Arizona Pavements / Materials Conference

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Geosynthetics in Roadway Applications

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Geosynthetic Materials in Roadways

Geotextiles:

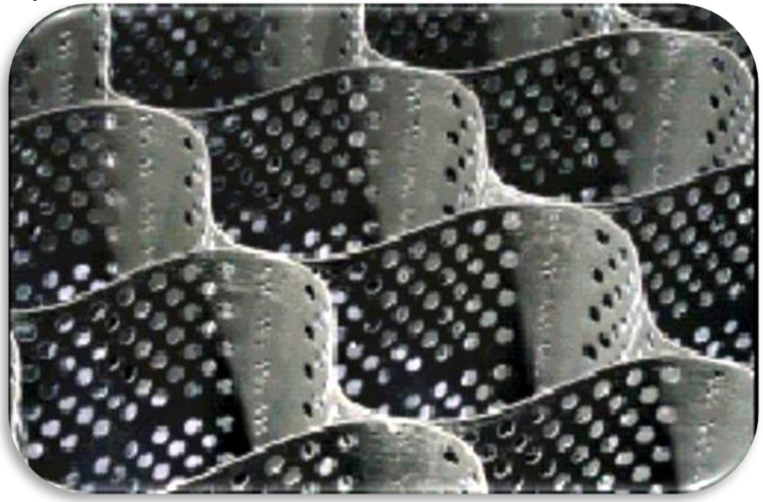
Woven or nonwoven

PP, PET

Geogrids:

Uniaxial, biaxial, multiaxial

HDPE, PP, PET, PVA



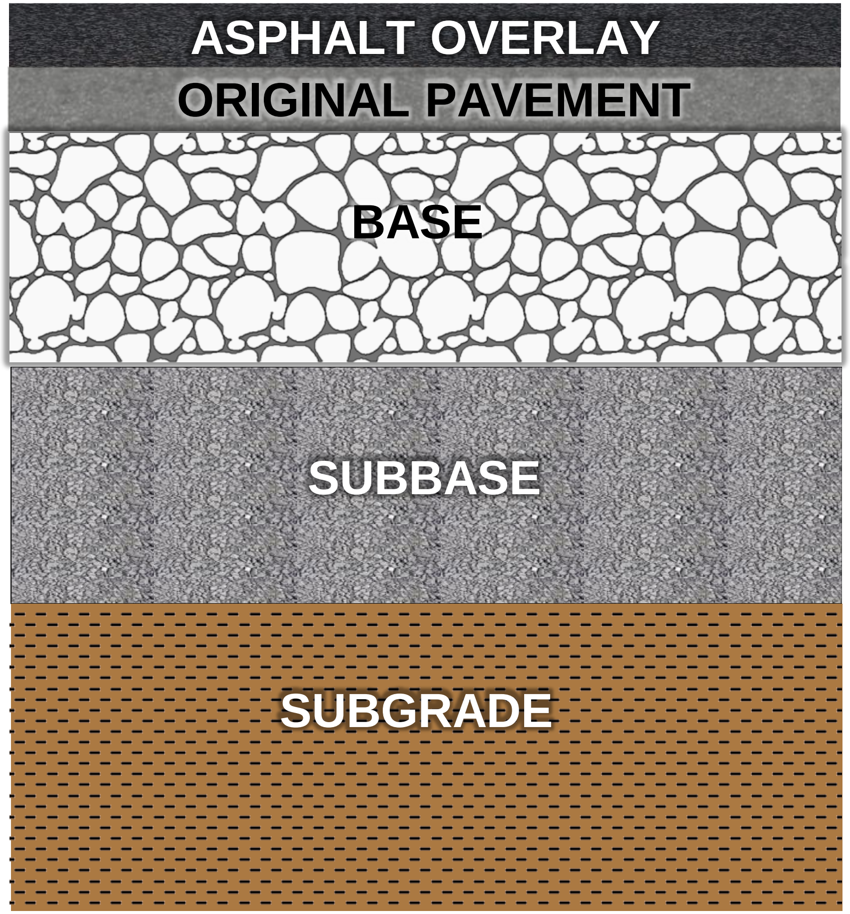
Geocells:

Smooth, perforated

HDPE

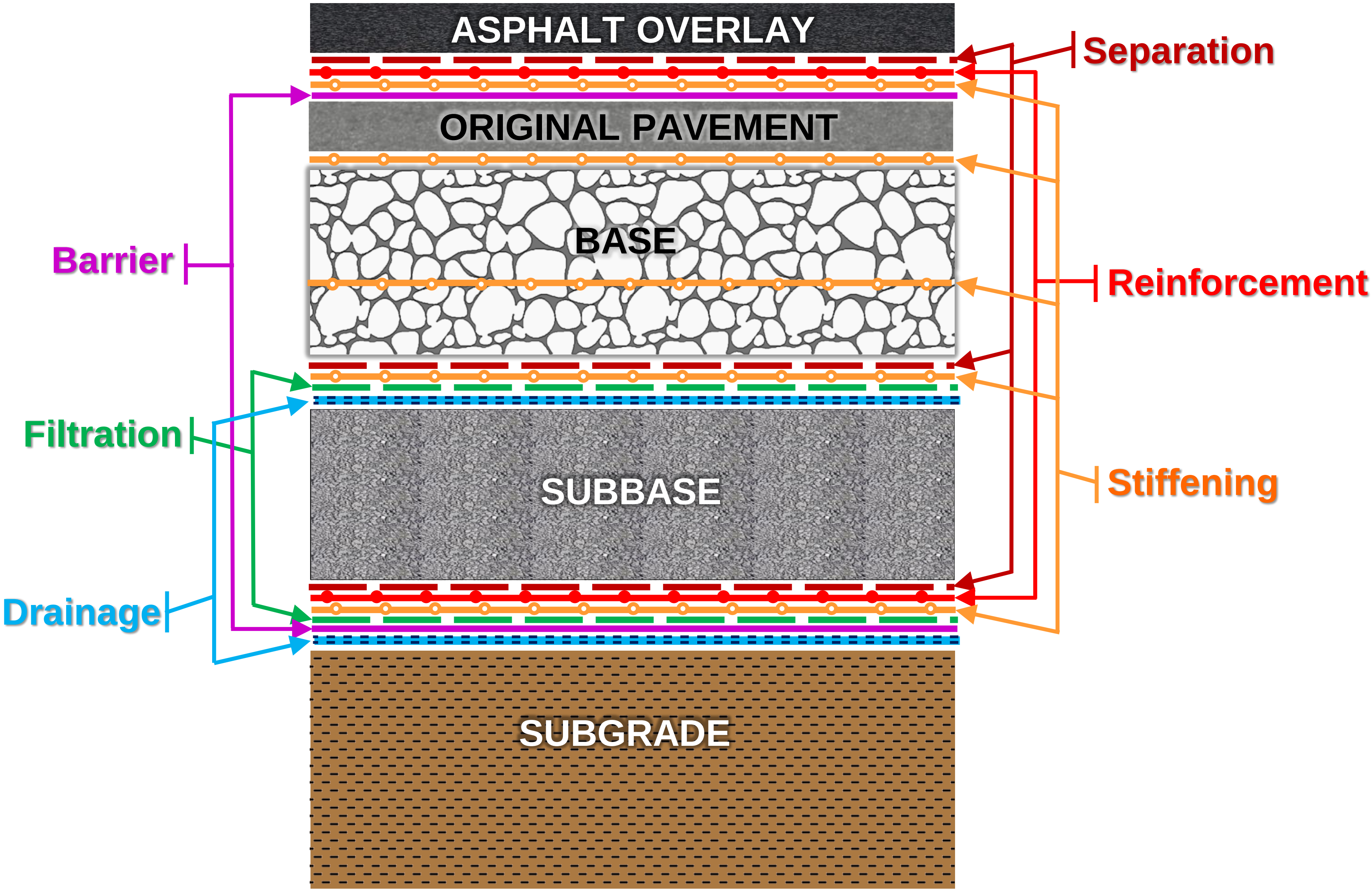
Source: Geosynthetic Institute (GSI)

Geosynthetic Functions in Roadways



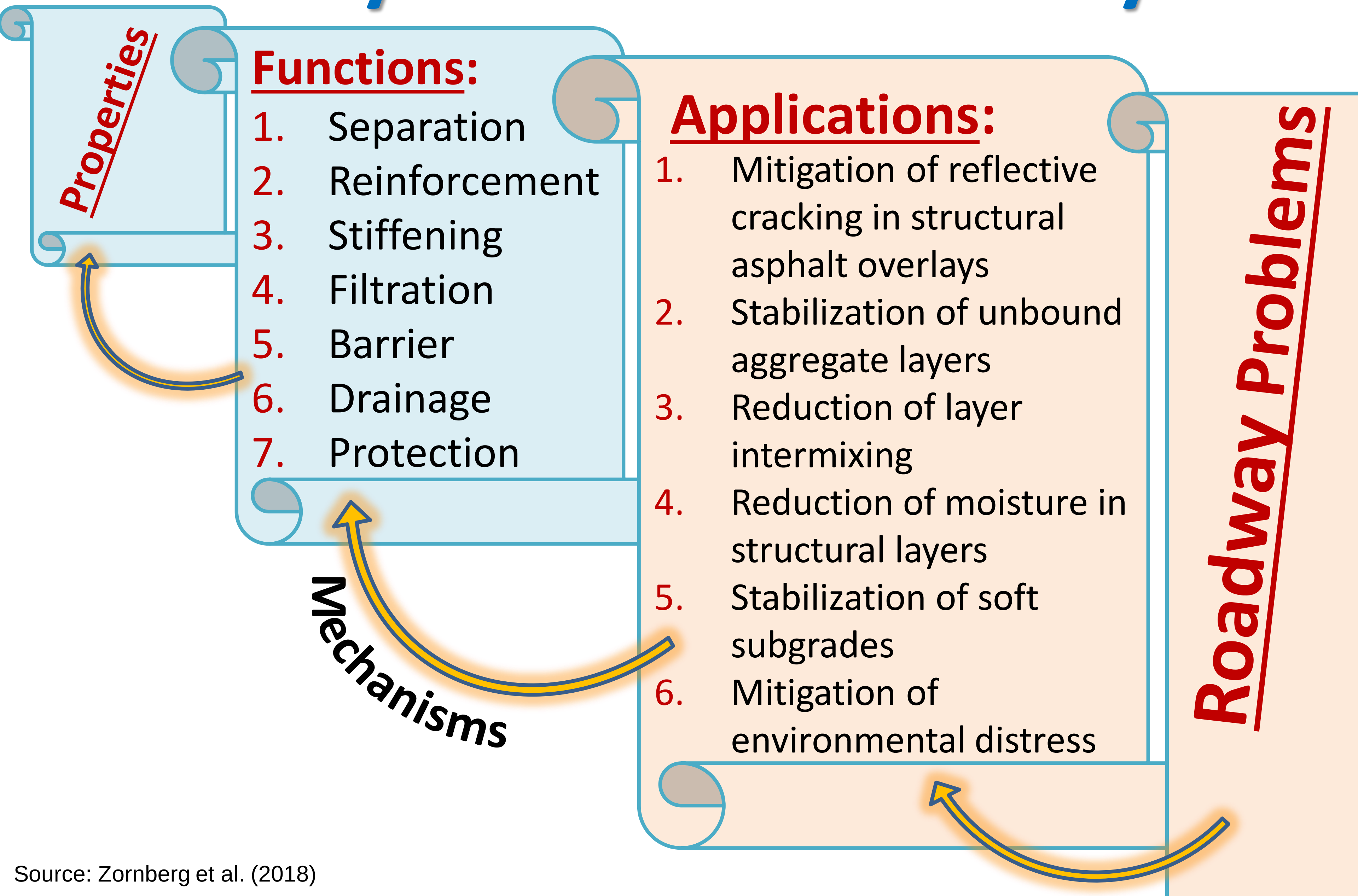
Source: Zornberg (2017a)

Geosynthetic Functions in Roadways



Source: Zornberg (2017a)

Geosynthetics in Roadways



Source: Zornberg et al. (2018)

Mitigation of Asphalt Reflective Cracking: Objective

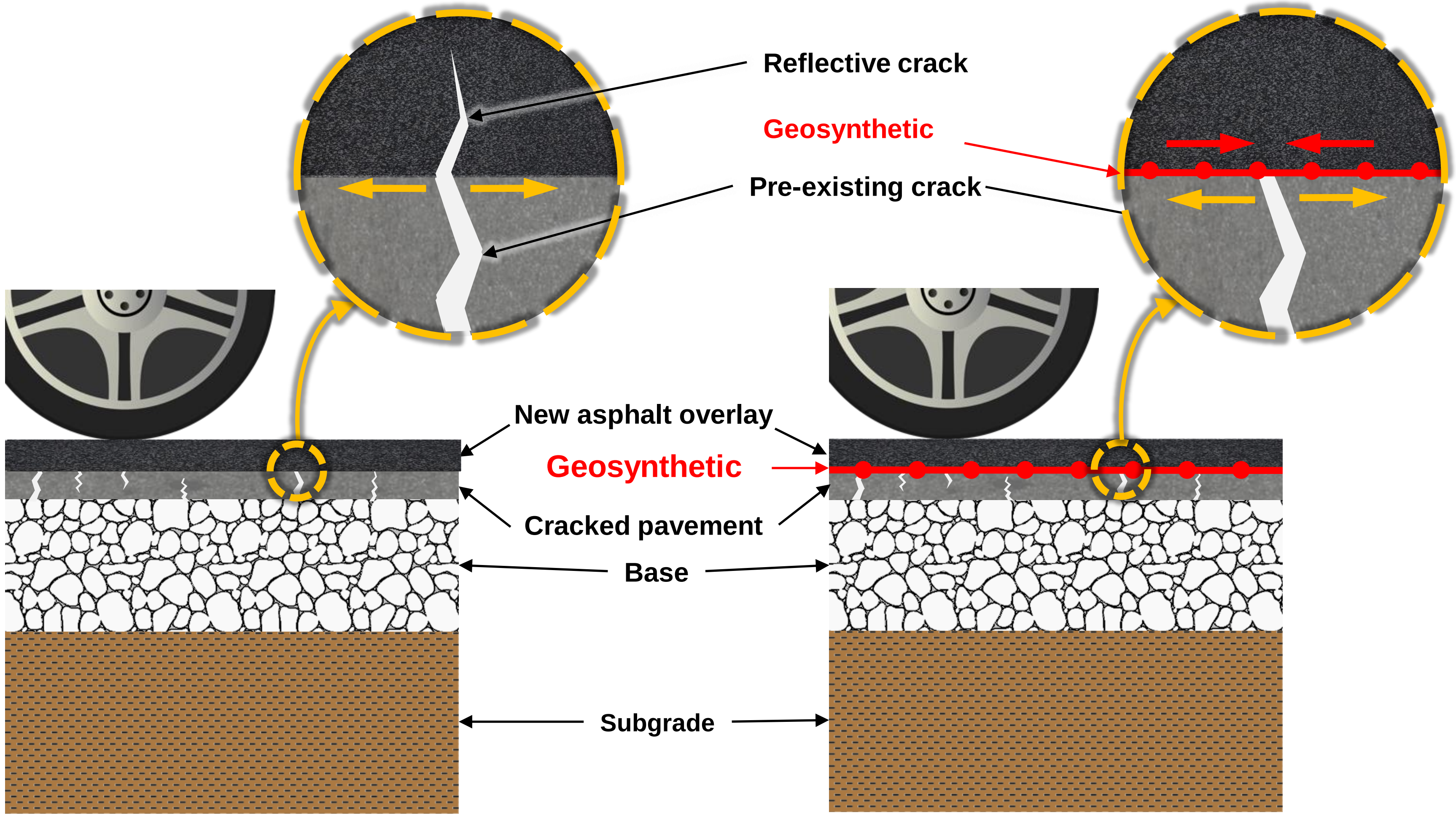
Maintain integrity of the structural asphalt overlay and, in turn, reduce/eliminate degradation mechanisms caused (or accelerated) by water intrusion through reflective cracks

Mitigation of Asphalt Reflective Cracking: Mechanisms

Identified mechanisms include:

- **Tension development:**
  - Distributing strains in the asphaltic layer, so that cracks are not triggered
  - Developing tension to maintain the confinement of the underlying (damaged) asphalt layer
- **Moisture barrier:**
  - Minimizing water infiltration
  - Maintaining low moisture in underlying pavement layers
- **Stress relief:**
  - Releasing the energy of crack propagation

Mitigation of Asphalt Reflective Cracking: Mechanisms

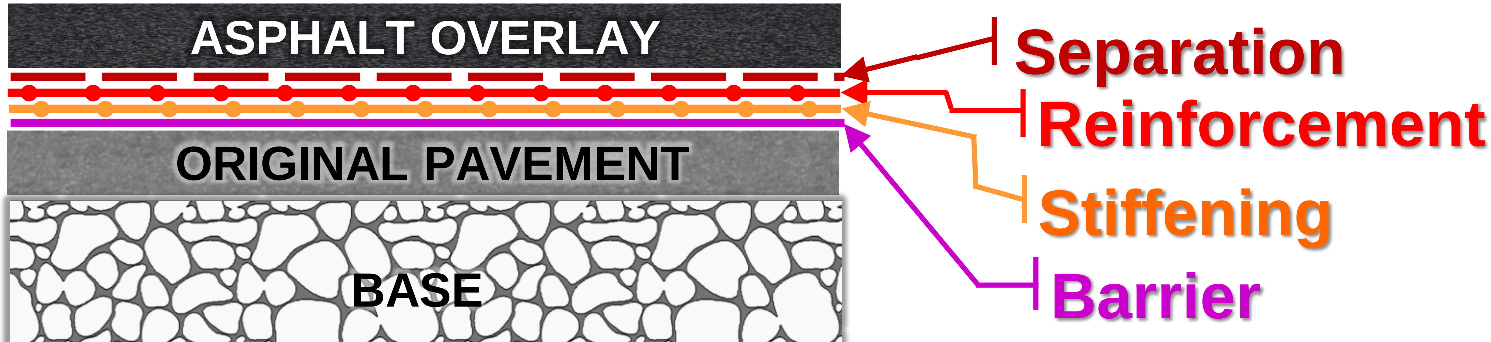


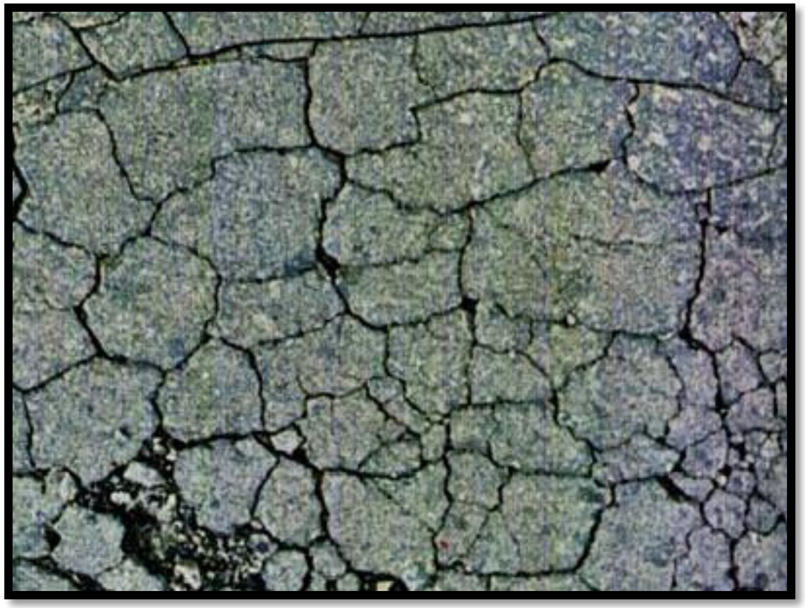
Overlay without Geosynthetic

Overlay with Geosynthetic

Source: Zornberg (2017)

Mitigation of Asphalt Reflective Cracking: GS Functions





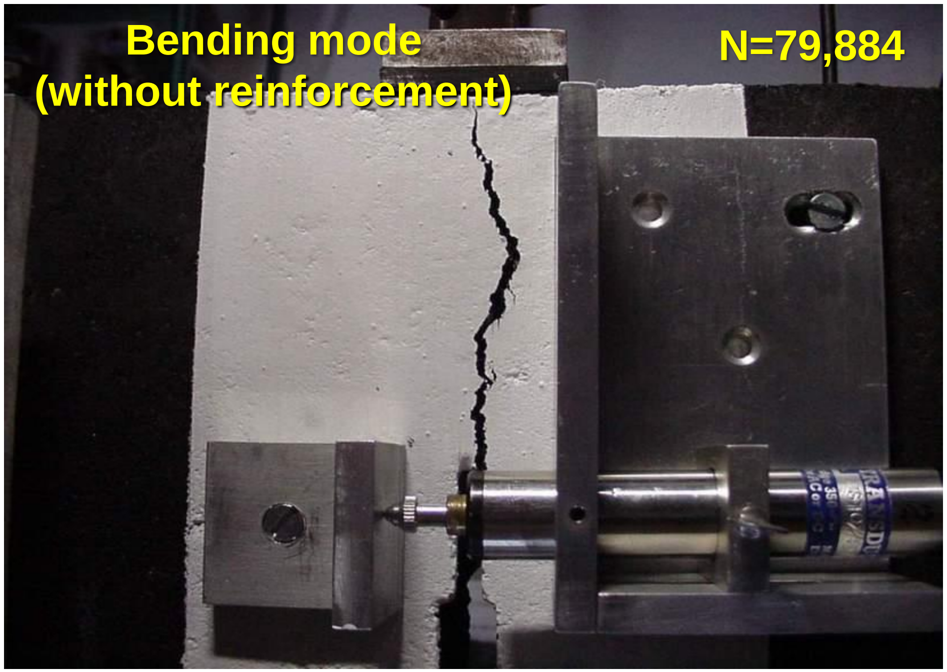
Source: Zornberg (2017a)

Mitigation of Asphalt Reflective Cracking : GS Properties

- Tensile Strength
- Unconfined Tensile Stiffness
- Asphalt Retention
- Survivability-related properties

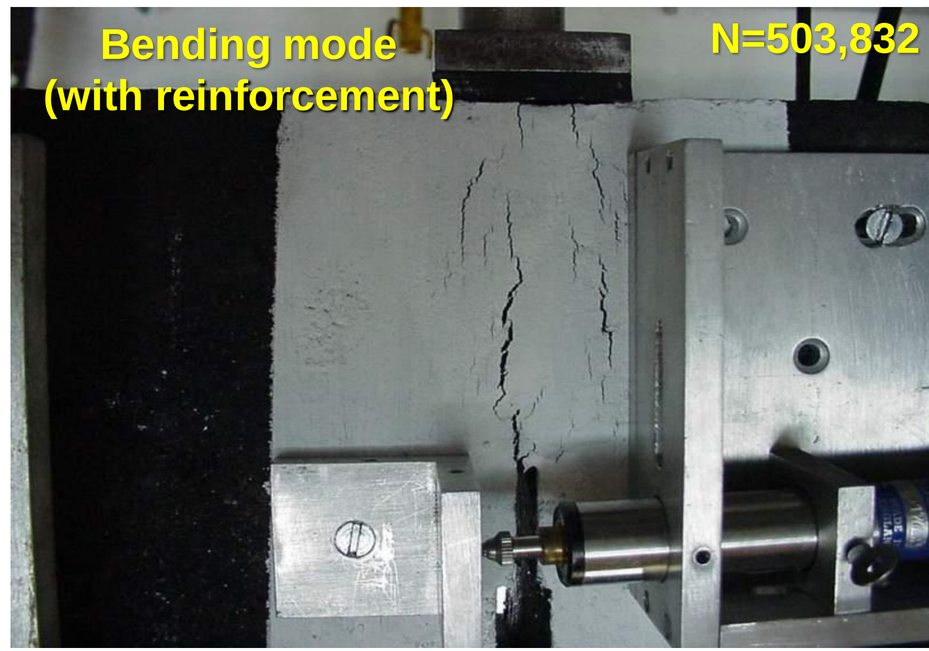
Dynamic Fatigue Tests

Bending mode:



Typical crack propagation
in unreinforced specimen

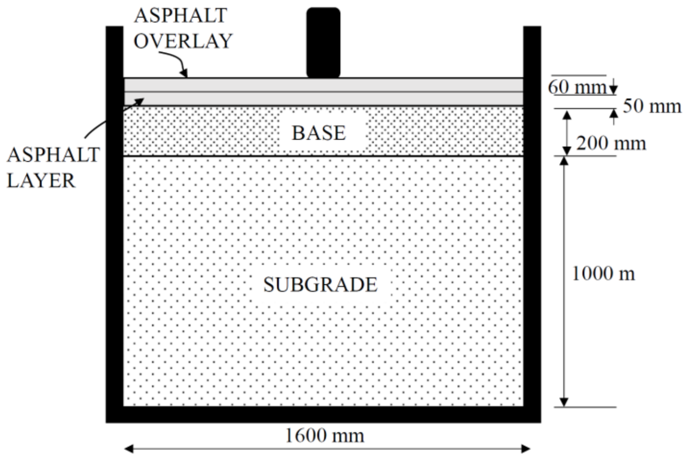
Typical crack propagation
in reinforced specimen



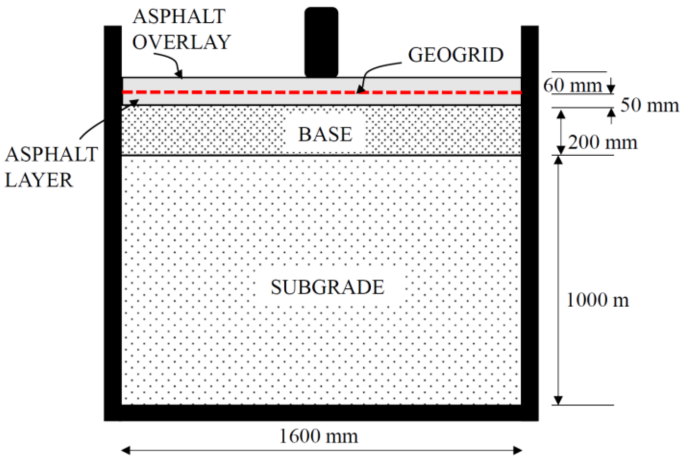
Source: Montestruque (2002)

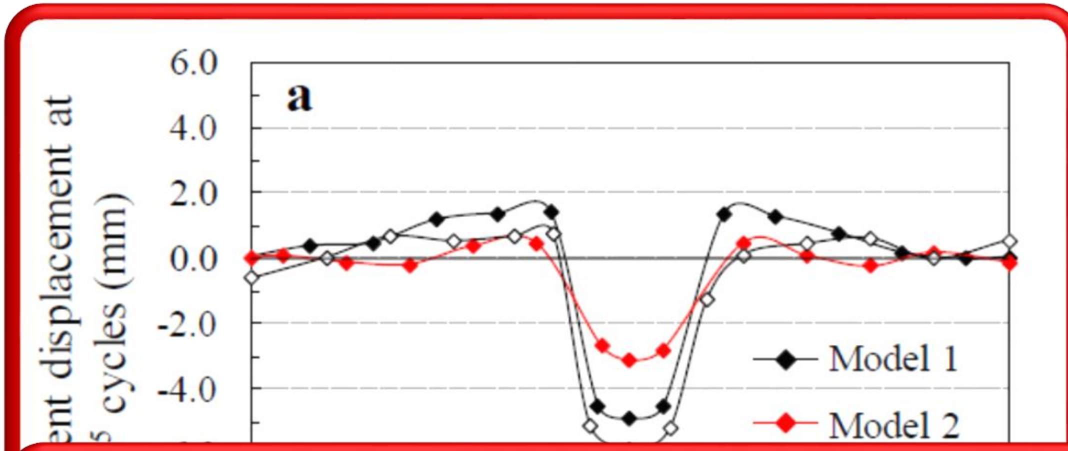
New! Improved Structural Capacity

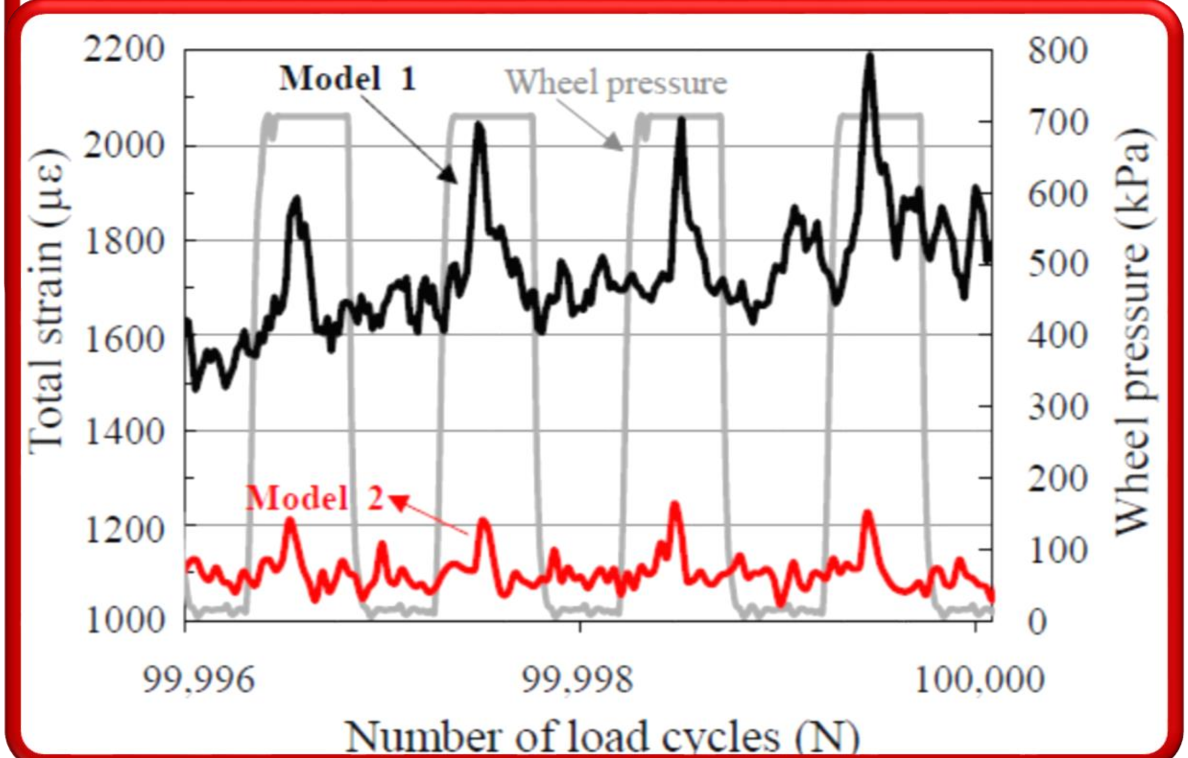
Model 1:



Model 2:







Source: Correia and Zornberg (2018)

Stabilization of Unbound Aggregate Layers: Objective

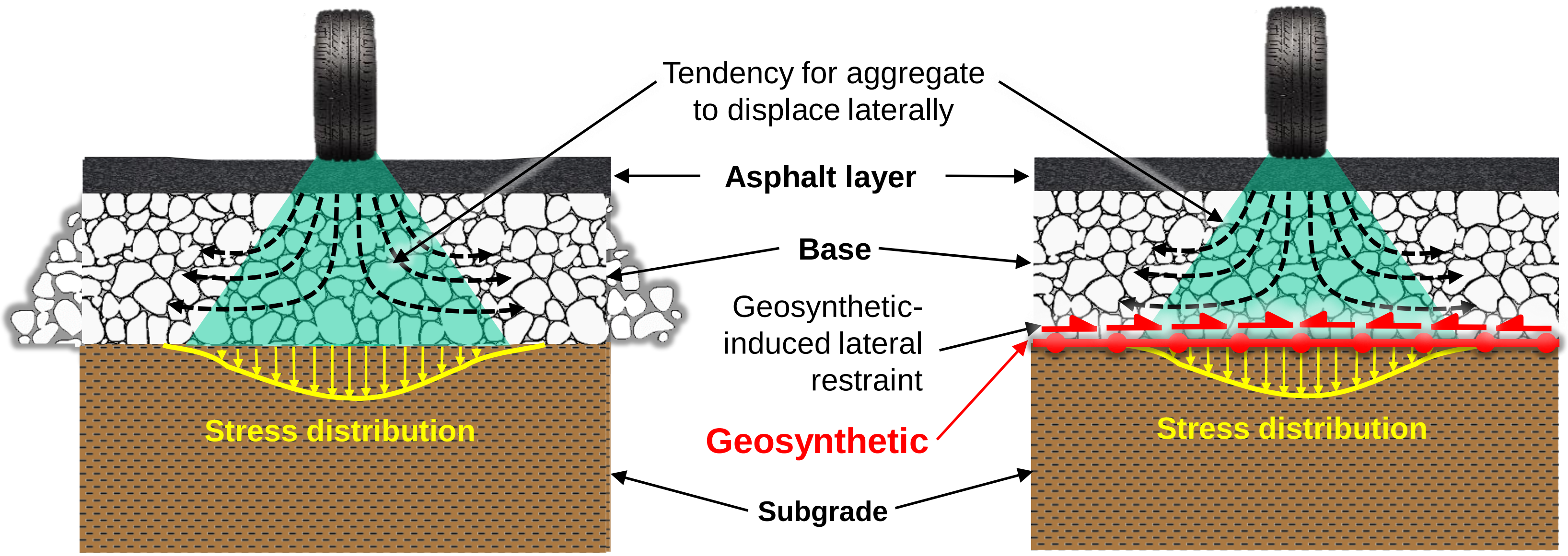
Minimize time-dependent lateral spreading and associated modulus decrease in base/ballast aggregate

Stabilization of Unbound Aggregate Layers: Mechanisms

Identified mechanism include:

- Develop lateral restraint to minimize the tendency of unbound aggregates to displace laterally

Stabilization of Unbound Aggregate Layers: <u>Mechanisms</u>

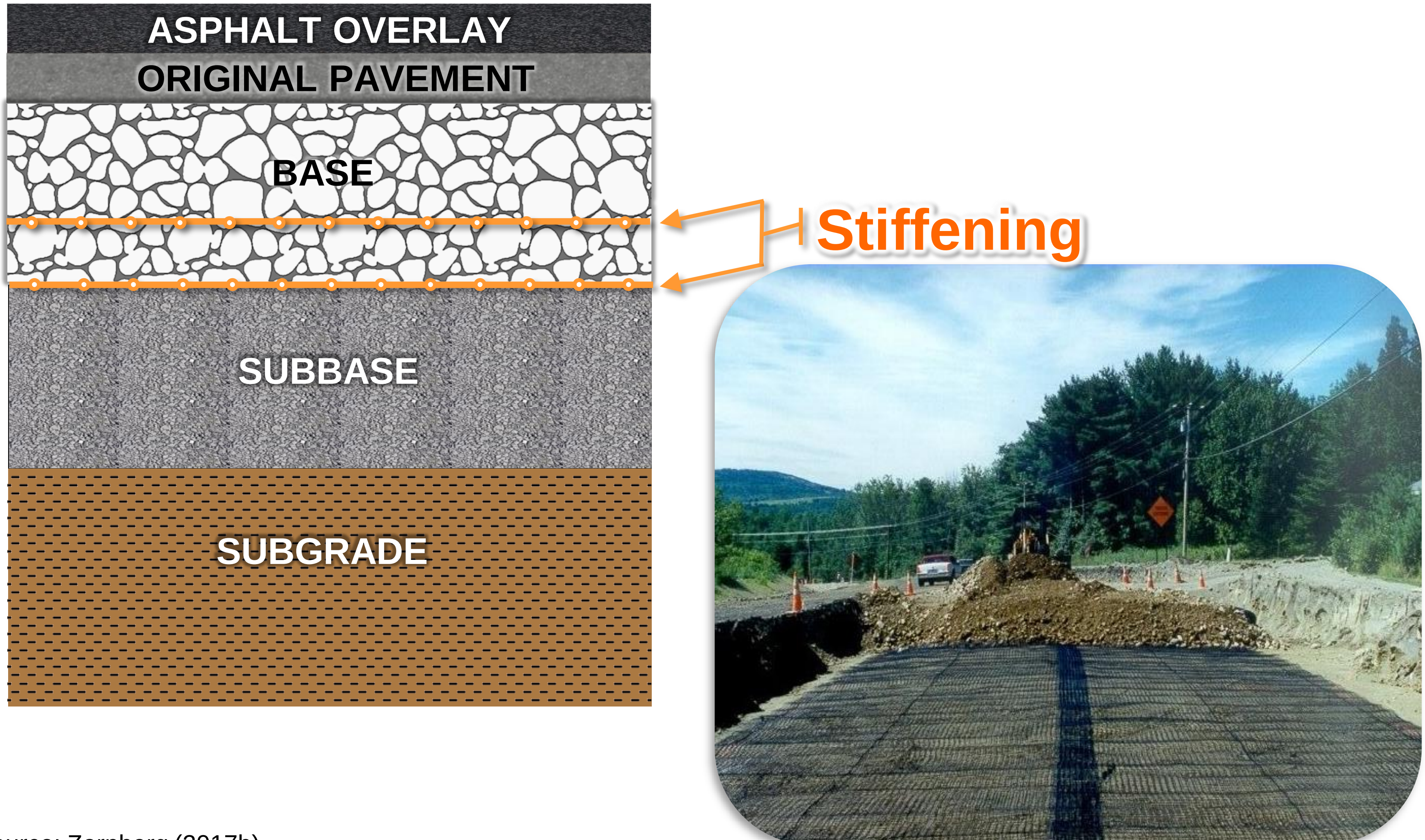


Non-stabilized Road Base

Stabilized Road Base

Source: Zornberg (2017)

Stabilization of Unbound Aggregate Layers: GS Functions

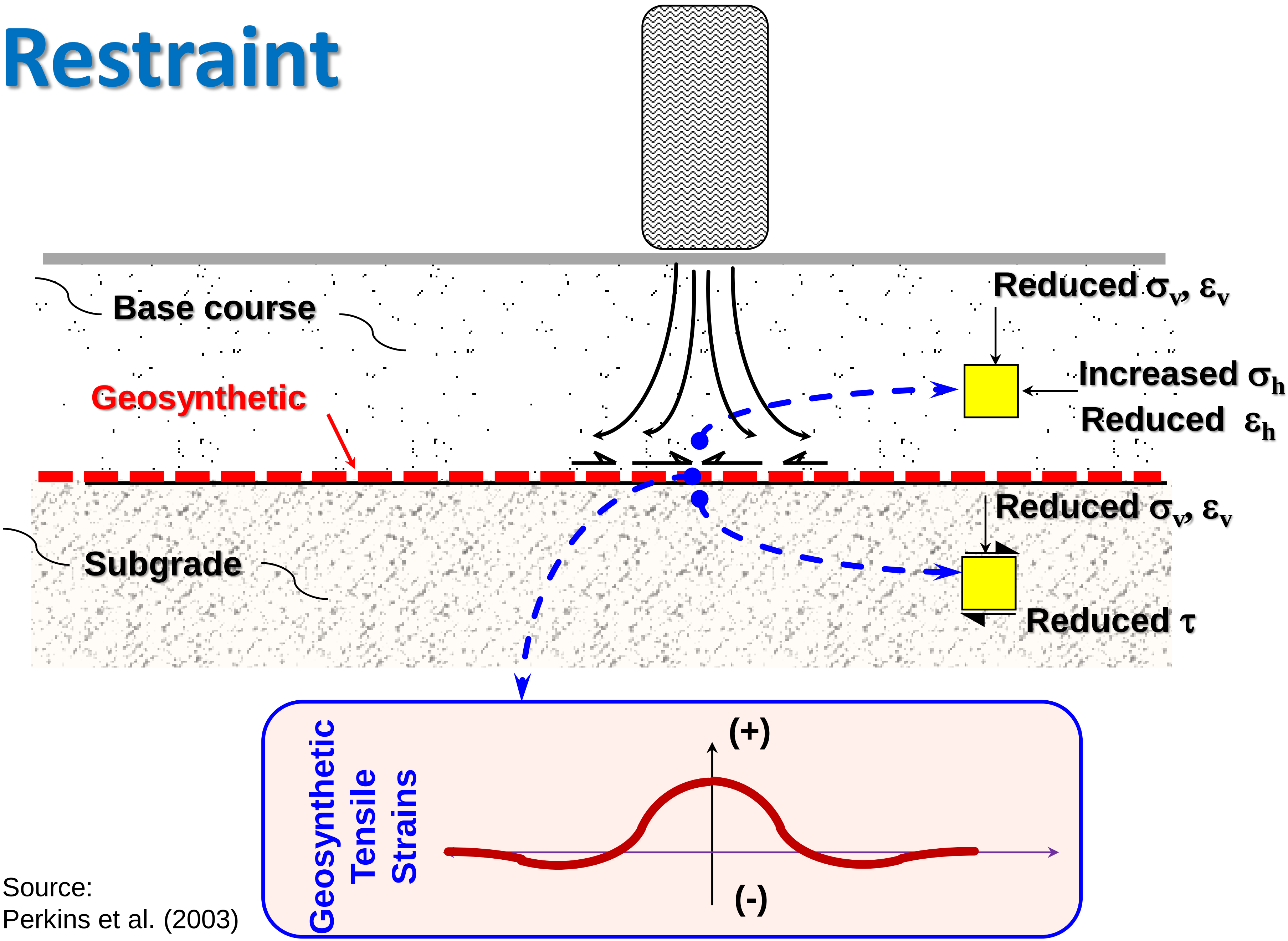


Source: Zornberg (2017b)

Stabilization of Unbound Aggregate Layers: GS Properties

- Stiffness of the soil-geosynthetic composite under small displacements
- Unconfined tensile stiffness
- Soil-geosynthetic interaction properties
- Junction strength

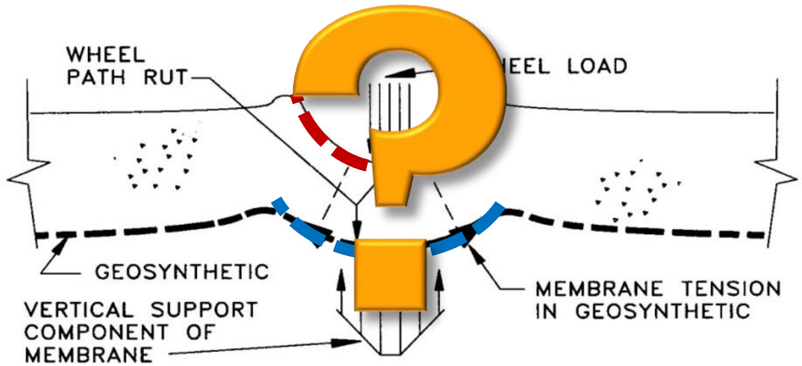
Basis for Lateral Restraint



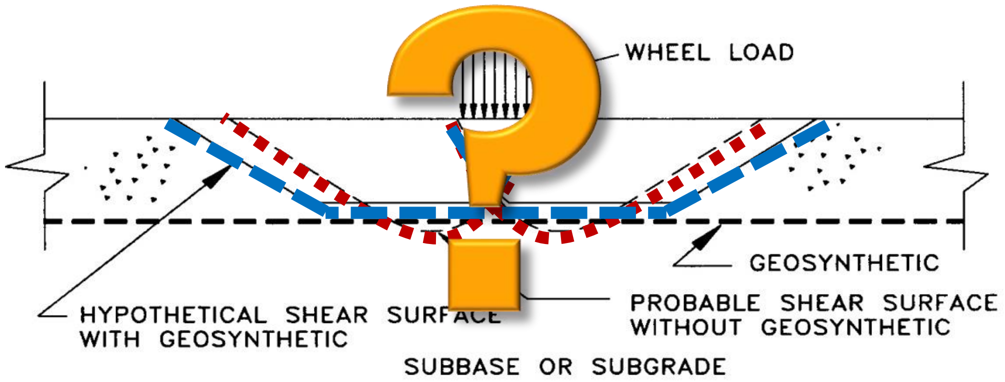
Source:
Perkins et al. (2003)

A New Property: Why?

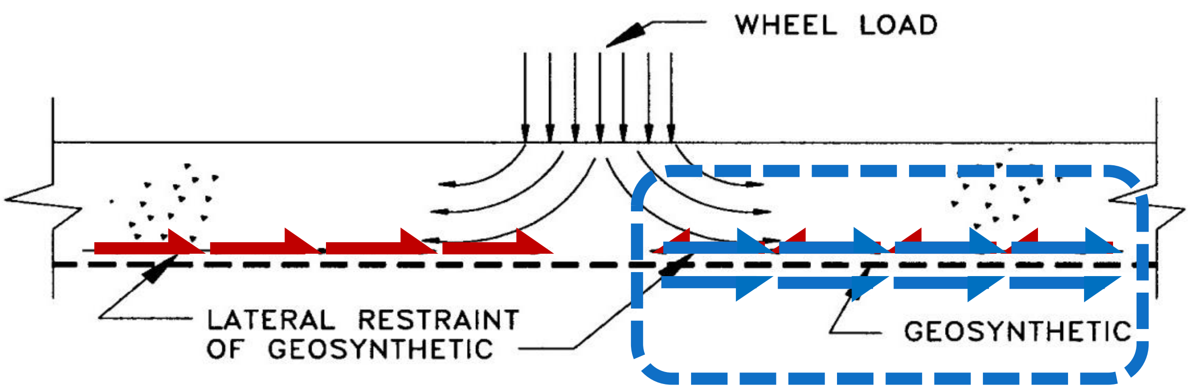
Back to the basics:



Membrane tension support



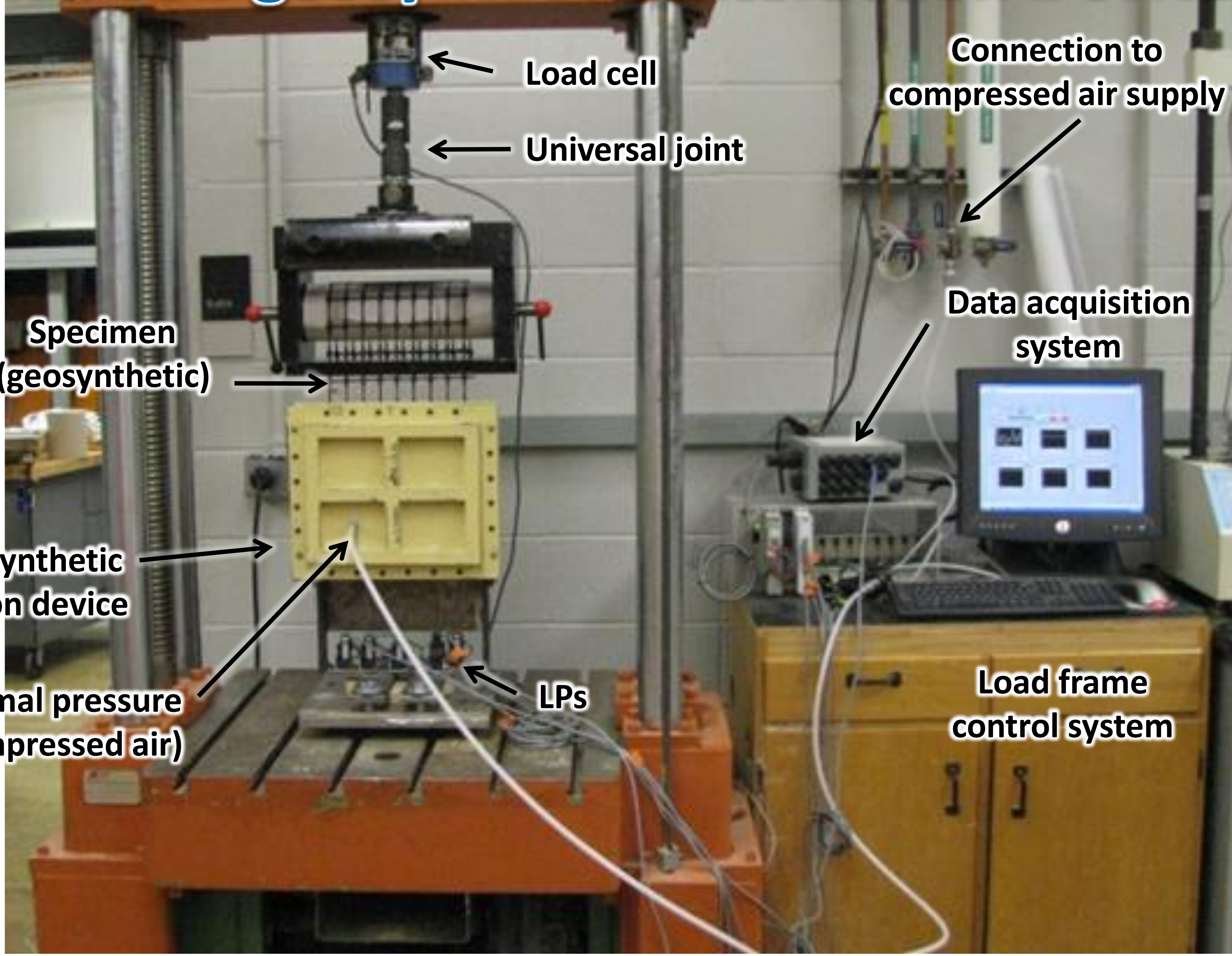
Bearing capacity increase

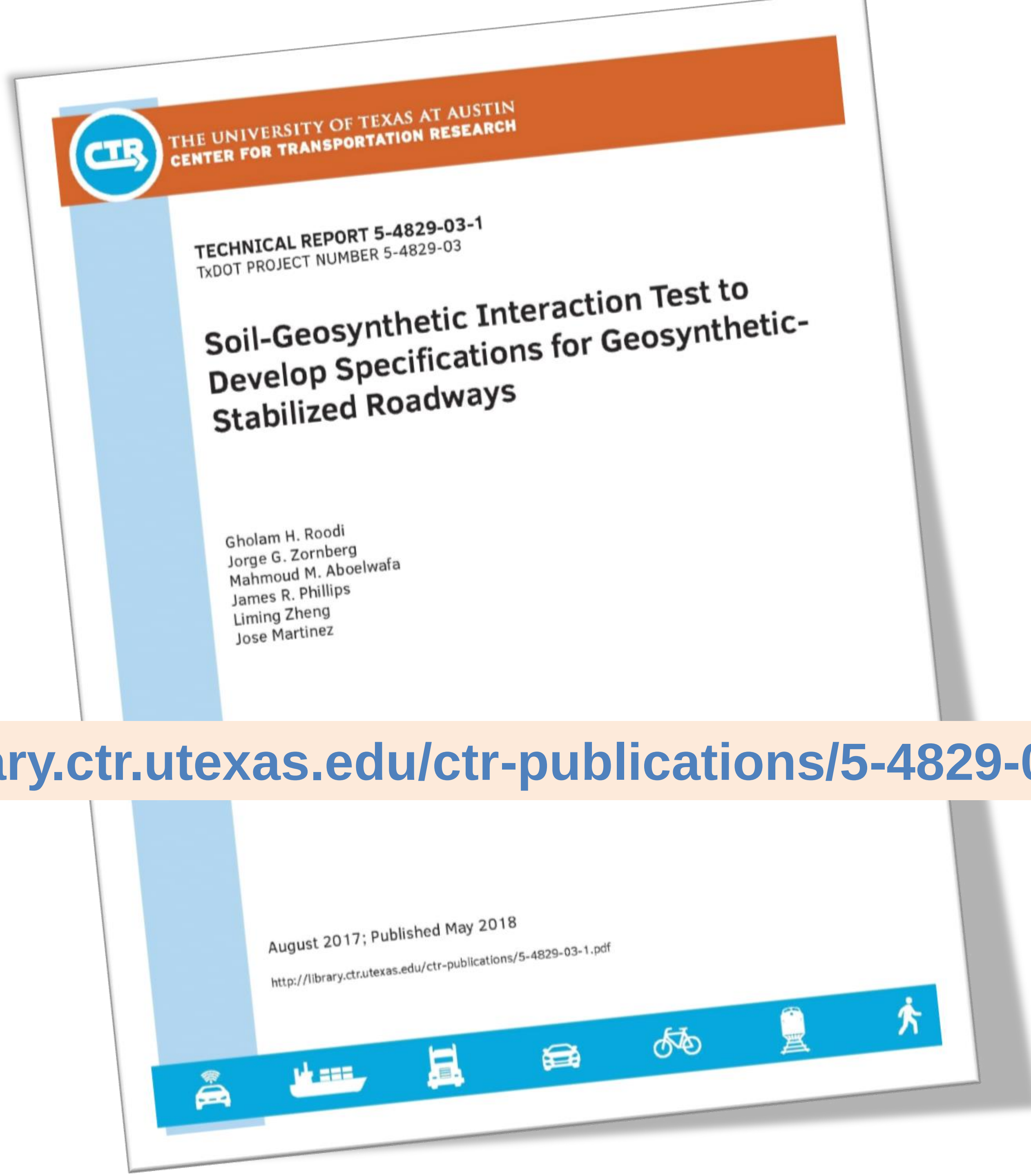


Lateral restraint

Source: Haliburton et al. 1981

Small Soil-geosynthetic Interaction Device




THE UNIVERSITY OF TEXAS AT AUSTIN
CENTER FOR TRANSPORTATION RESEARCH

TECHNICAL REPORT 5-4829-03-1
TxDOT PROJECT NUMBER 5-4829-03

Soil-Geosynthetic Interaction Test to Develop Specifications for Geosynthetic-Stabilized Roadways

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http://library.ctr.utexas.edu/ctr-publications/5-4829-03-1.pdf

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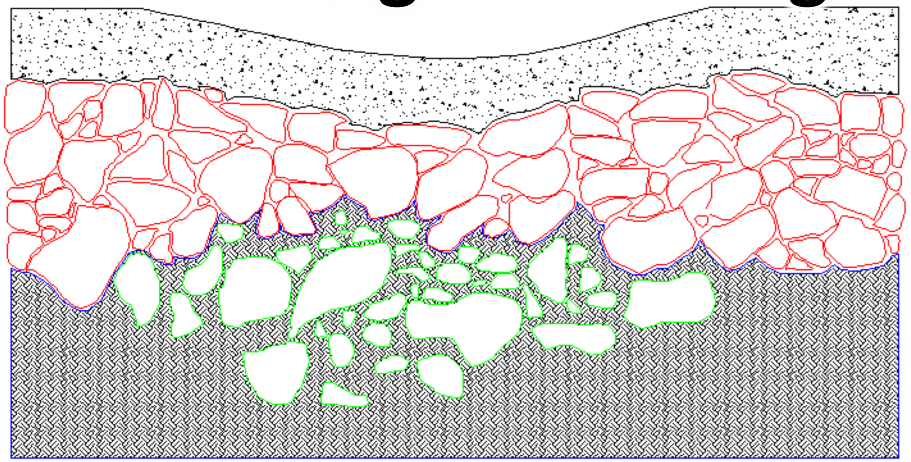
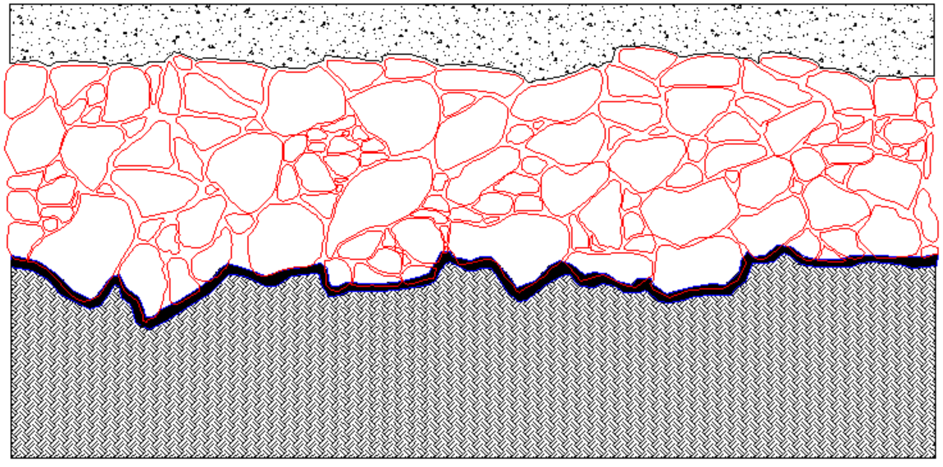
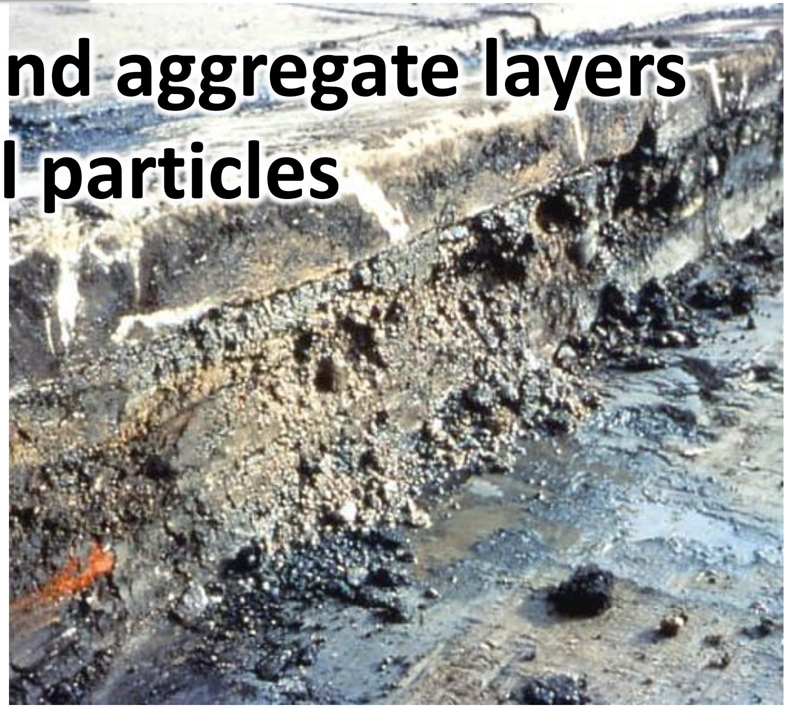
Reduction of Layer Intermixing: Objective

Avoid contamination of unbound aggregate layers with fine-grained subgrade soil particles





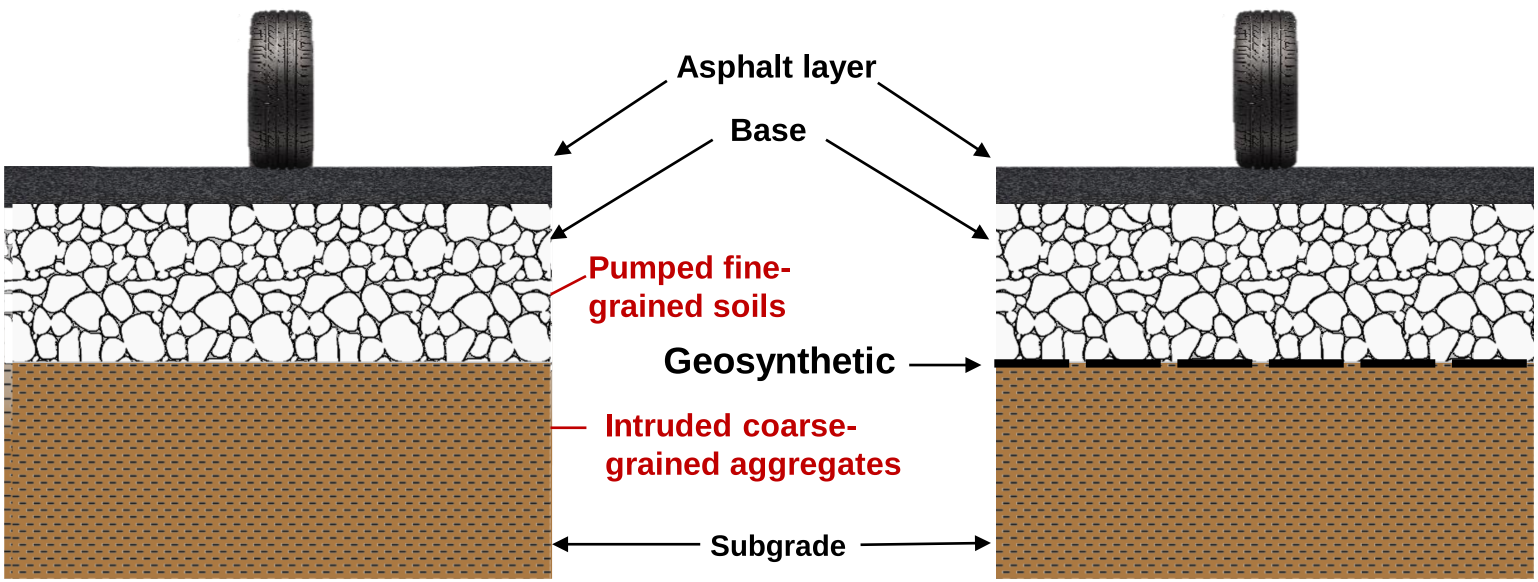


Reduction of Layer Intermixing: Mechanisms

Identified mechanisms include:

- Pumping of subgrade fine-grained soils:
  - Fines migrate from subgrade into aggregate voids
  - Migration results from pore water pressures generated in the subgrade
- Intrusion of base aggregates:
  - Localized penetration of individual aggregate particles into subgrade
  - Induced by local bearing capacity type failure mechanisms

Reduction of Layer Intermixing: Mechanisms

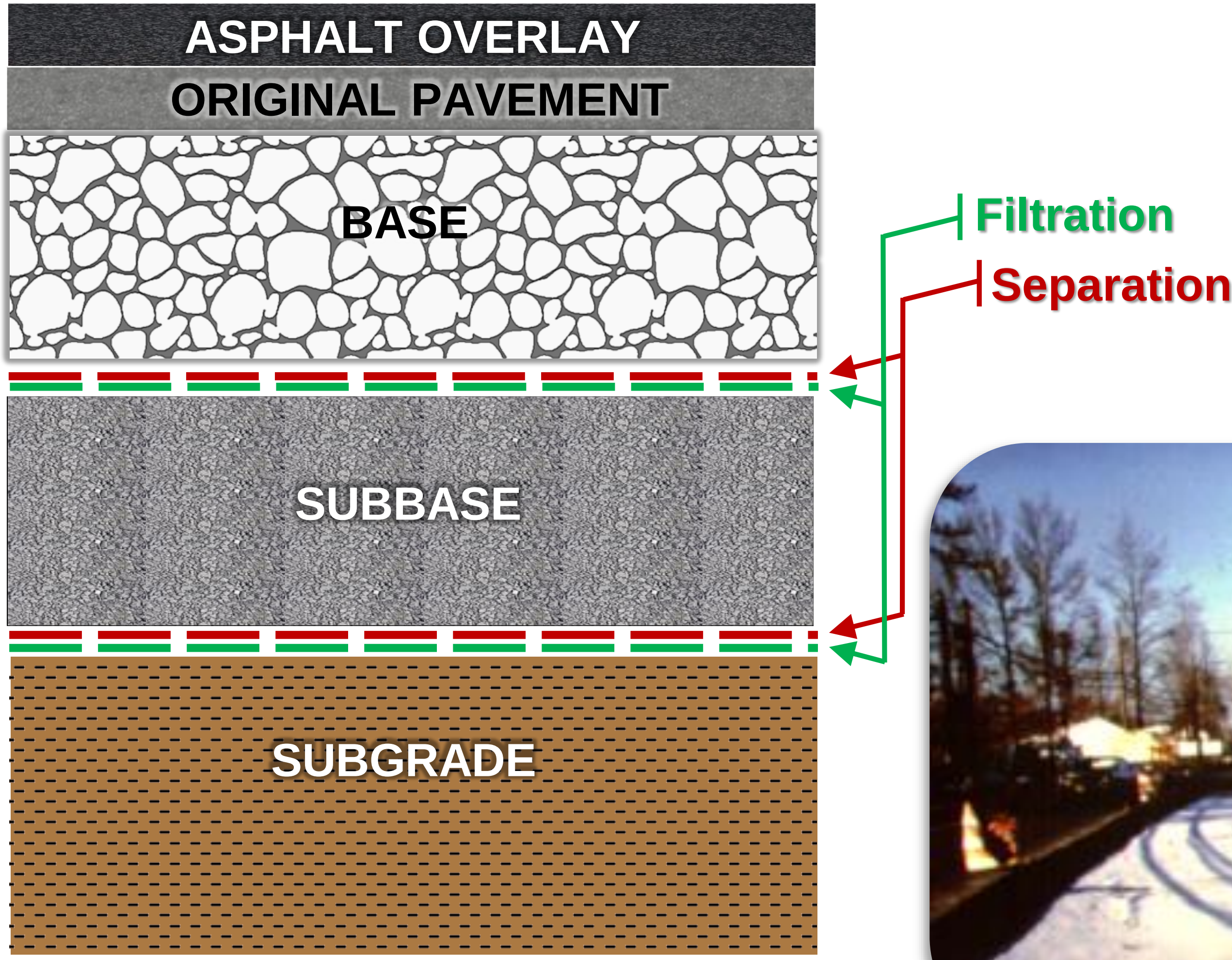


Road without Geosynthetic Separator

Road with Geosynthetic Separator

Source: Zornberg (2017)

Reduction of Layer Intermixing: GS Functions



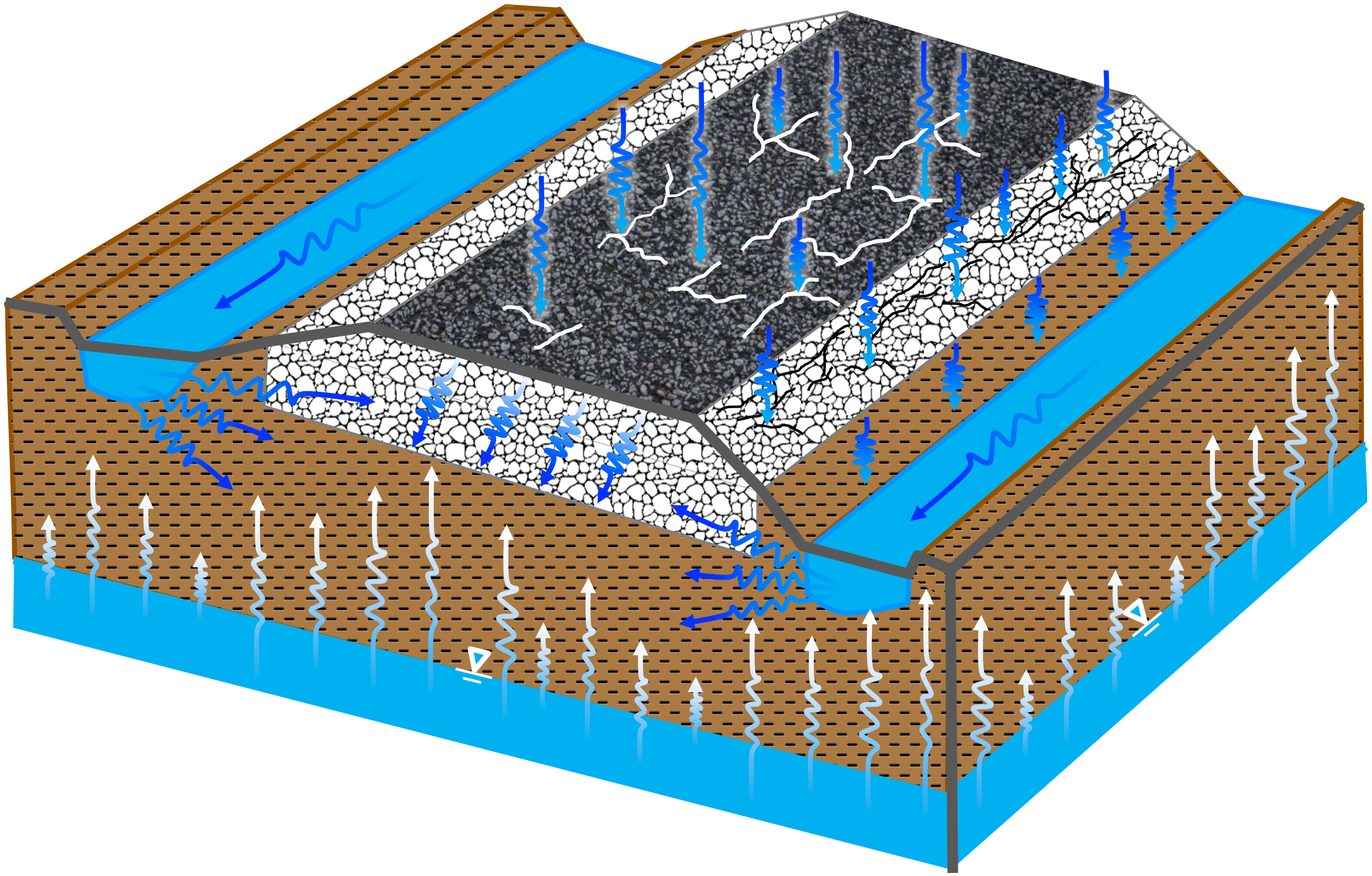
Source: Zornberg (2017a)

Reduction of Layer Intermixing: GS Properties

- Survivability-related properties
- Permittivity
- AOS

Moisture Reduction: Objective

Minimize the accumulation of moisture within structural layers



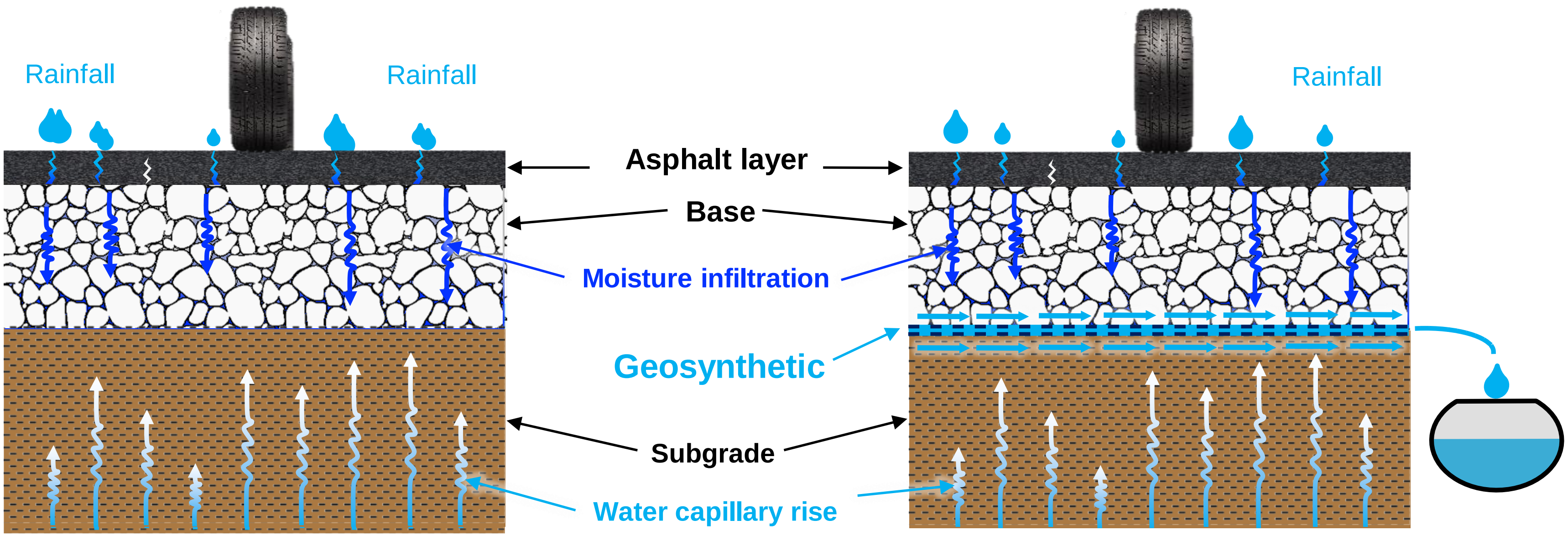
Source: Zornberg et al. (2016)

Moisture Reduction: Mechanisms

Identified mechanisms include:

- Conventional (gravity-driven) lateral drainage:
  - Involves in-plane flow that occurs under saturation of the soil-geotextile interface:
    - In Non-Woven Geotextiles: Through the large void spaces in its open structure
    - In Woven Geotextiles: Through void spaces of crossed-over yarns
  - Does not allow decrease of soil moisture stored within the pores under unsaturated conditions
- Enhanced (suction-driven) lateral drainage:
  - Involves in-plane flow that occurs under unsaturated conditions
  - Allows decrease of soil moisture stored within the pores under unsaturated conditions

Moisture Reduction: Mechanisms

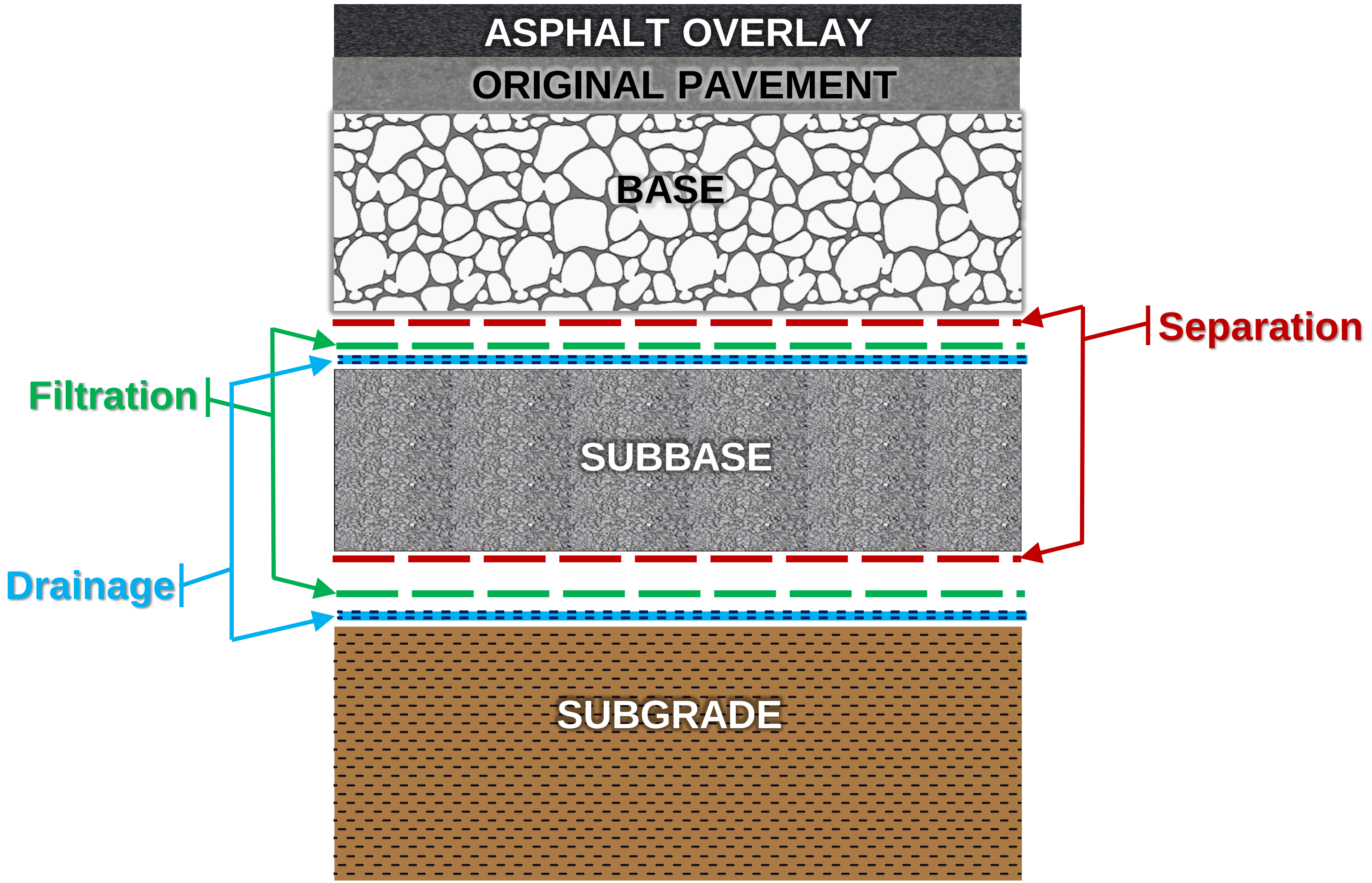


Road without Lateral Drainage

Road with Lateral Drainage

Source: Zornberg et al. (2017)

Moisture Reduction: GS Functions



Source: Zornberg (2017a)

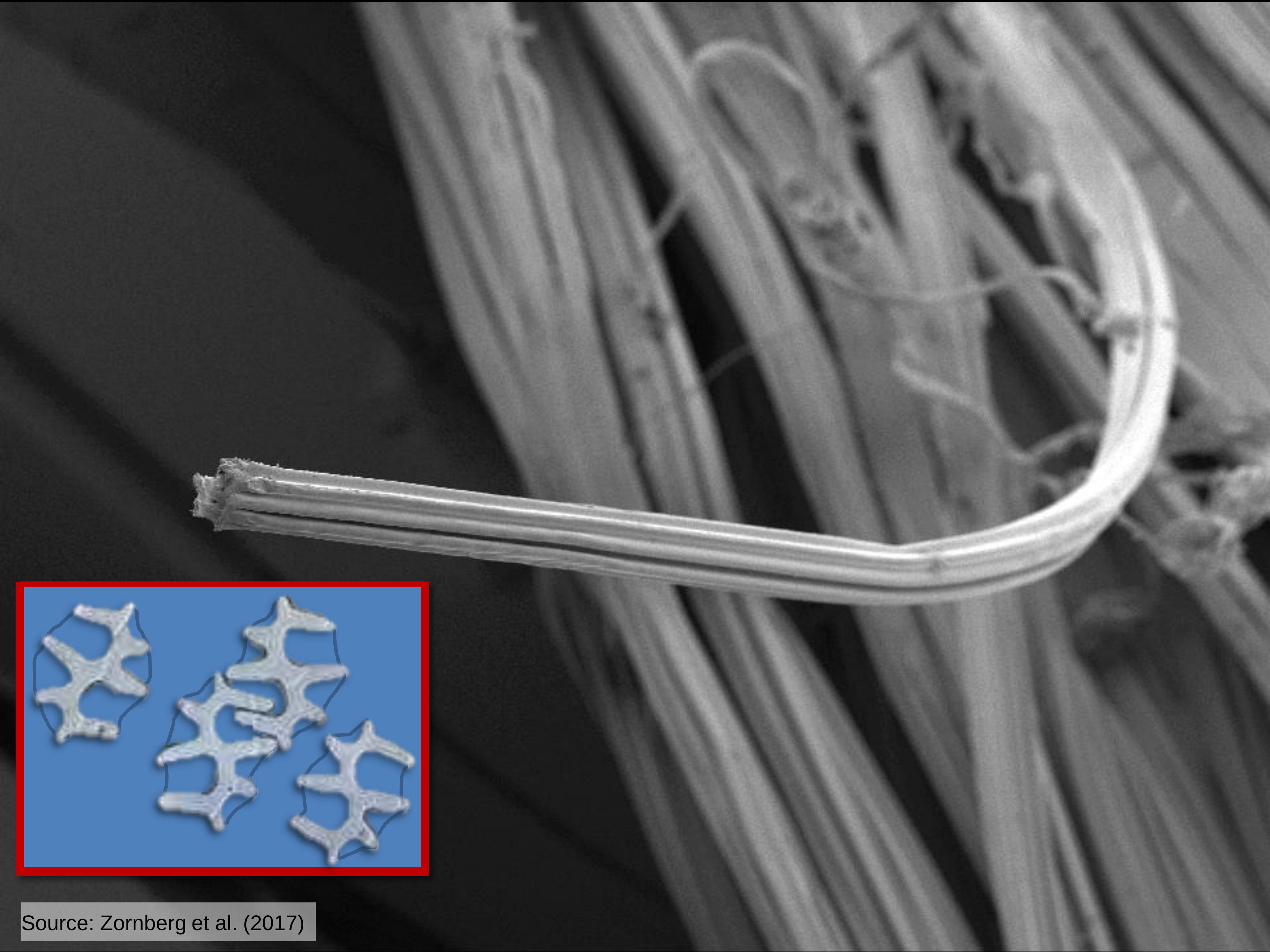
Moisture Reduction: GS Properties

- Transmissivity
- Suction-driven flow capacity
- Permittivity
- AOS
- Survivability-related properties

Moisture Reduction

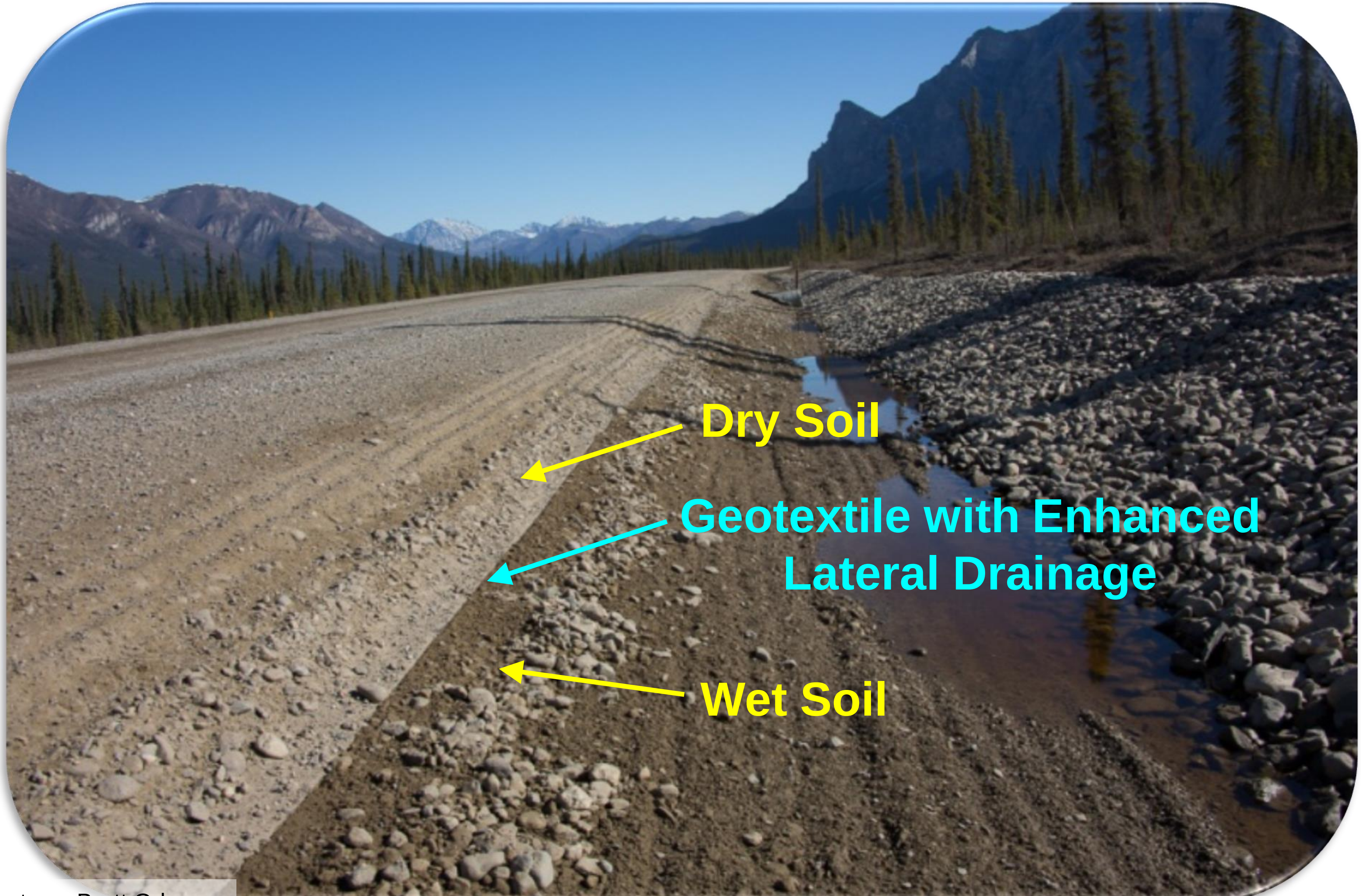
GS products have included:

- NW Geotextile separation/filter for free draining base and/or subbase layers
- Geocomposite horizontal drainage layers (to replace or augment free draining base)
- Woven geotextiles with enhanced lateral drainage capabilities ("wicking" geotextiles)



Source: Zornberg et al. (2017)

Dalton Highway, Alaska



Courtesy: Brett Odgers

Subgrade Stabilization: <u>Objective</u>

Increase the bearing capacity of subgrade soils

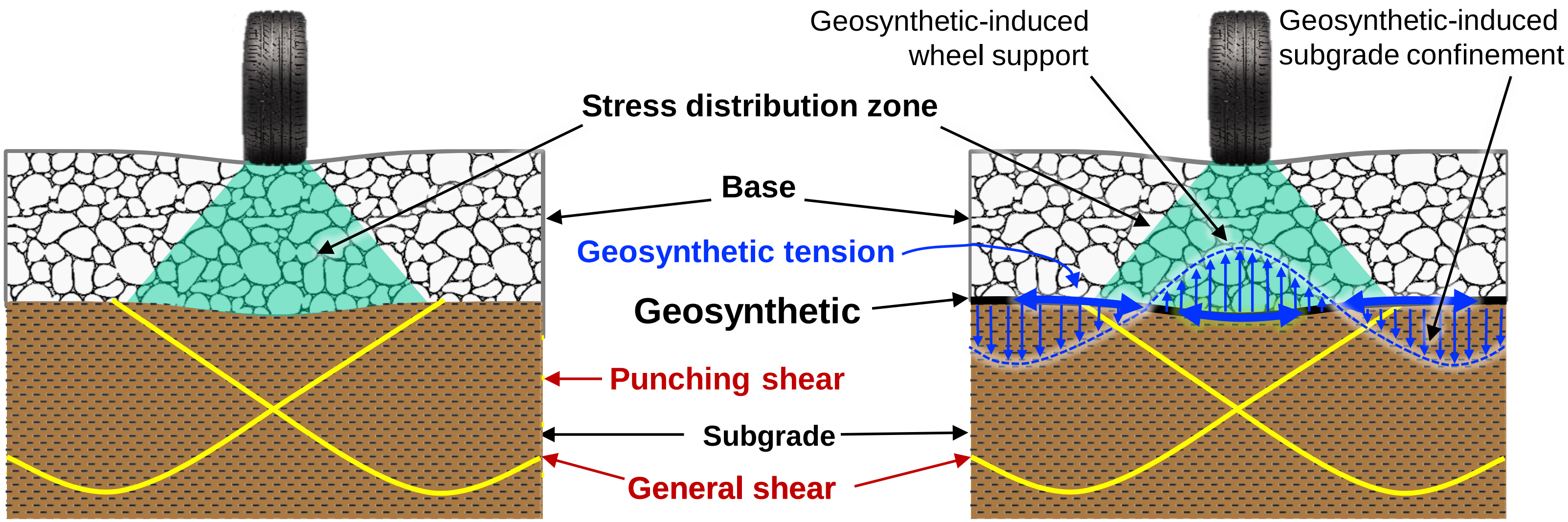
Source: Geosynthetic Institute (GSI)

Subgrade Stabilization: Mechanisms

Identified mechanisms include:

- Vertical restraint of the subgrade:
  - Accounts for the increased vertical confinement induced by the geosynthetic
  - Provides a relevant contribution to subgrade stabilization
- Membrane effect:
  - Requires significant deflection of the subgrade
  - Provides a comparatively minor contribution to subgrade stabilization

Subgrade Stabilization: Mechanisms

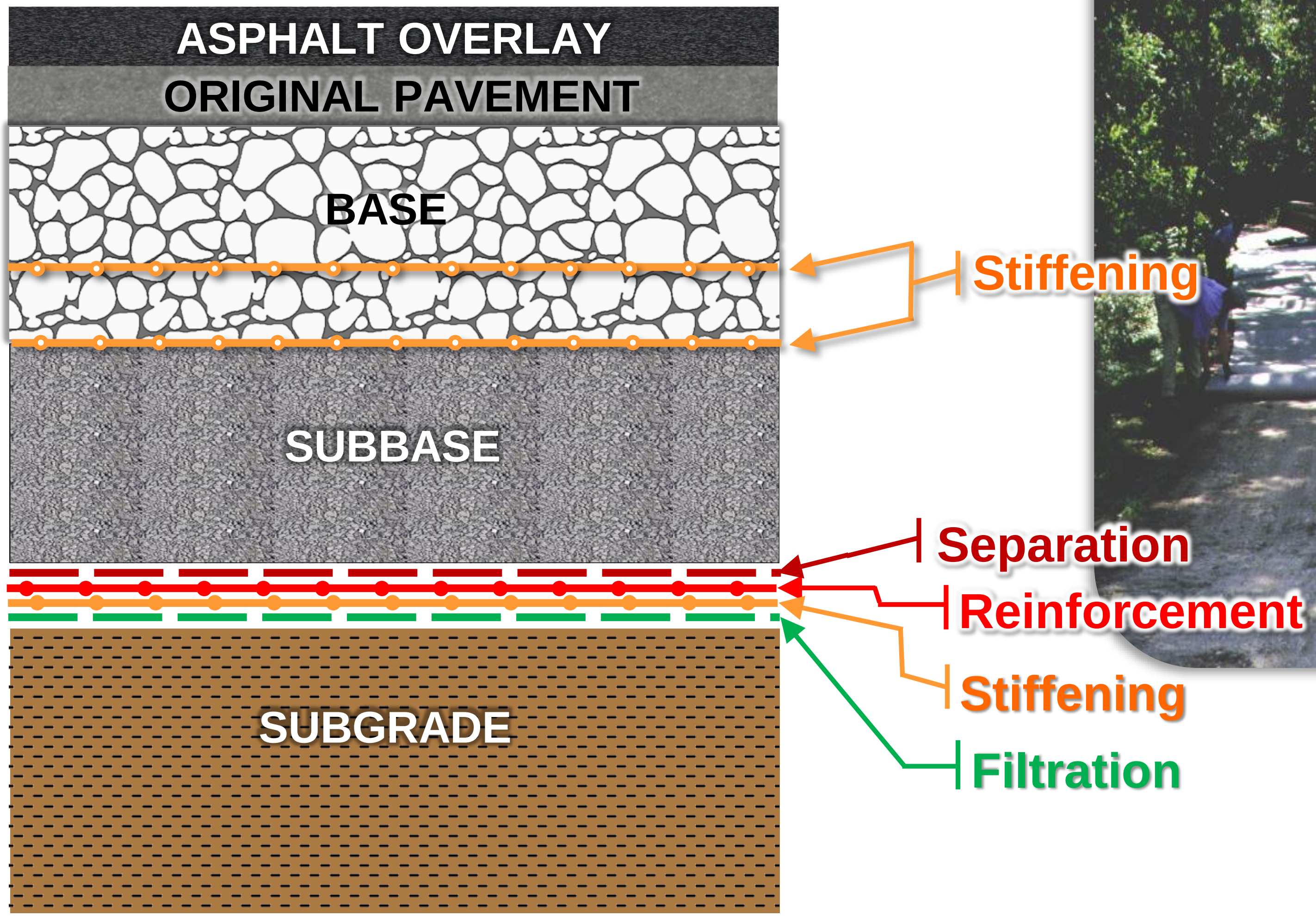


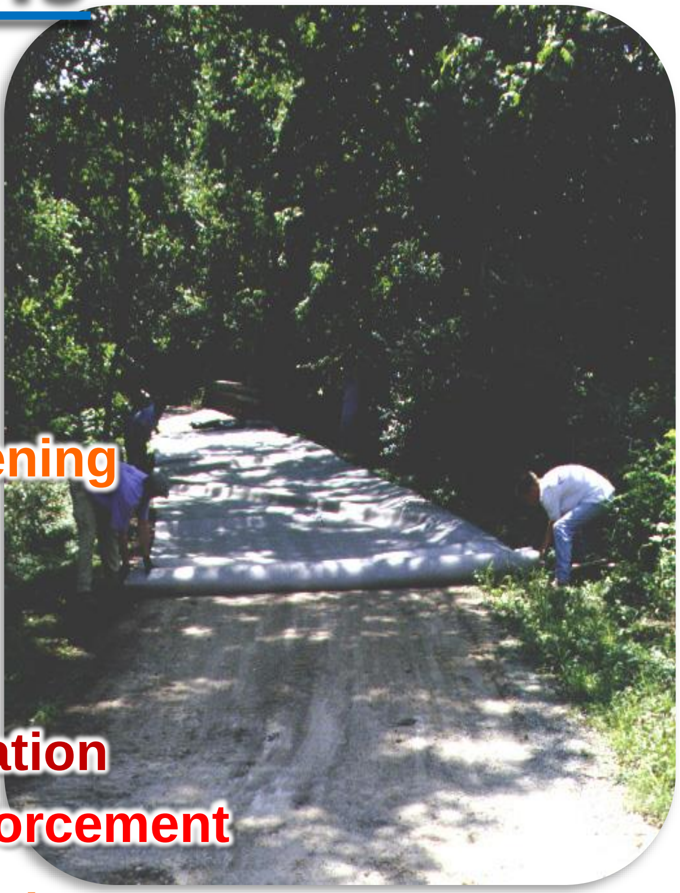
Non-stabilized Road Subgrade

Stabilized Road Subgrade

Source: Zornberg (2017)

Subgrade Stabilization: GS Functions





Source: Zornberg (2017)

Subgrade Stabilization: GS Properties

- Ultimate tensile strength
- Reduction factors (installation damage, creep, degradation)
- Unconfined stiffness
- Stiffness of the soil-geosynthetic composite
- Permittivity
- AOS
- Survivability-related properties

Source: Geosynthetic Institute (GSI)

Source: Geosynthetic Institute (GSI)

Mitigation of Environmental Distress: <u>Objective</u>

Retard or eliminate environmental longitudinal cracks induced by volume changes due to expansive or frost-susceptible subgrade soils

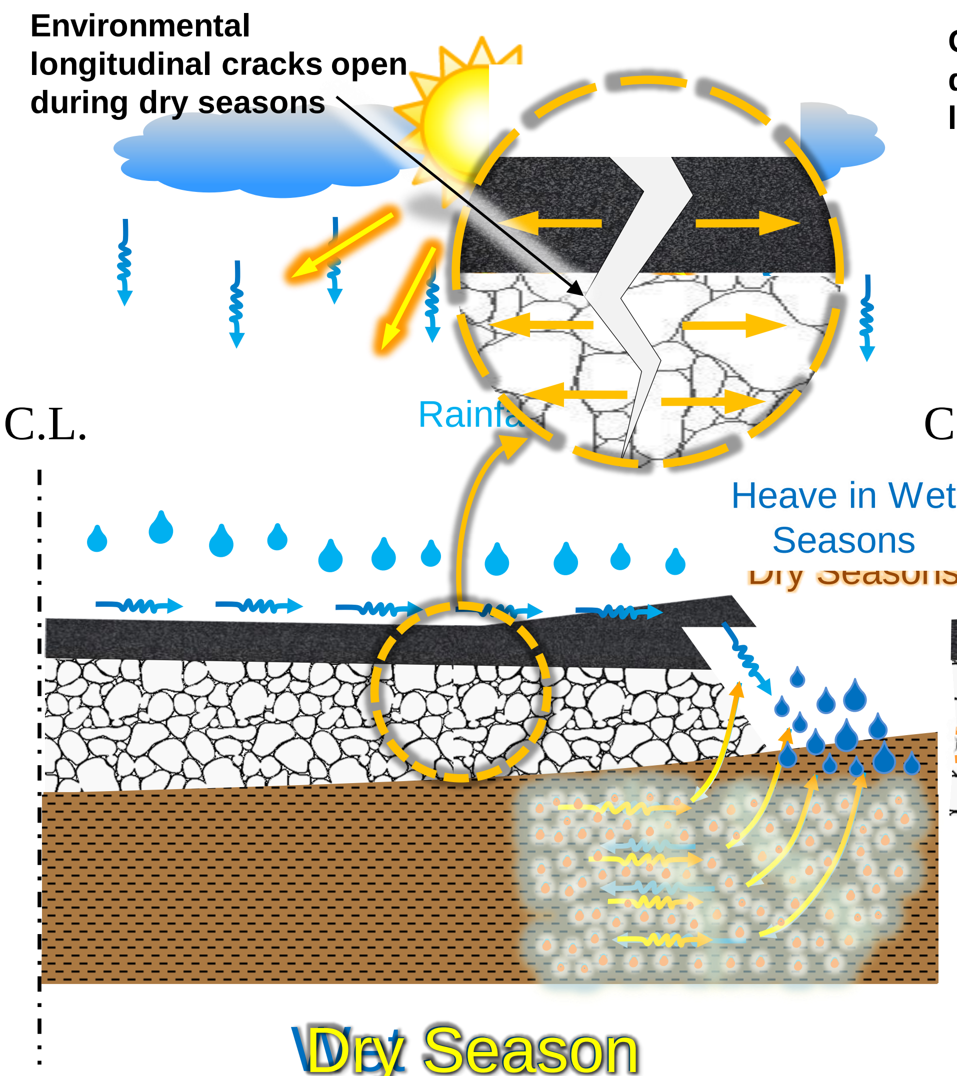
Mitigation of Environmental Distress: Mechanisms

Identified mechanisms include:

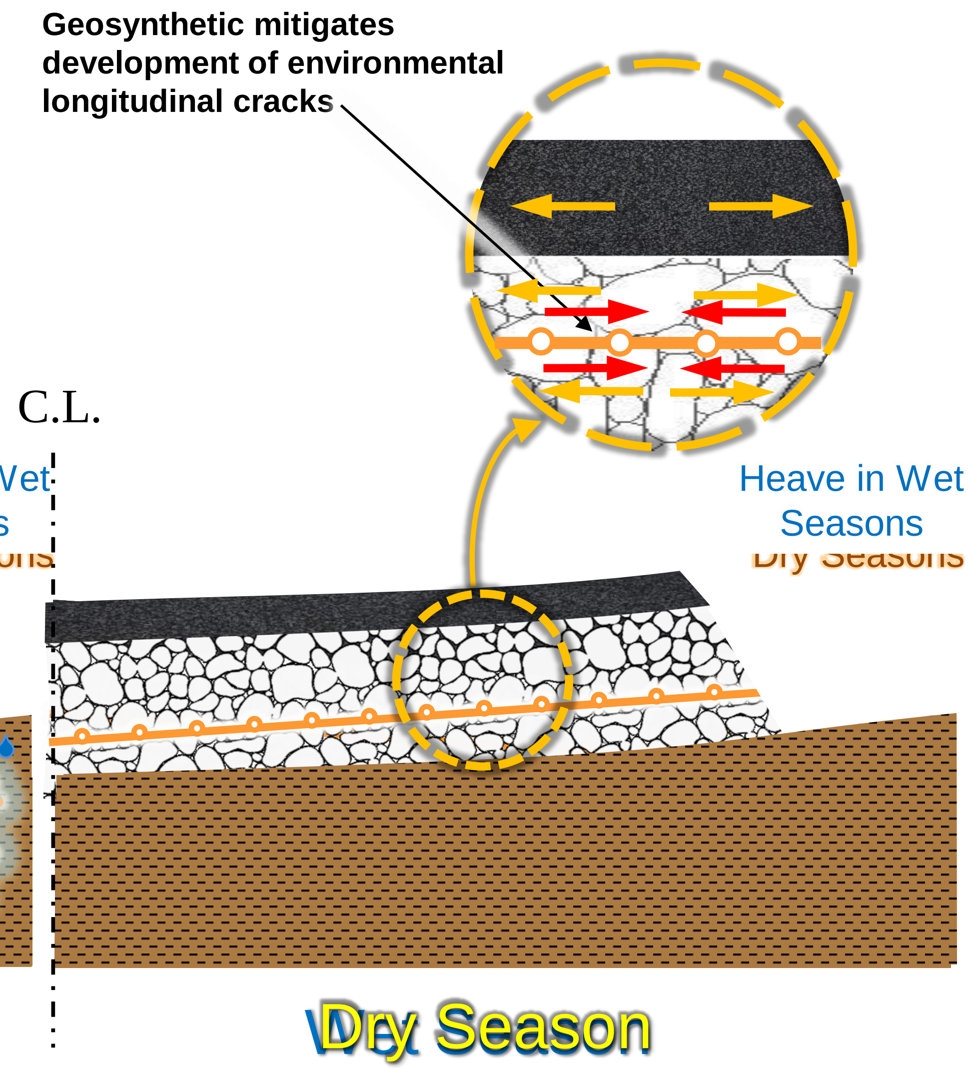
- Providing lateral restraint to the base layer:
  - Maintaining the base lateral confinement
  - Maintaining homogeneity in base mechanical properties
- Adding ductility to the base layer:
  - Minimizing the concentration of stresses responsible for triggering longitudinal cracks
  - Maintaining the integrity of the base layer

Mitigation of Environmental Distress: Mechanisms

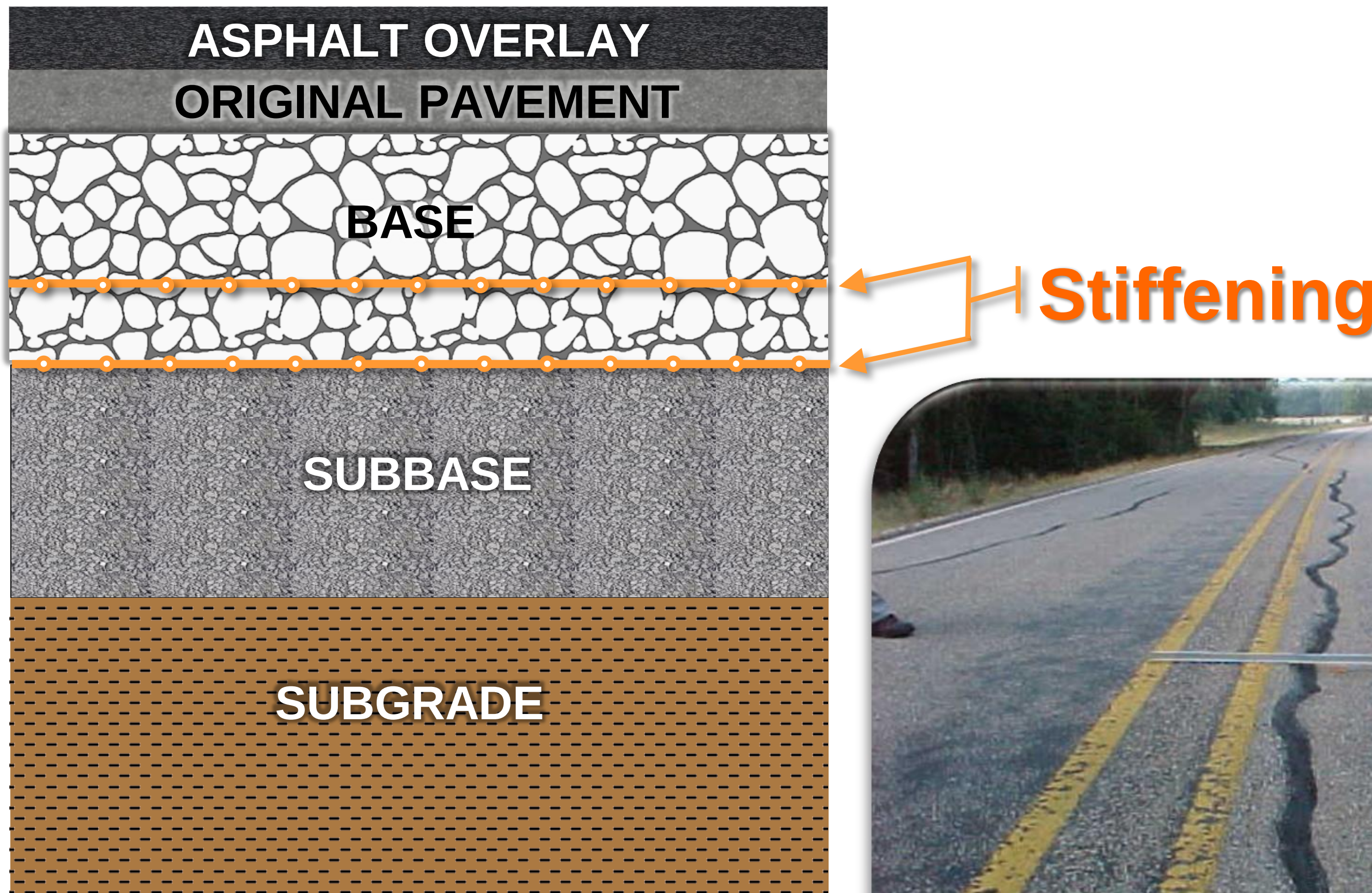
Non-Stabilized Roadway



GS-Stabilized Roadway



Mitigation of Environmental Distress: GS Functions



Source: Zornberg et al. (2018)

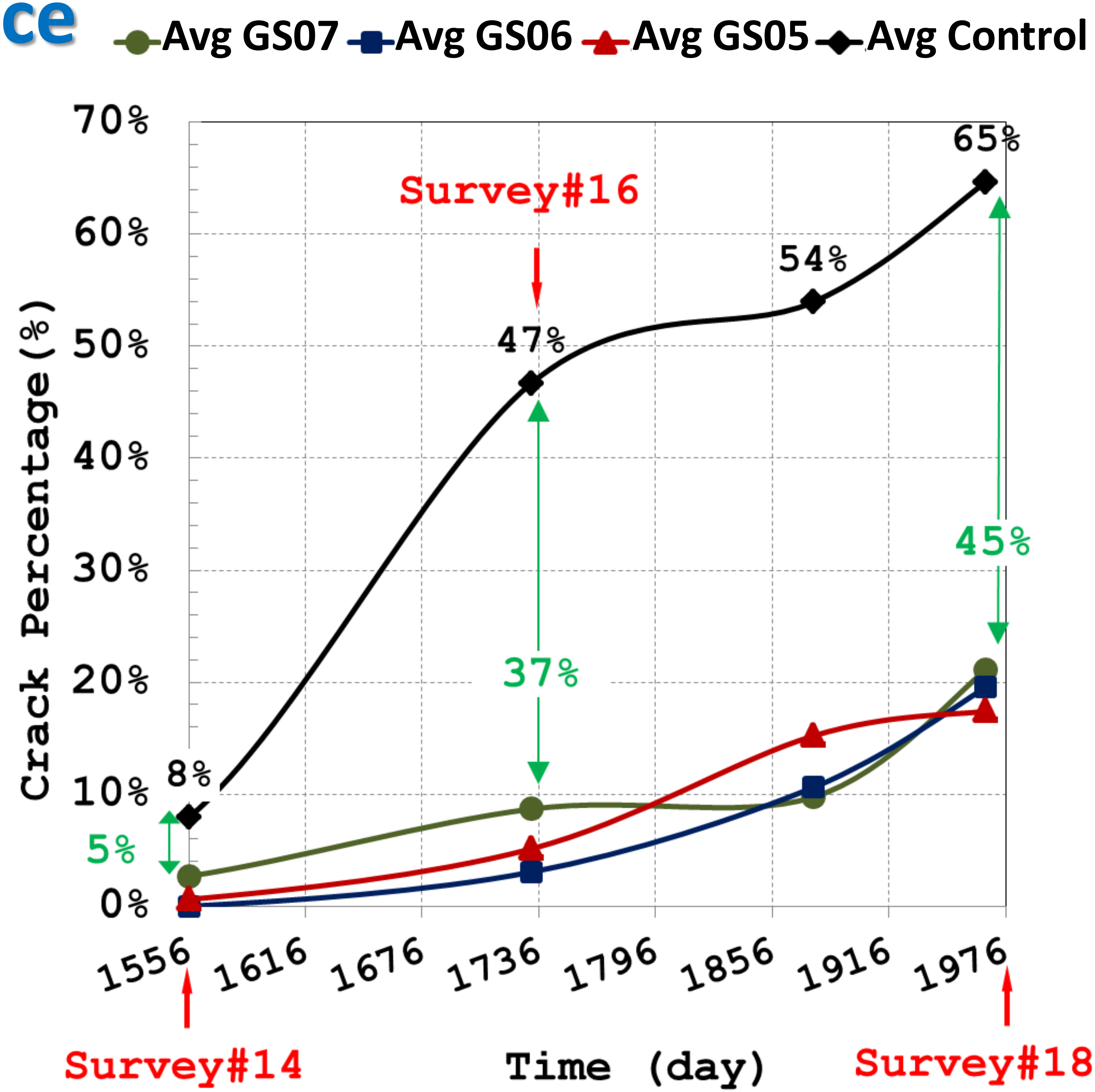
Mitigation of Environmental Distress: GS Properties

- Stiffness of the soil-geosynthetic composite under small displacements
- Unconfined tensile stiffness
- Soil-geosynthetic interaction properties
- Junction strength

Geosynthetic-stabilized Section

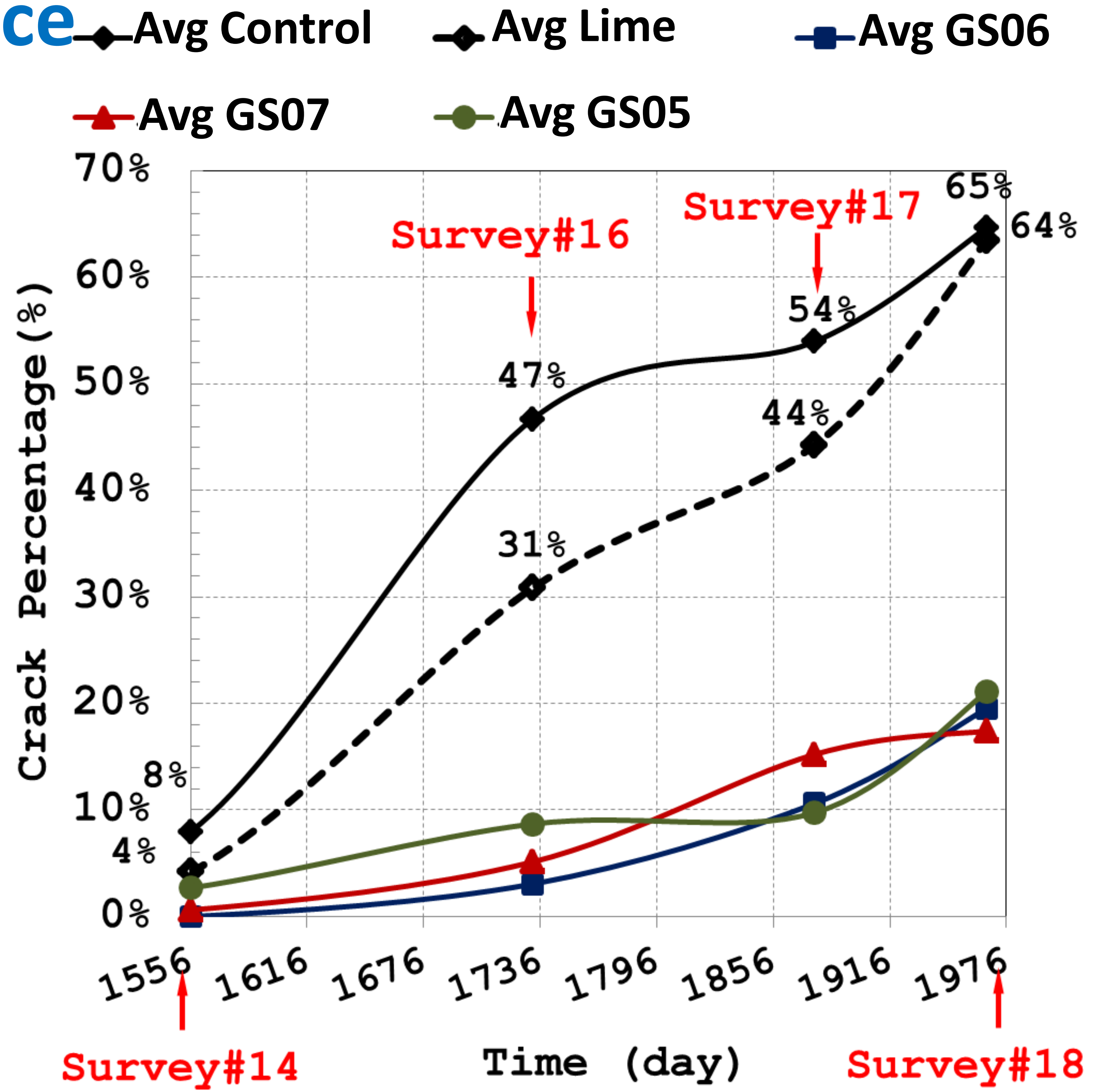
Control Section

Performance over time



Control and Geosynthetic-stabilized Sections (Survey #14 to #18)

Performance over time



Control, Lime-treated, and Geosynthetic-reinforced Sections (Survey #14 to #18)

Summary

- Applications of GSs in Roadways involve well-defined mechanisms and geosynthetic functions
- There are significant opportunities for design improvement by using GS in applications such as:
  - Stabilization of subgrades
  - Reduction of layer intermixing
  - Moisture reduction
  - Stabilization of base/ballast layers
  - Mitigation of reflective cracking in structural asphalt overlays
  - Mitigation of environmental distress
- Identification of the mechanisms in each application is key to determine the relevant GS Functions
- Identification of the relevant GS Functions is key to determine the appropriate GS Properties for design and specification

Final Remarks

In roadway applications:

- Geosynthetics have been demonstrated to improve, often significantly, the system performance
- Geosynthetics have generally led to cost-effective solutions
- Geosynthetics have consistently resulted in more sustainable alternatives

Thank You