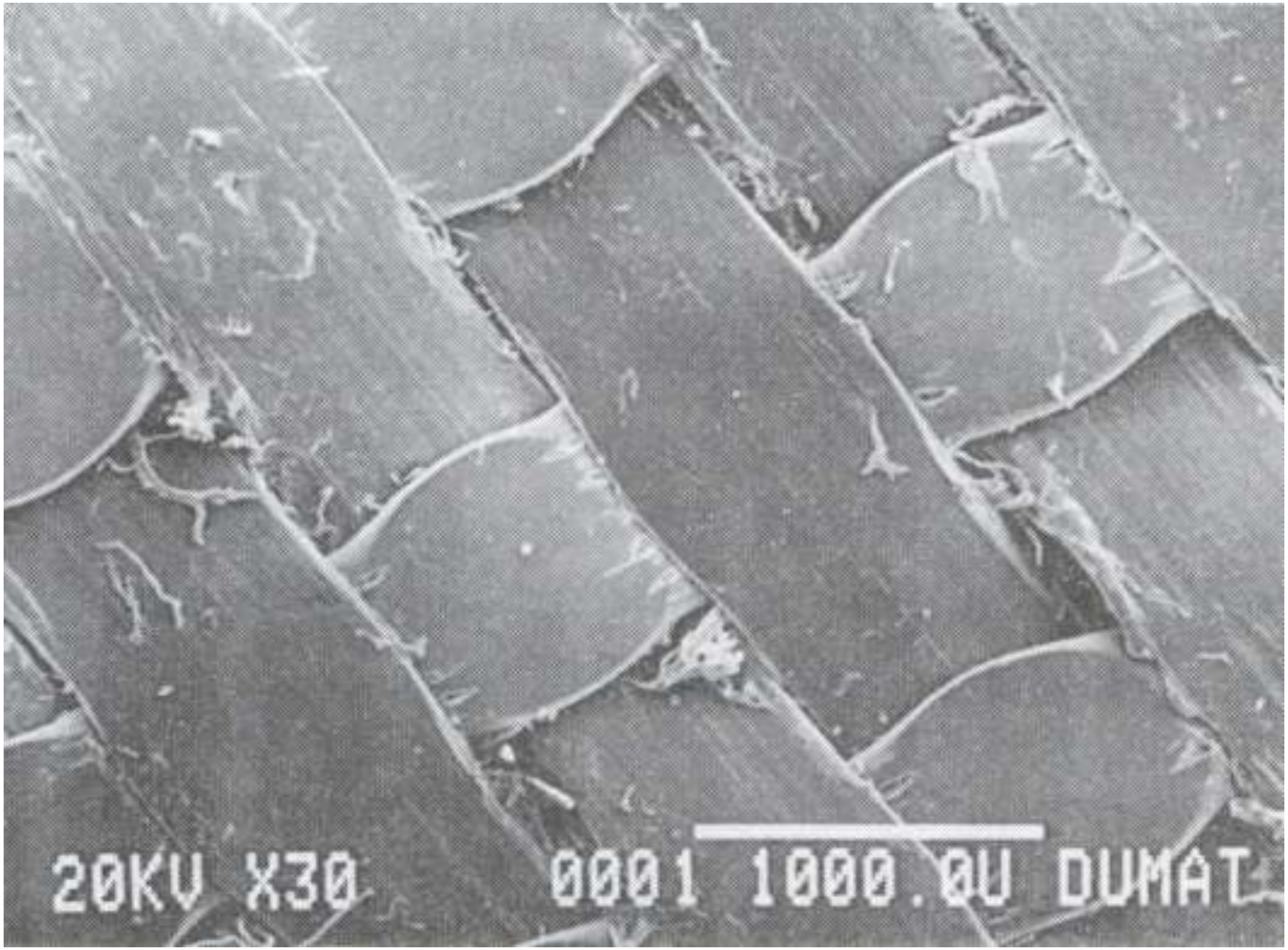
Geosynthetic Types

- Geotextile
- Geogrid
- Geocomposite
- Geonet
- Geomembrane

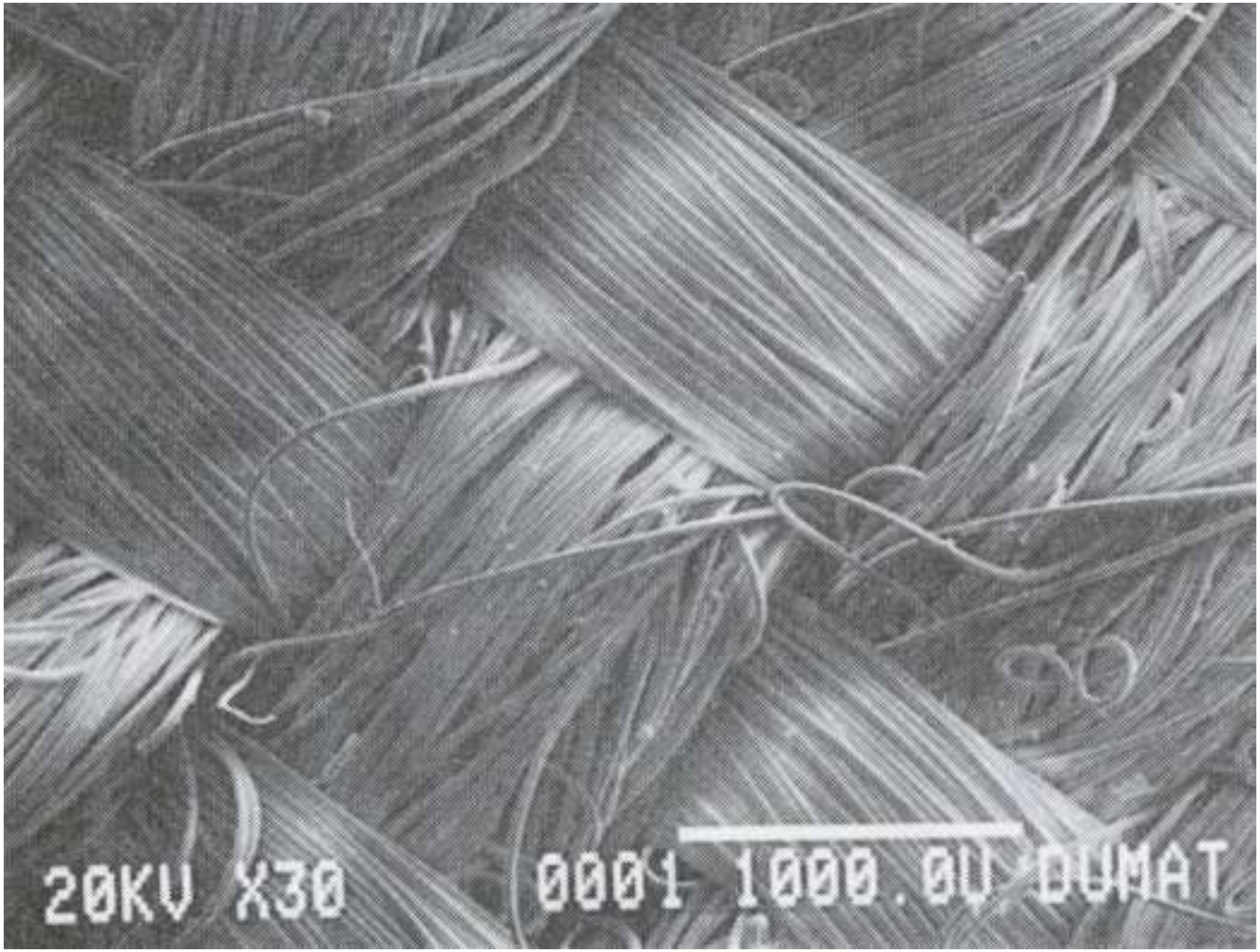
Geotextiles

- ASTM D4439: "*A permeable geosynthetic comprised solely of textiles.*"
- Woven geotextile
  - monofilament
  - multifilament
  - slit film tape
- Non-woven geotextile
  - needle punched
  - heat bonded

Geotextile: Woven Monofilament



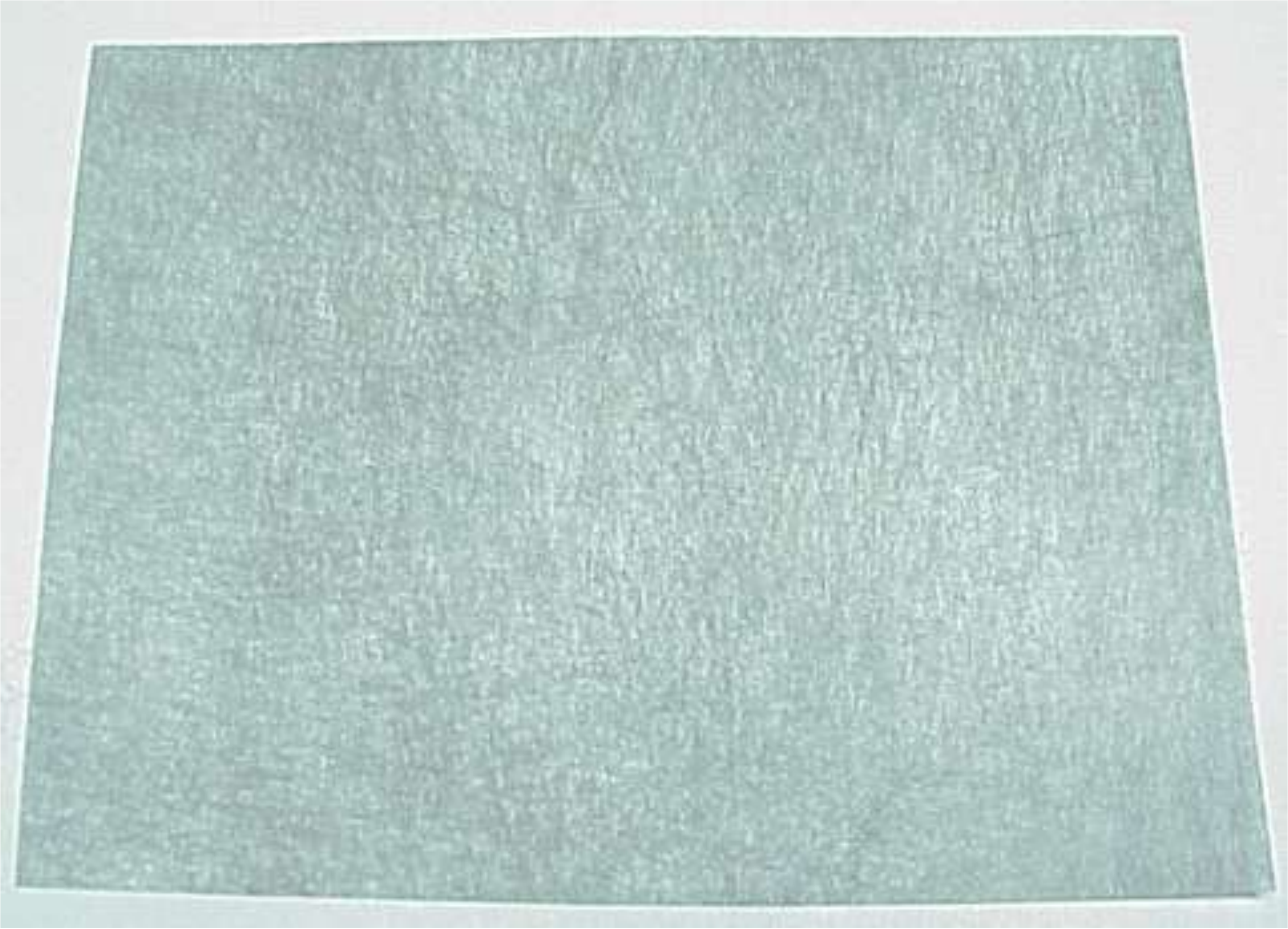
Geotextile: Woven Multifilament



Geotextile: Woven Slit Film Tape

Geotextile: Nonwoven Needle Punched

Geotextile: Nonwoven Heat Bonded

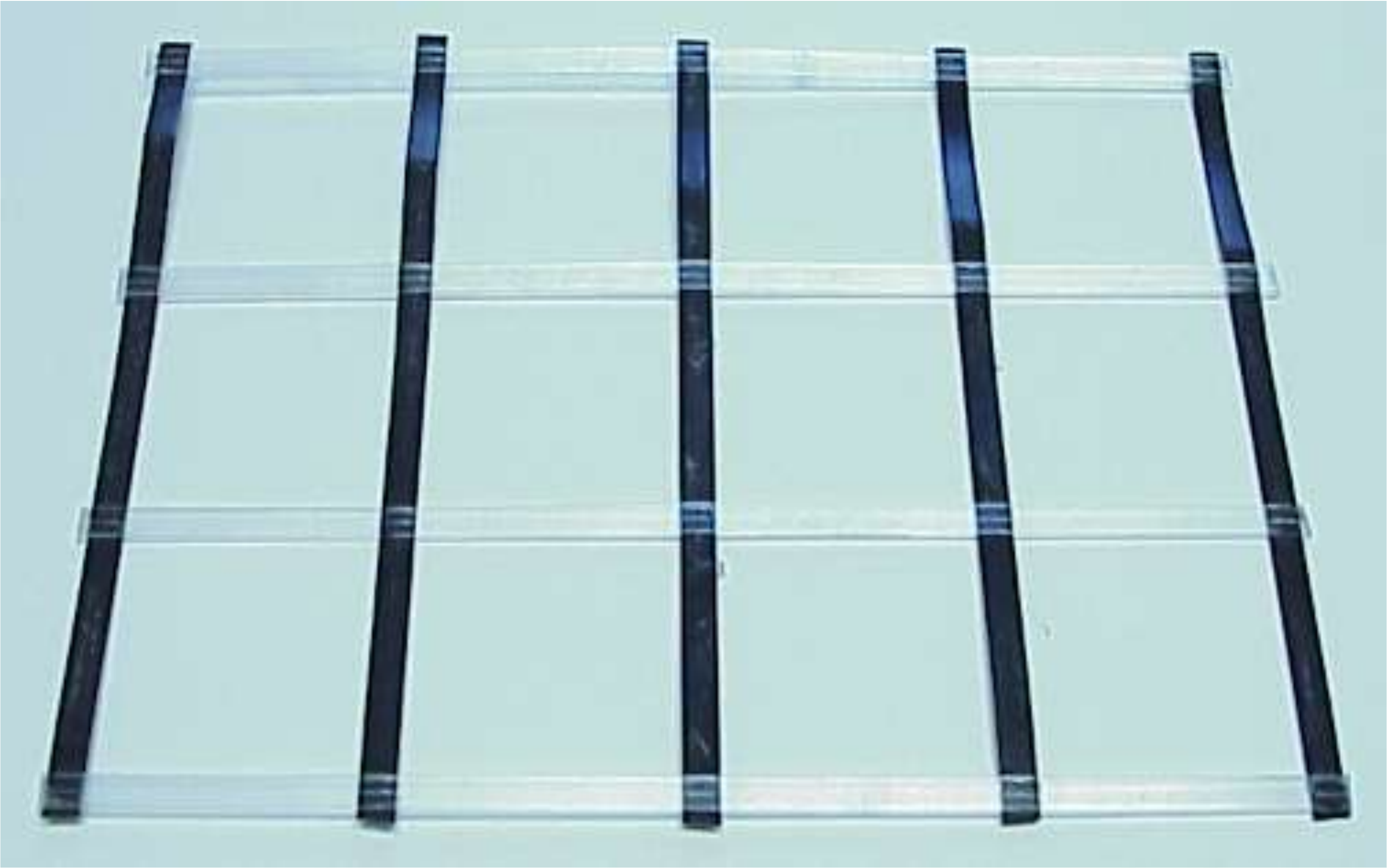


Geogrid

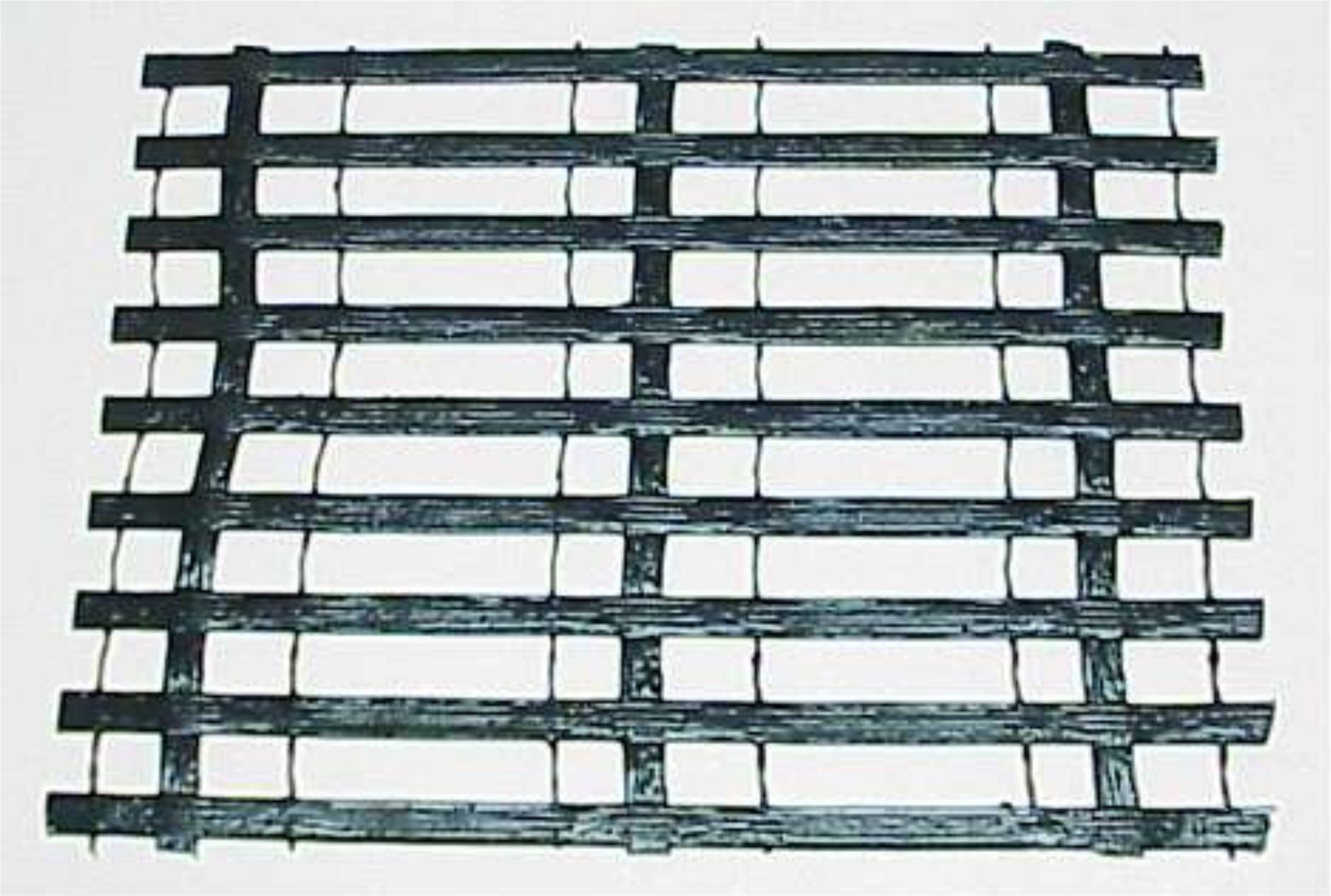
- ASTM D4439: "*A geosynthetic formed by a regular network of integrally connected elements with apertures greater than ¼ in. to allow interlocking with surrounding soil, rock, earth, and other materials to function primarily as reinforcement.*"
- Categories based on junction type:
  - Extruded geogrid
  - Bonded geogrid
  - Woven geogrid

Geogrid: Biaxial Extruded or Integrally-Formed

Geogrid: Laser Welded



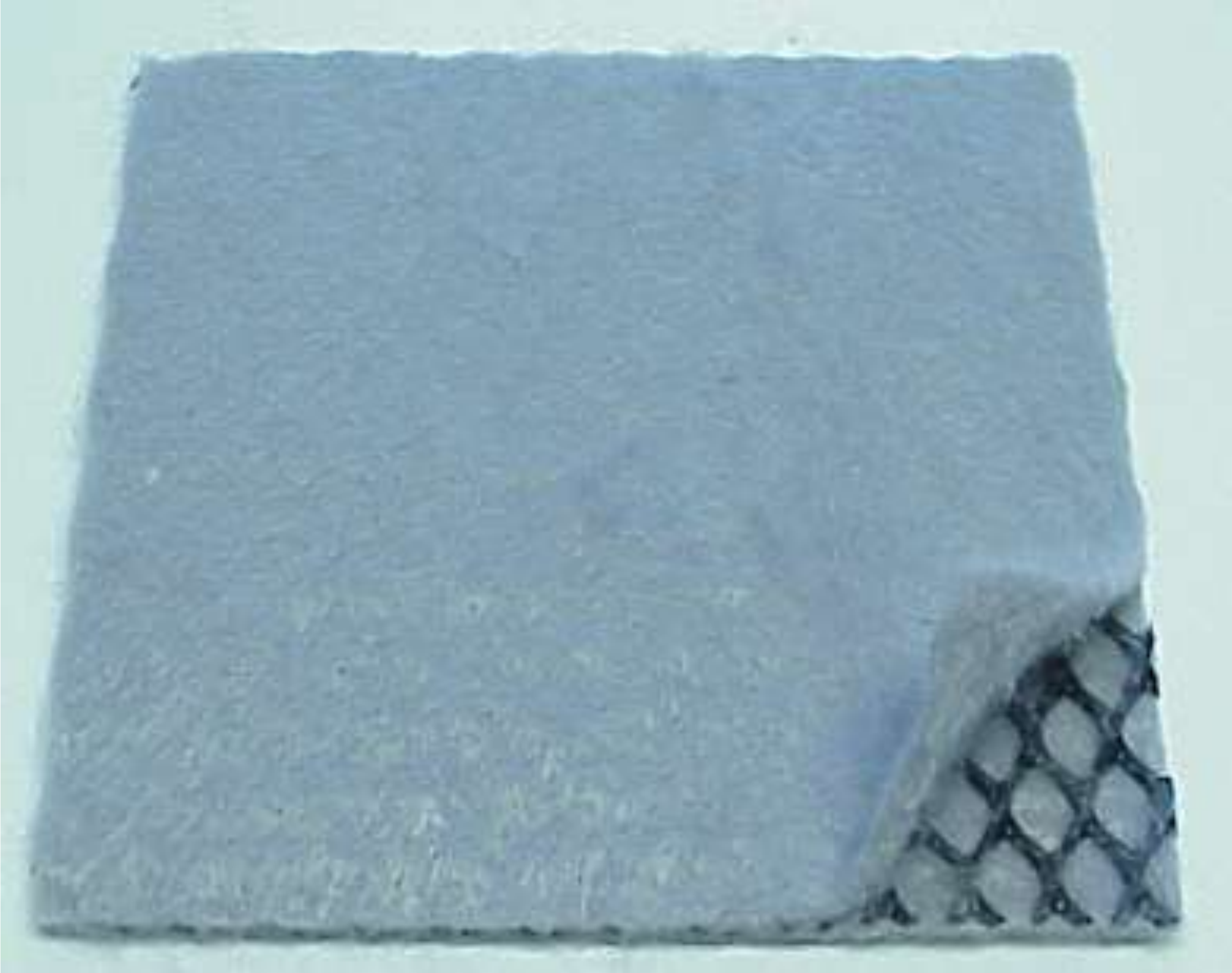
Geogrid: Woven



Geocomposite

- <u>ASTM D4439</u>: "*A product composed of two or more materials, at least one of which is a geosynthetic.*"
- Common combinations:
  - Geotextile and geonet
  - Geotextile and geogrid
  - Geotextile and drainage pipes
  - Geonet and erosion mat

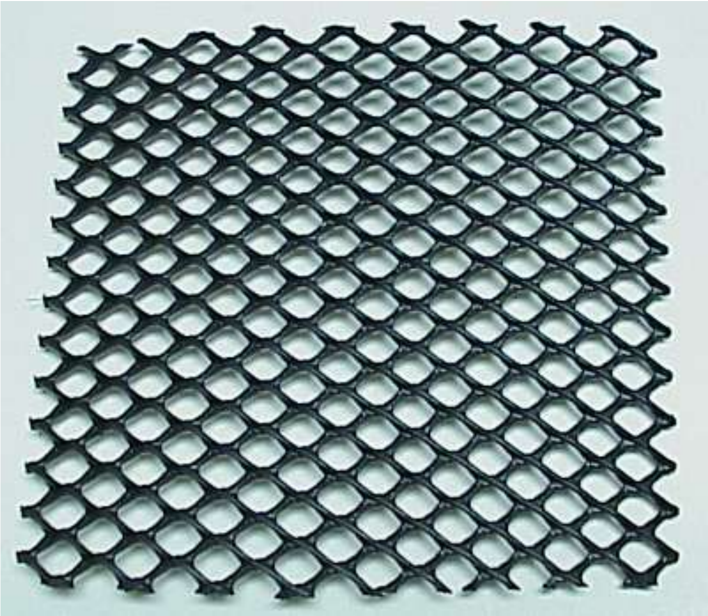
Geocomposite: Geotextile/Geonet



Geocomposite: Geotextile/Pipe

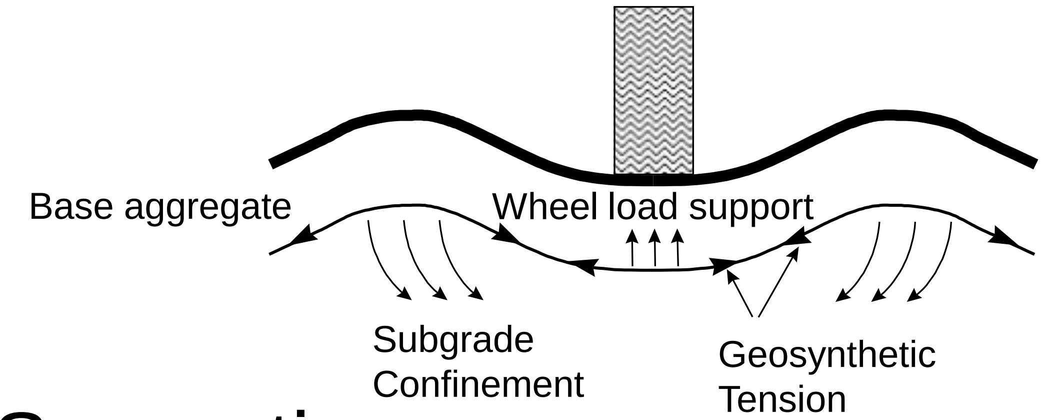
Geonet

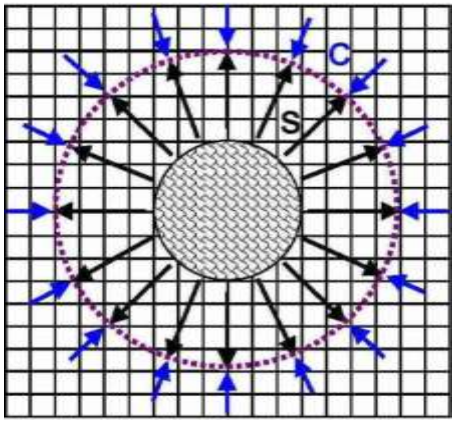
- ASTM D4439: "*A geosynthetic consisting of integrally connected parallel sets of ribs overlying similar sets at various angles for planar drainage of liquids and gases.*"



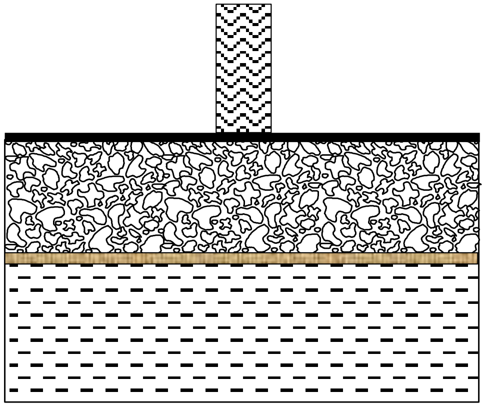
Geosynthetic Functions in Pavements

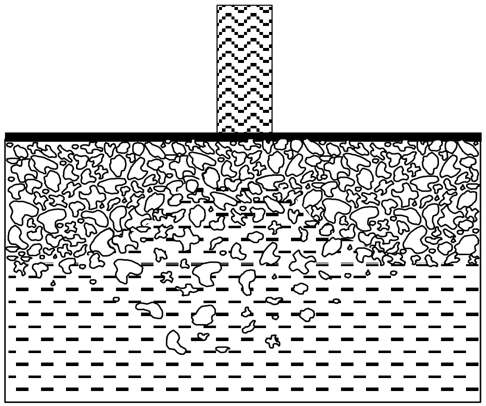
1) Stabilization / Reinforcement





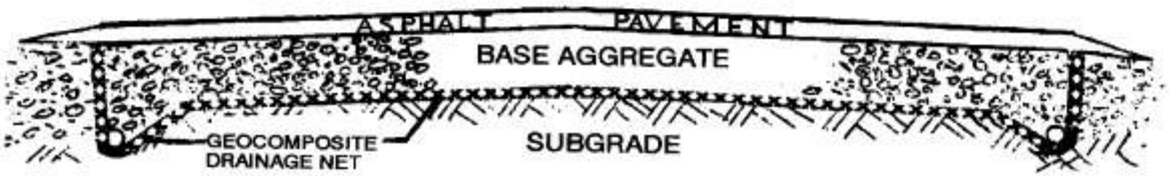
2) Separation



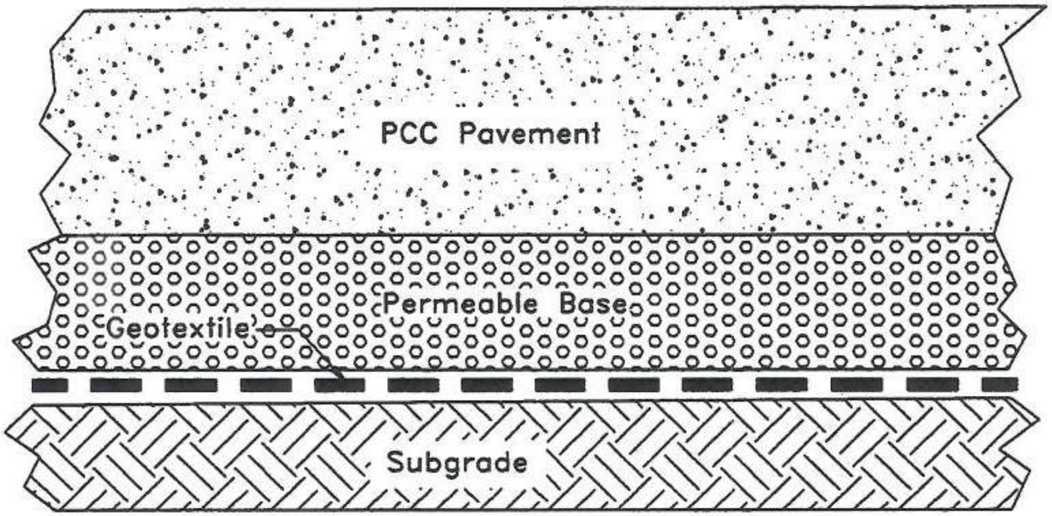


Geosynthetic Functions in Pavements

3) Drainage



4) Filtration

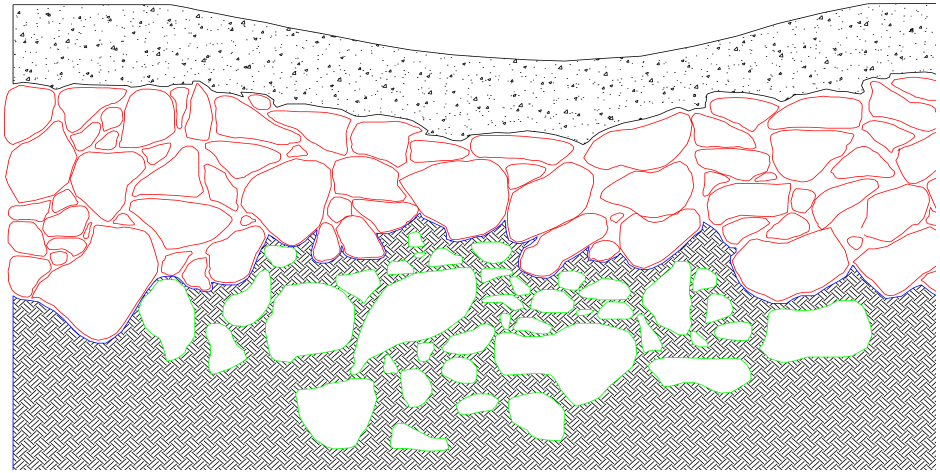


What is Stabilization?

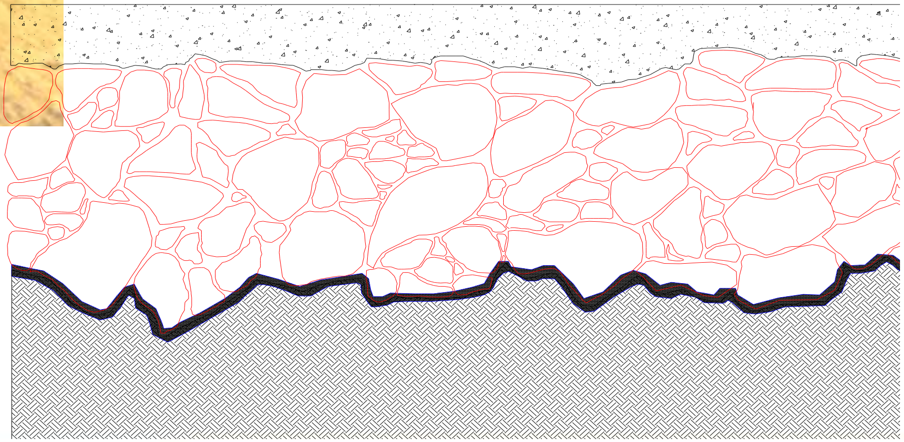
Placement and maintenance of aggregate that serves as a stable layer for support of the remaining pavement structure

Instabilities During Construction

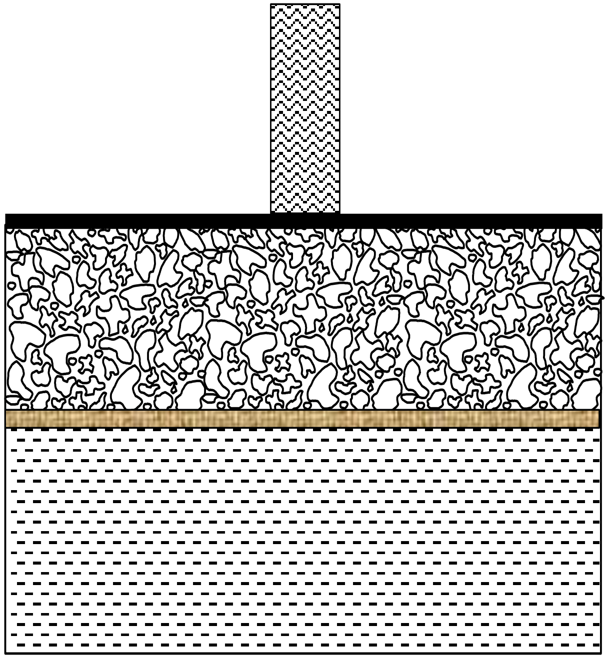
Instabilities During Operating Life

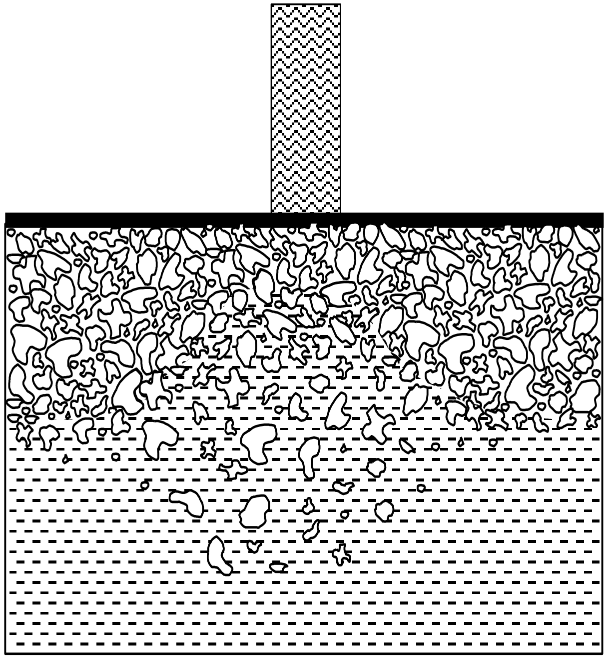


Stabilization



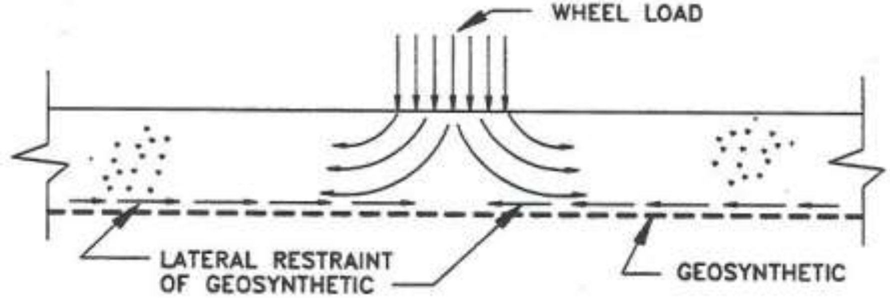
Stabilization: Separation Function



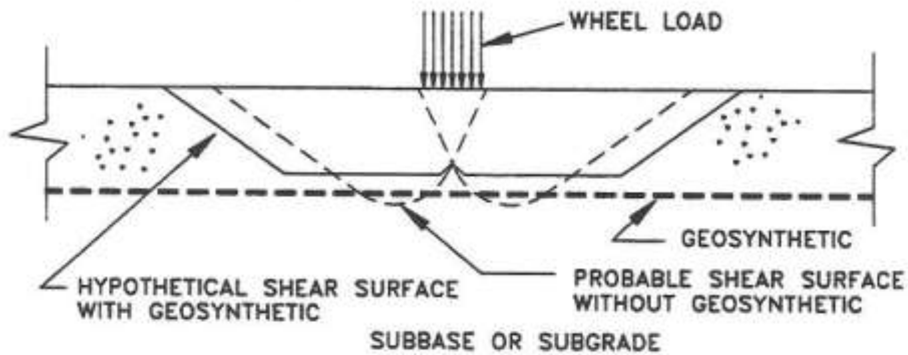


Stabilization: Reinforcement Function

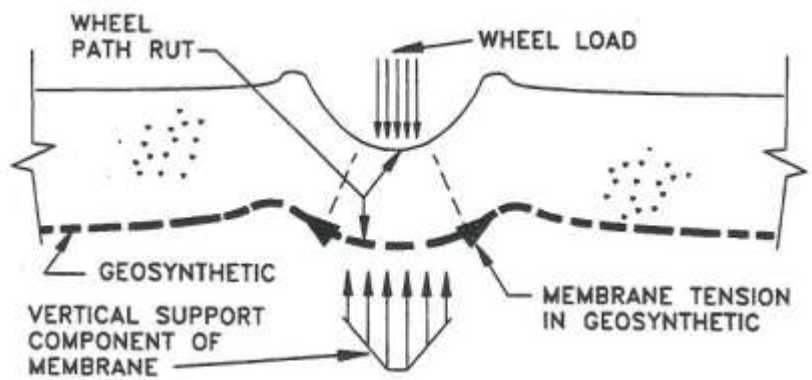
– Lateral Restraint



– Bearing Capacity Increase



– Membrane Tension Support



Full-Scale Field Study of Geosynthetics Used as Subgrade Stabilization

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Background

- Problem
    - Lack of universally accepted design that uses generic geosynthetic properties
    - Understanding of which properties are most relevant
- Objective – assess performance and survivability of various geosynthetics when used as subgrade stabilization
    - Weak subgrade
    - Constructed uniformly
    - Controlled traffic

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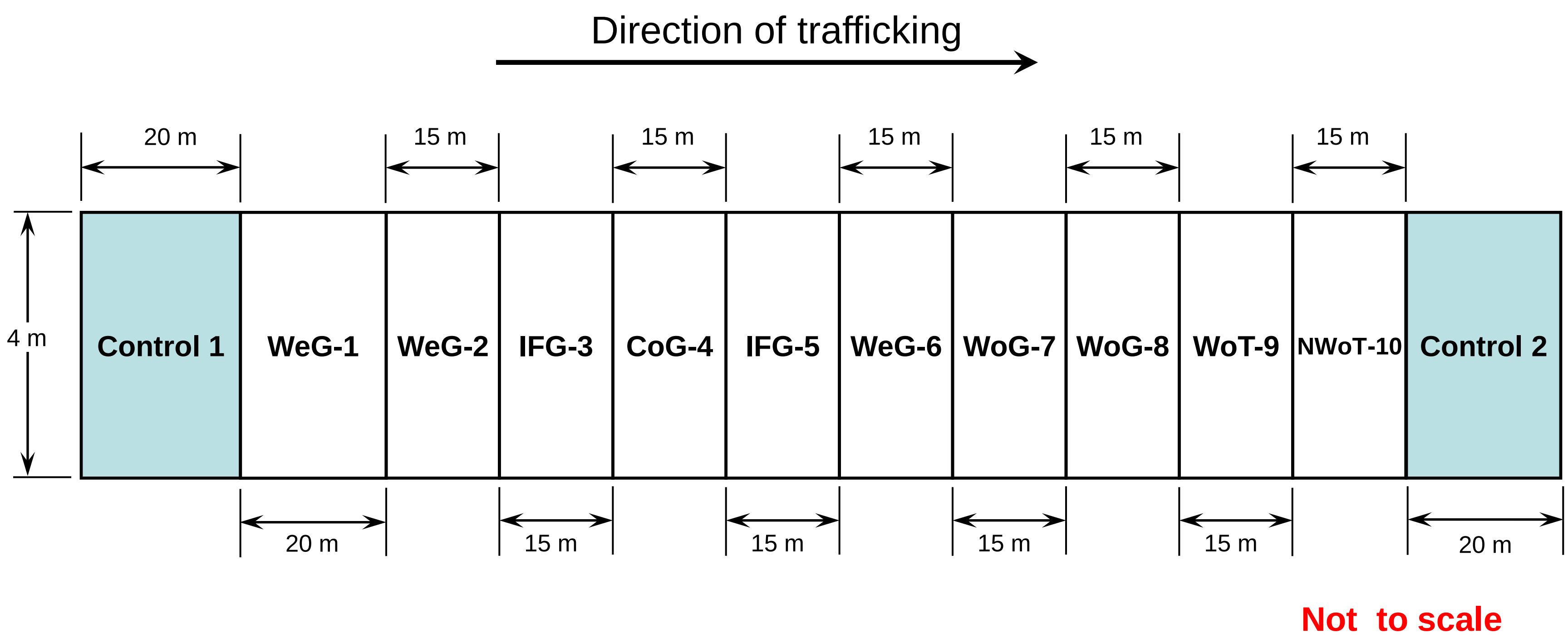
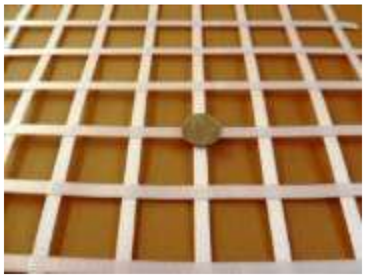
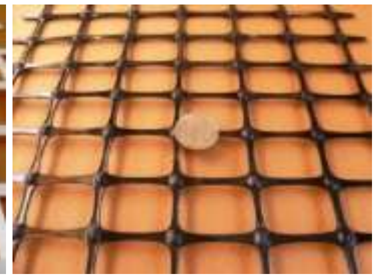
Test Section Layout



Geosynthetics

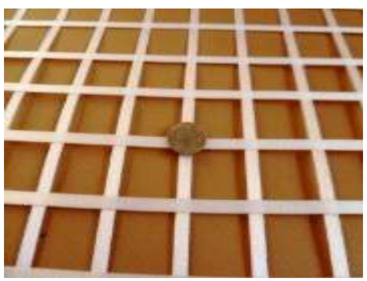

WeG-1

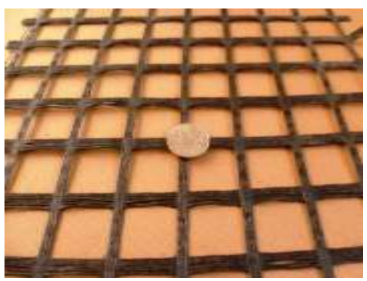

WeG-2

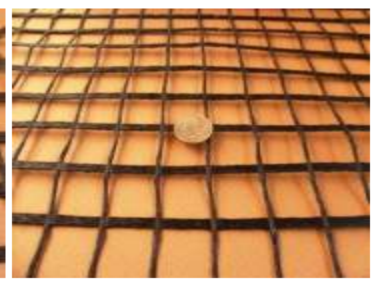

IFG-3


CoG-4


IFG-5


WeG-6


WoG-7


WoG-8


WoT-9


NWoT-10

Constructing Trench

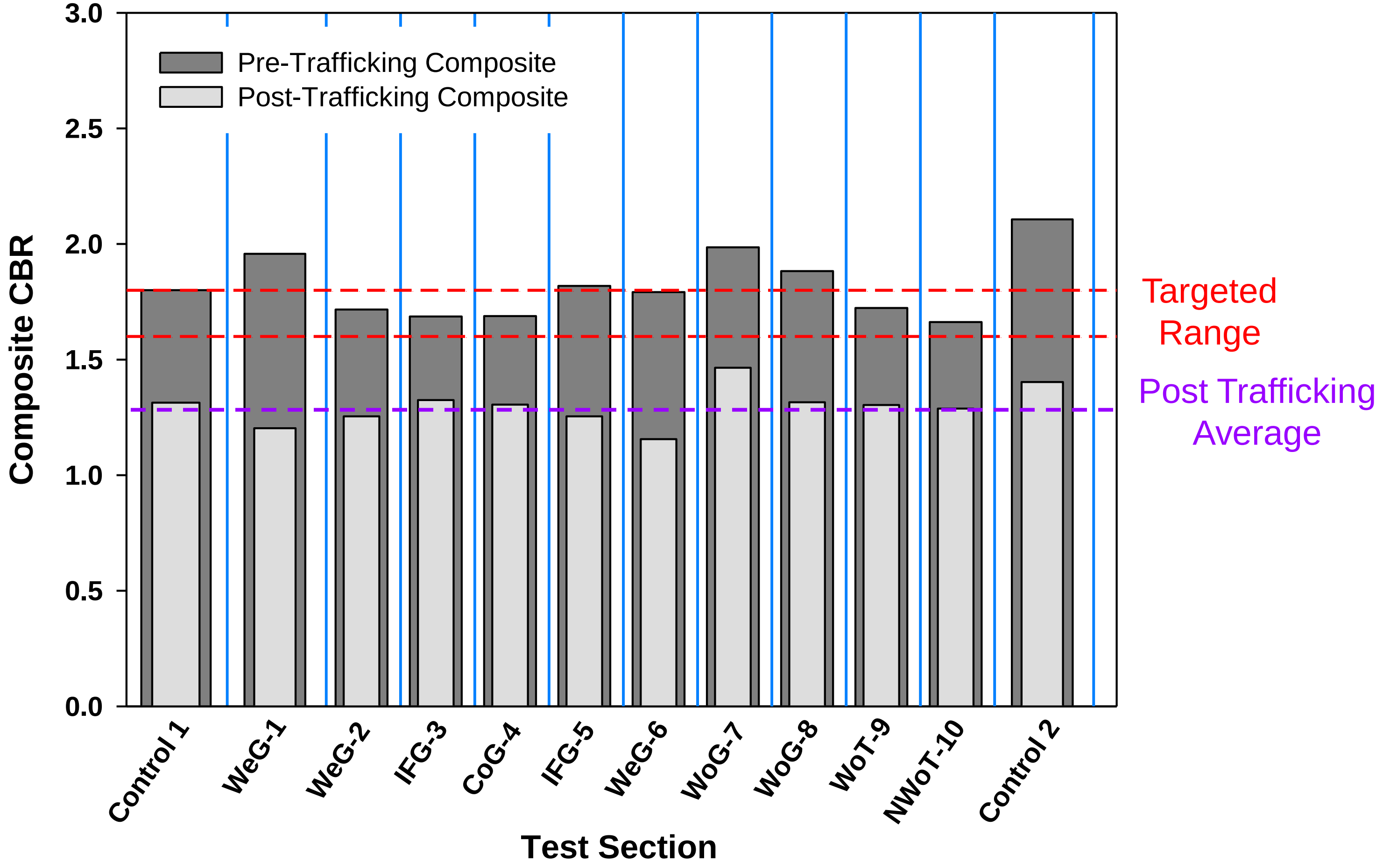
Construction of Artificial Subgrade


Tilling
JOHN DEERE
665

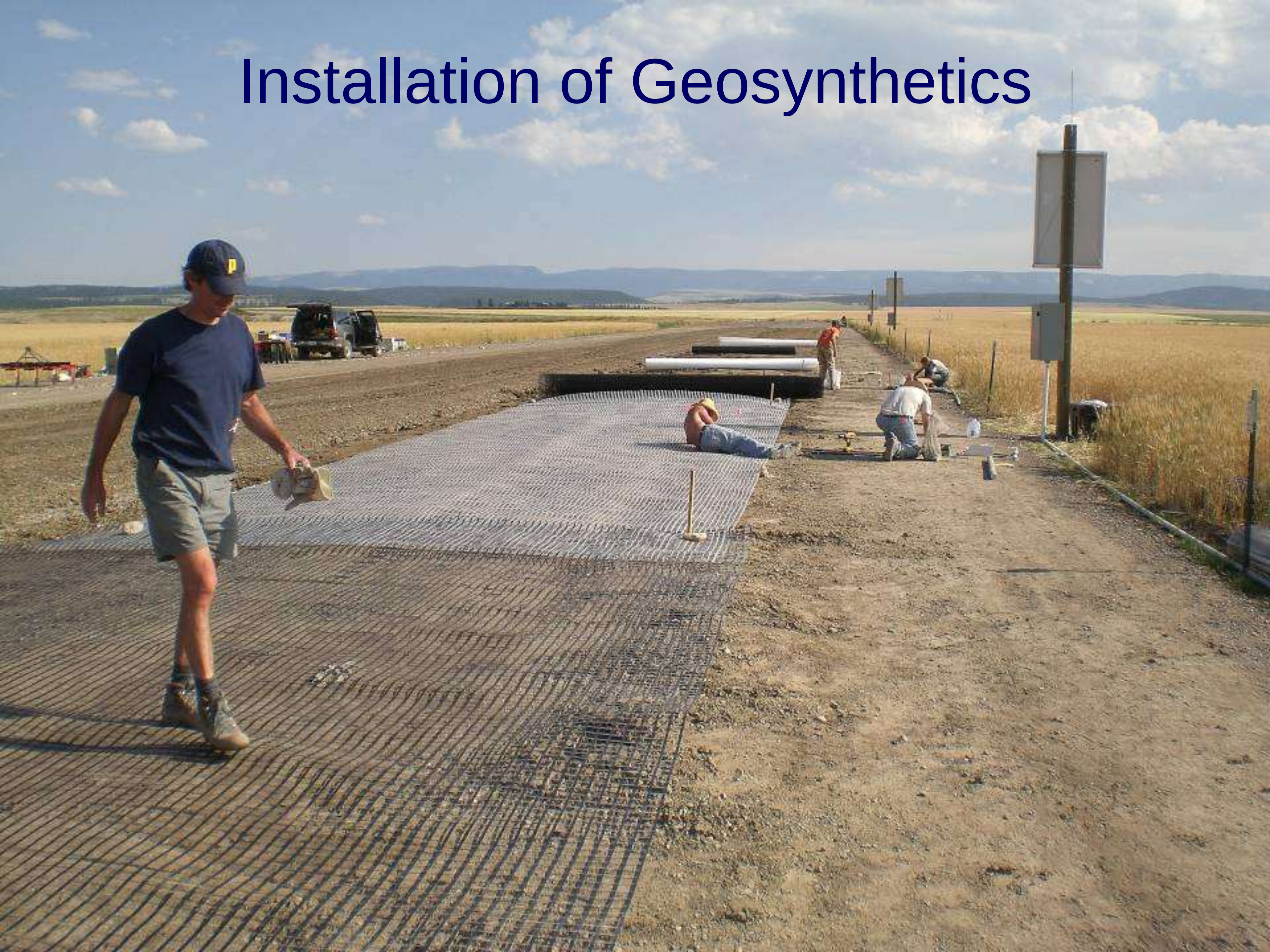
Moisture Control

Compaction

Pre and Post Trafficking Subgrade Strength



Installation of Geosynthetics



Base Course Aggregate

- Well-graded gravel
- 20 cm thick based on FHWA design
- Control sections ~100 mm of rut at 45 truck passes
- Geosynthetic sections ~100 mm rut at 455 truck passes

Grading the Base Course

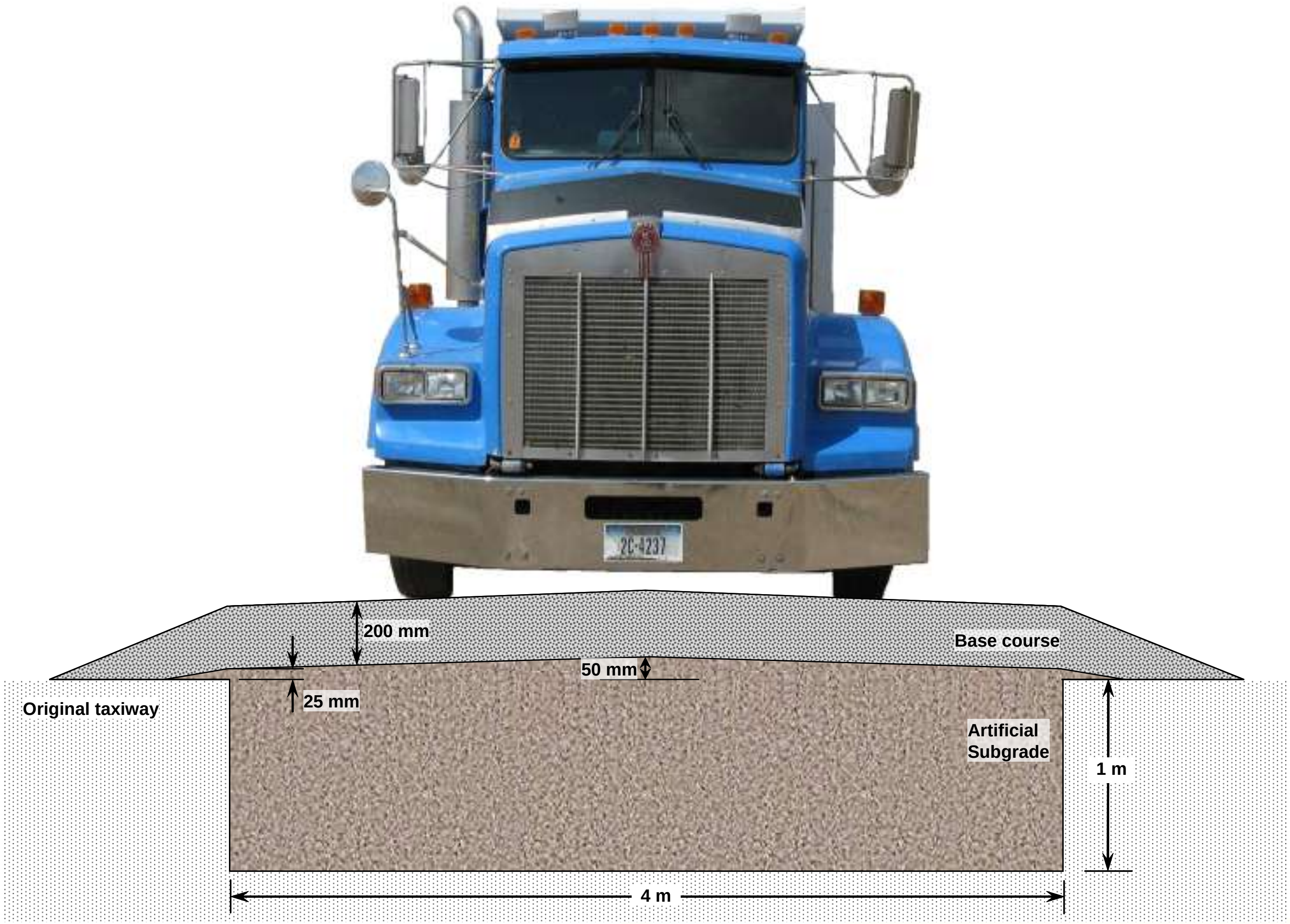
Compacting the Base Course

Ready for Trafficking

Trafficking

- Total weight = 46 kips (20,860 kg)
- Speed = 10 mph (15 kph)

Final Layout



Pass 1

Pass 2

Pass 3

Pass 5


Pass 20

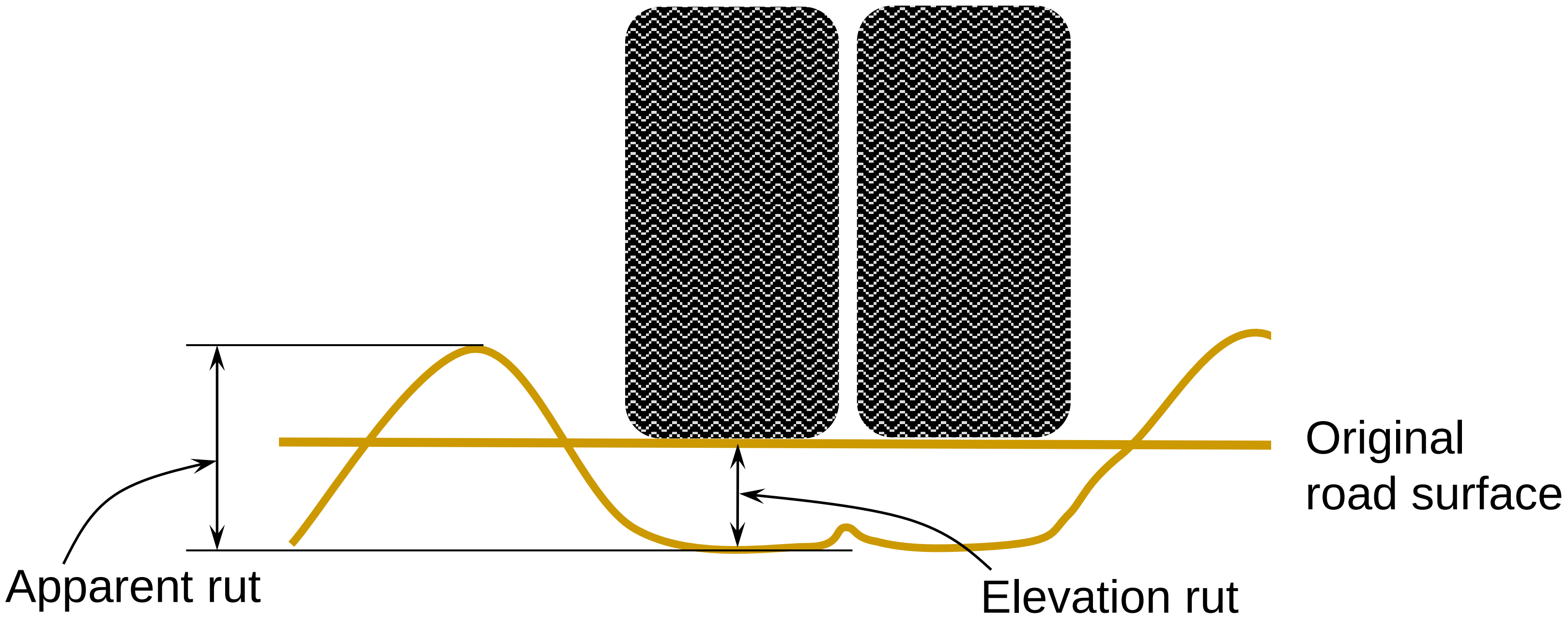
Pass 25

Pass 40

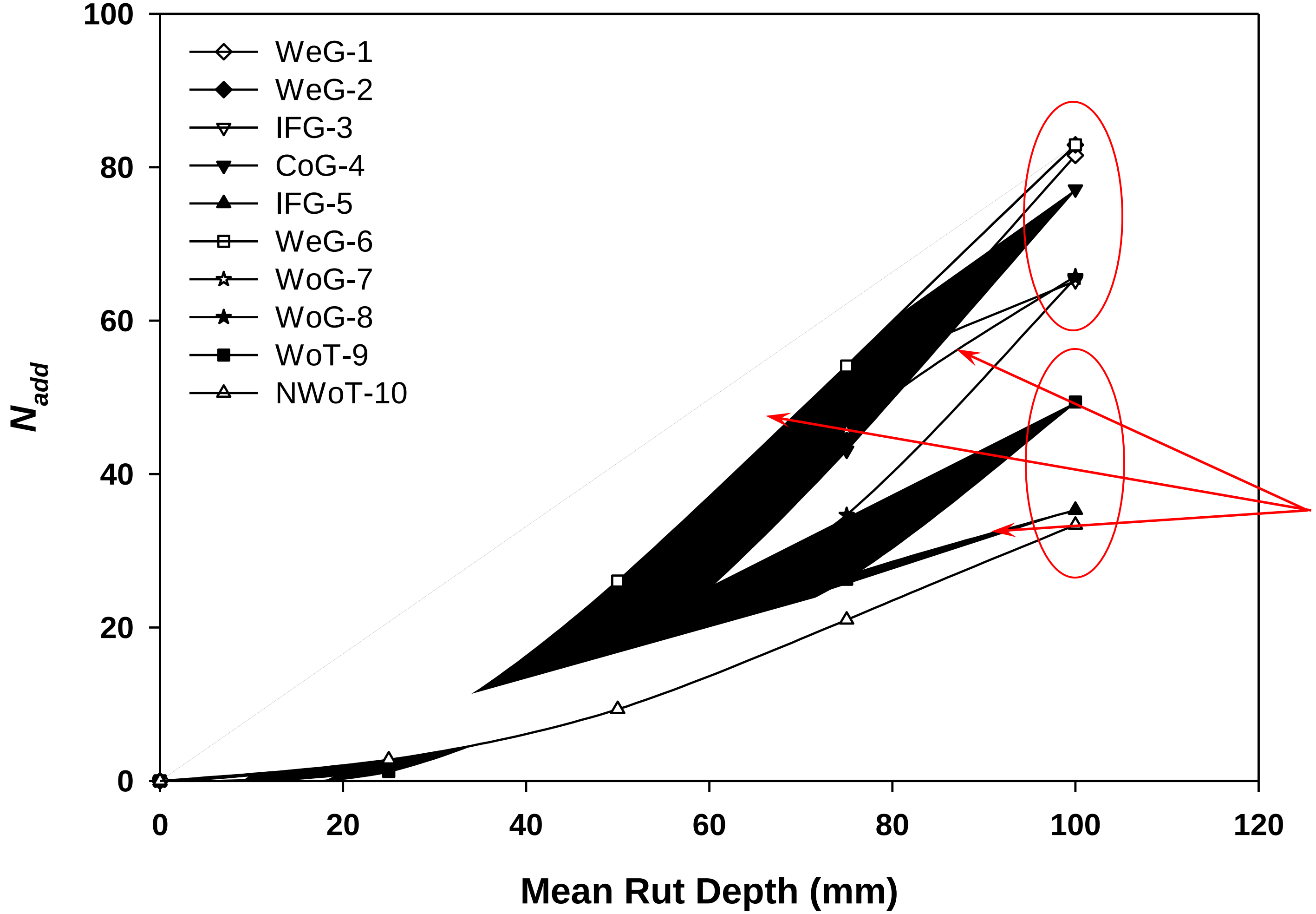
Filling in Ruts

Rut Measurements

- Differences in elevation as rut accumulates
- Two outermost wheel ruts in each test section
- Relate traffic passes to specific rut levels
- 1 truck pass = 2.2 traffic passes



Mean Rut Depth vs. N_{add}



Forensic Investigations

Extracting Geosynthetics

Post Trafficking Measurements

Conclusions

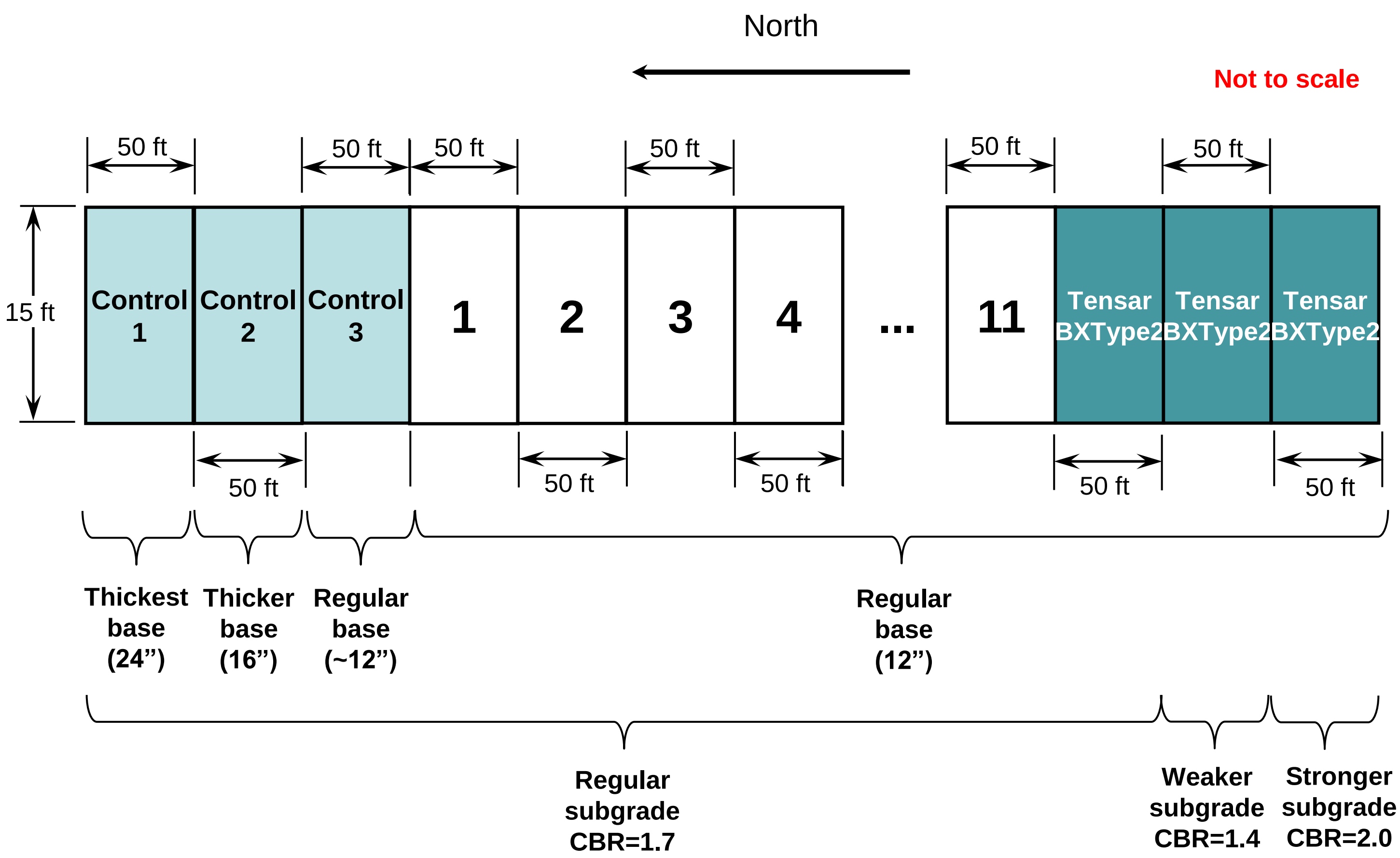
- All geosynthetics provided improvement when compared to controls
- Welded, woven and stronger integrally formed grids performed best
- Two textiles and weaker integrally formed grid provided significantly less benefit
- Current design methods underpredicted base layer thickness for this situation
- Tensile strength in cross-machine direction plays a significant role in rut suppression

Phase II Subgrade Stabilization Study

Objective: match geosynthetic material properties to field performance

- Pooled-fund study (9 states, MT is lead)
- 17 full-scale test sections

Phase II Test Section Layout



Base Reinforcement

- Improve long-term load bearing capacity
- Improve structural support
- Geosynthetics incorporated into design of road structure
- Improve roadway longevity

Application

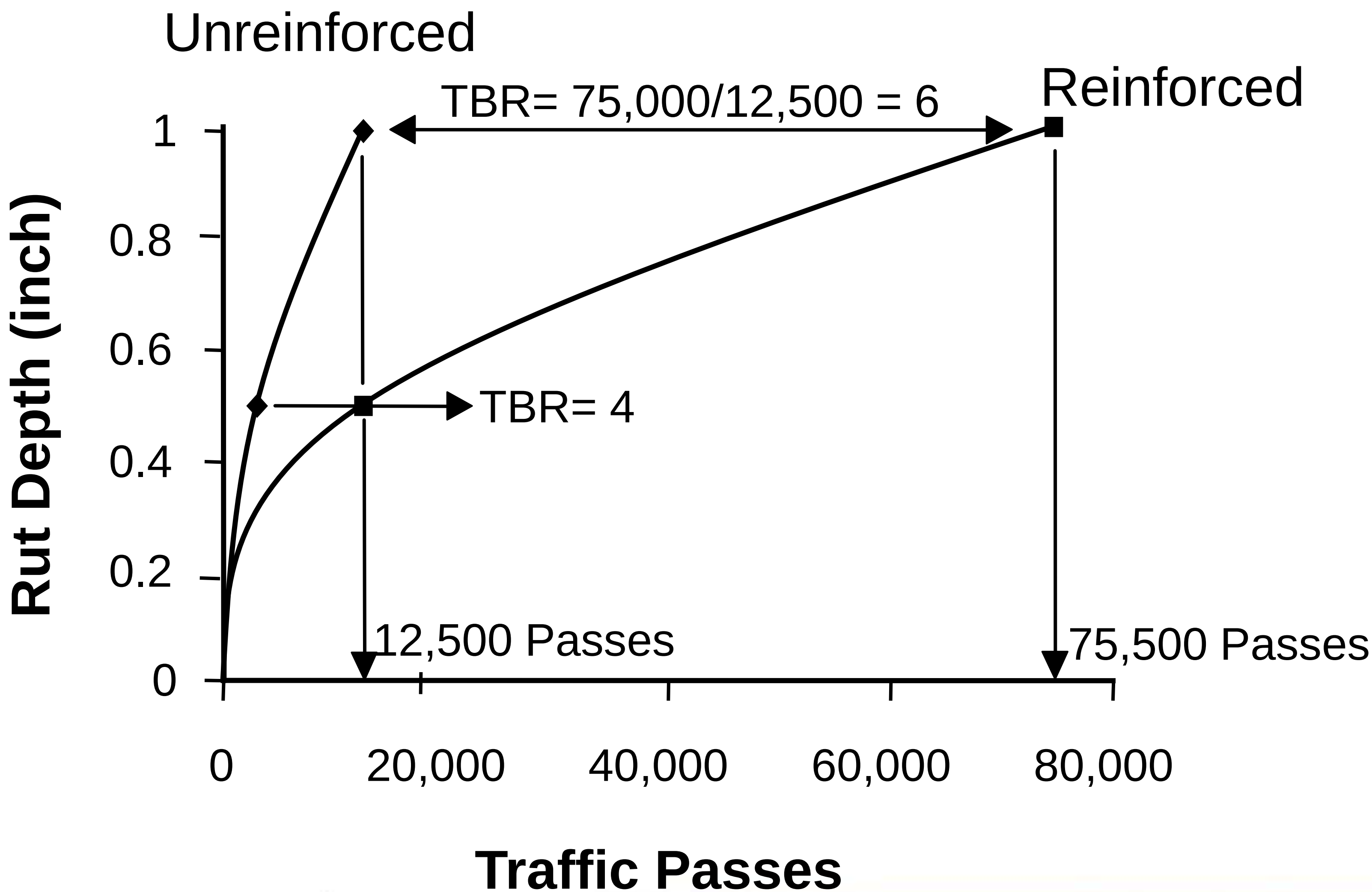
- Tend to be lower volume roads
  - AC thickness 2 to 4 inches
  - Base thickness 8 to 16 inches
- CBR < 8
- Pavement surface distresses
  - Rutting
  - Fatigue cracking

- Reinforcement placed at bottom of base layer

Structural Contribution Based on Empirical Methods

- Traffic Benefit Ratio (TBR)
  - Comparison of equivalent pavement systems
  - Ratio of load applications in reinforced sections over load applications in unreinforced sections
- Base Course Reduction Factor (BCR)
  - Comparison of equivalent traffic capacity
  - Percent reduction in base thickness

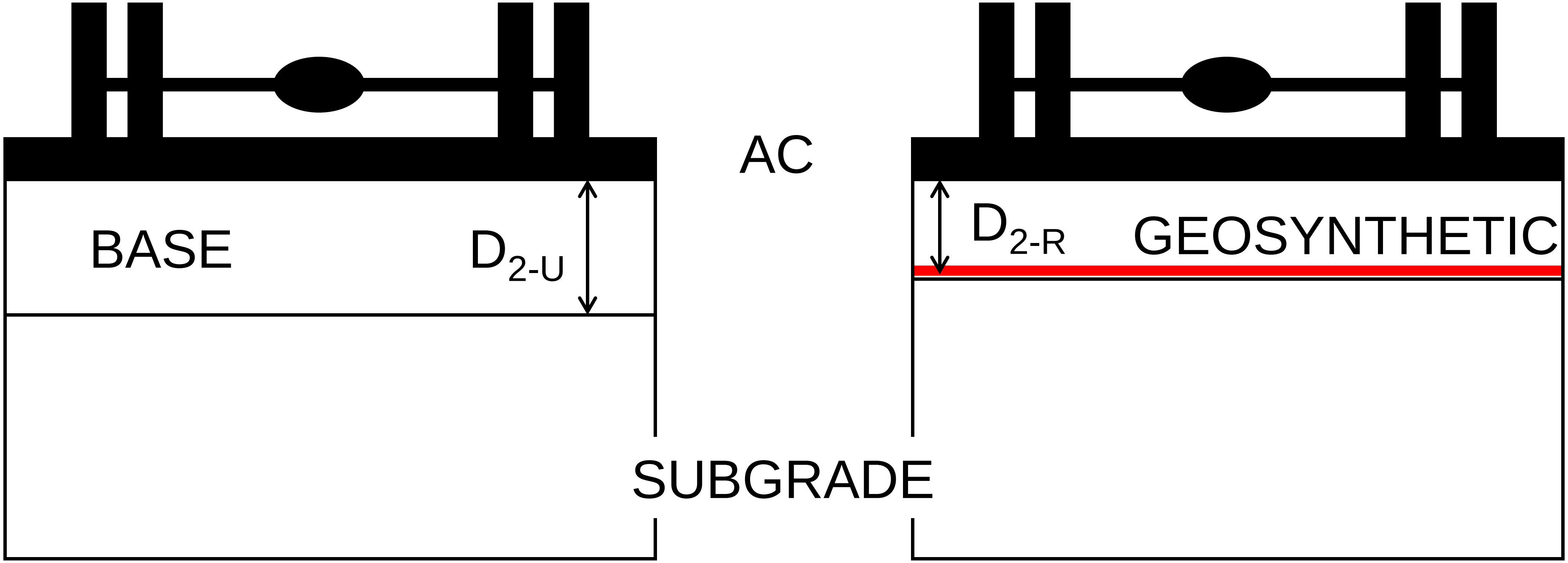
TBR


Unreinforced
Reinforced
TBR= 75,000/12,500 = 6
TBR= 4
Rut Depth (inch)
1
0.8
0.6
0.4
0.2
0
12,500 Passes
75,500 Passes
0
20,000
40,000
60,000
80,000
Traffic Passes

BCR

$$BCR = (D_{2\text{-}U} - D_{2\text{-}R})/D_{2\text{-}U}$$

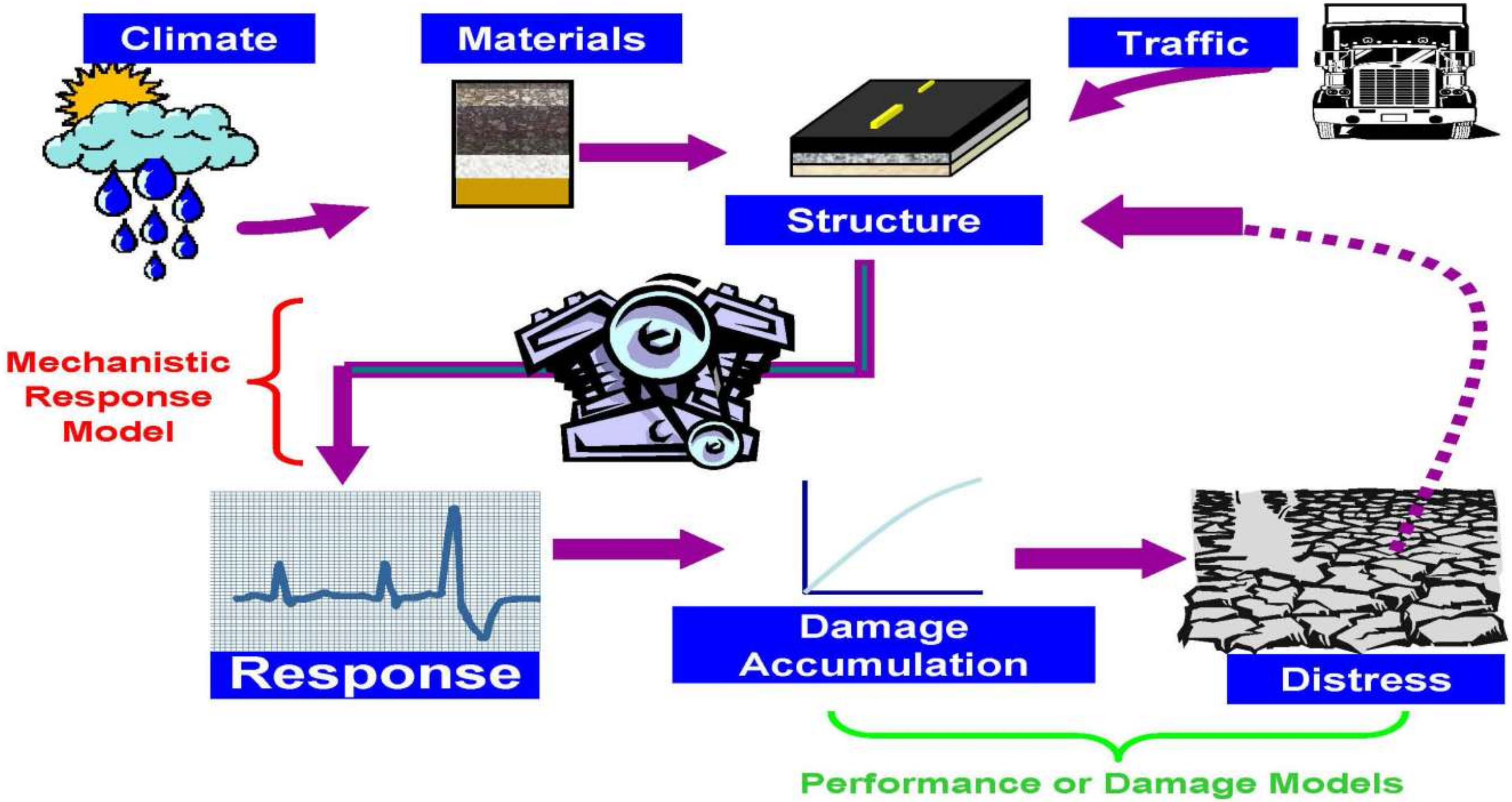
with identical life



Benefit Results

- Requires comparative studies
- Typical TBRs from test sections
  - Geogrids: 1.5 to 70
  - Geotextiles: 1.5 to 10
- BCR
  - 22% to 50%

Mechanistic-Empirical Design

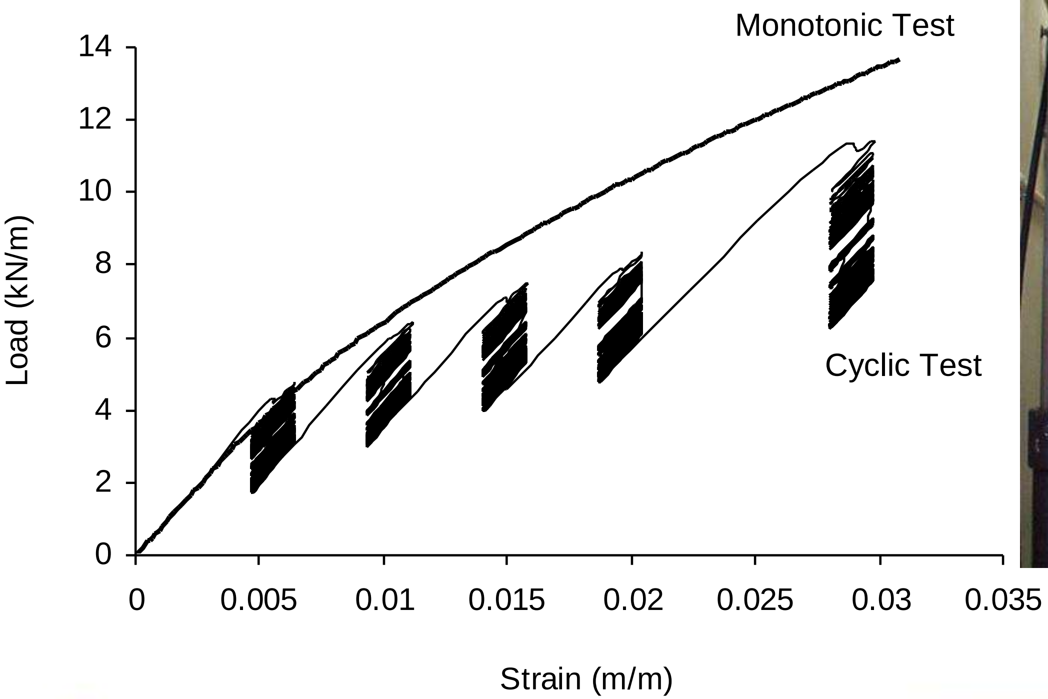


Geosynthetic Modeling

- Finite element model by Perkins et al. (2004)
  - Based on 2-D axisymmetric FEM contained in NCHRP Project 1-37A
  - Includes geosynthetic reinforcement
- Geosynthetic material models need constitutive properties pertinent to pavement design
  - Elastic modulus in principal strength directions (tension tests)
  - Soil-geosynthetic interaction (pullout tests)
  - In-plane Poisson's ratio (biaxial test)

Cyclic Tension Tests

- Low-strain cyclic modulus (ASTM D7556)

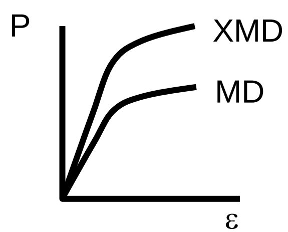


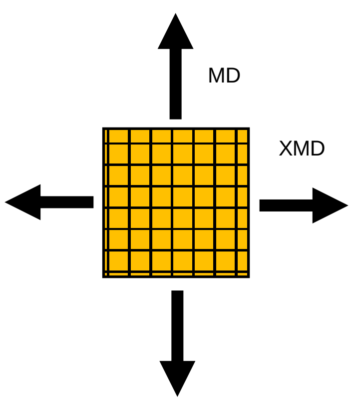
Cyclic Pullout Tests

- Resilient interface shear modulus (ASTM D7499)

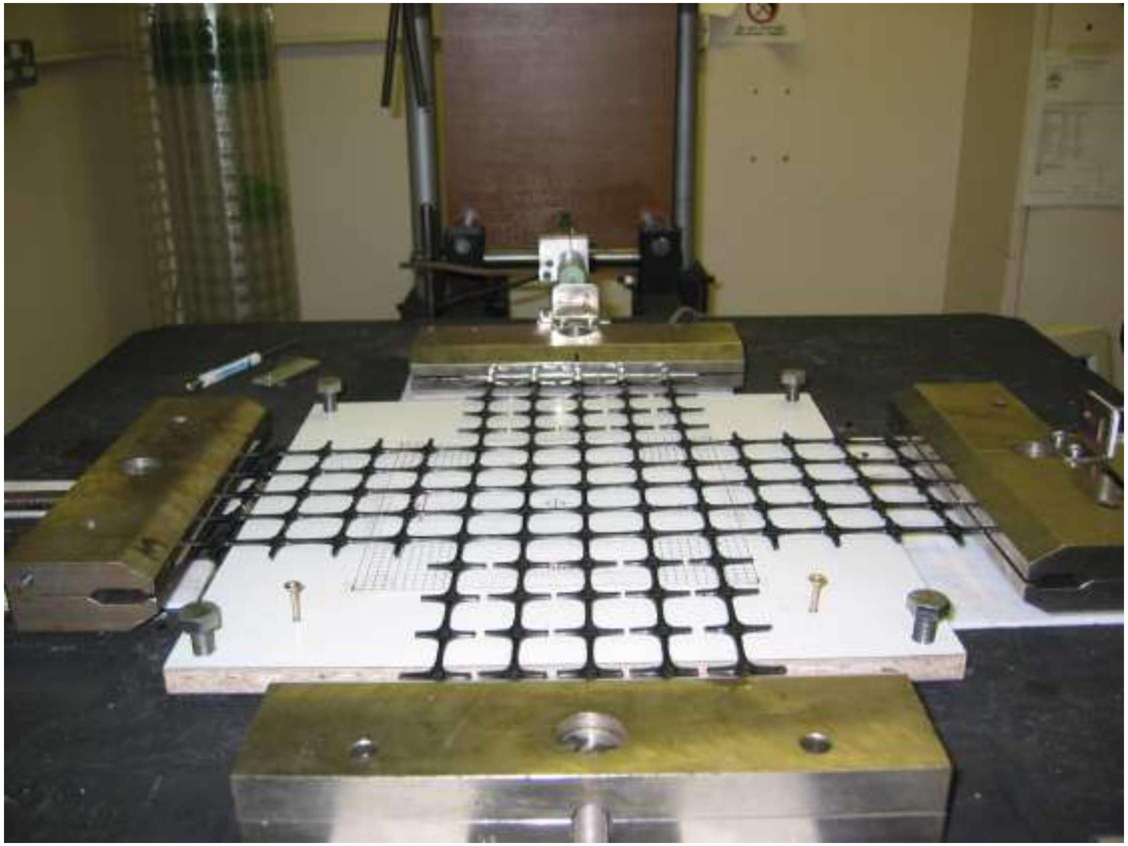
Biaxial Tension

- Poisson's ratio





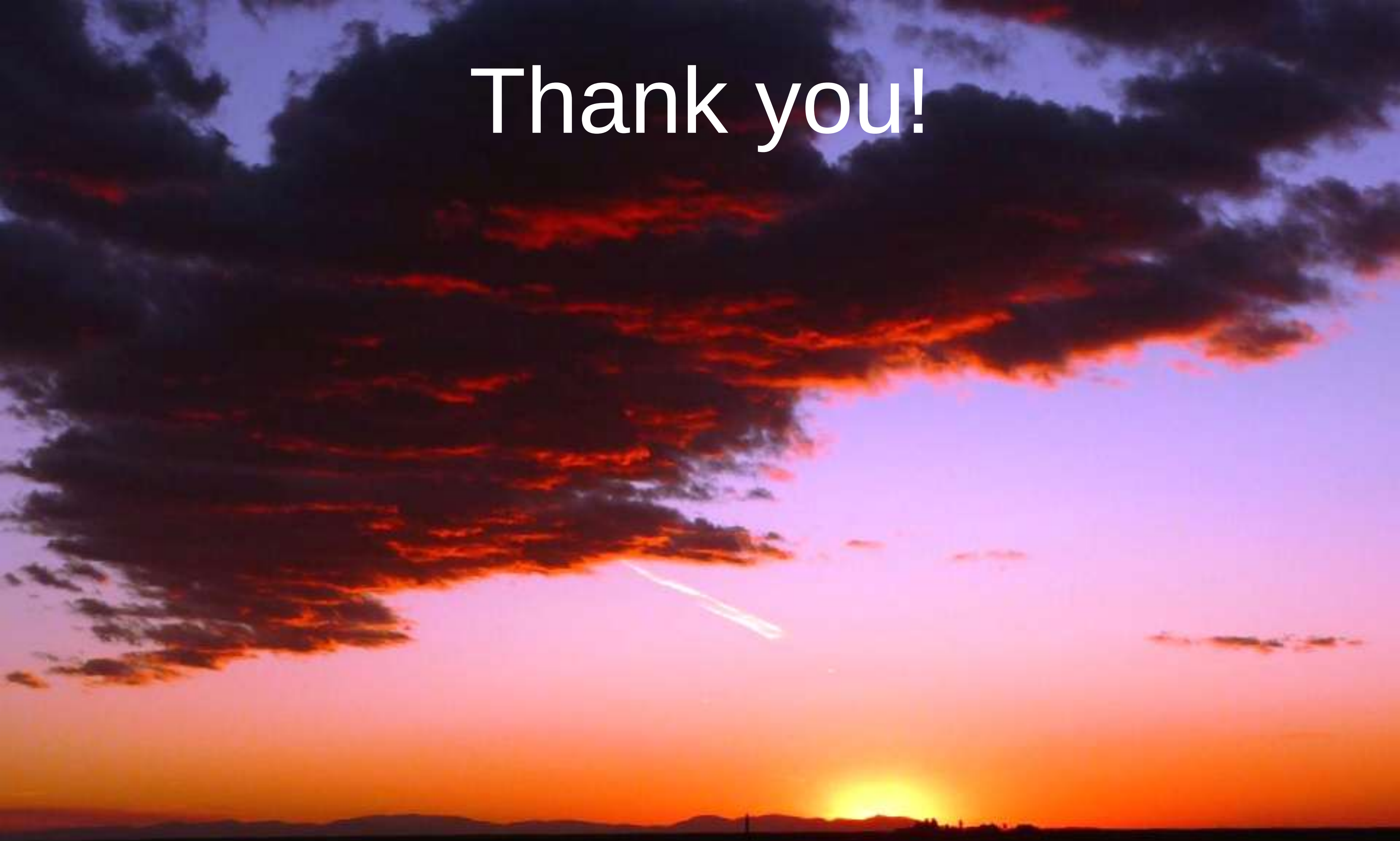
$\nu_{XMD\text{-}MD}$



Practical Use of This Information

- Areas of weak subgrade material
  - Need for stable platform to build road
  - Maintain separation between layers
- Areas where gravel sources are limited or costly
- Low-volume roads experiencing increased truck traffic
- FHWA NHI Manual: Geosynthetic Design & Construction Guidelines (2008)

Thank you!



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