Innovative Moisture-Managing Reinforcement (MMR) Geosynthetic for Mechanical and Hydraulic Stabilization

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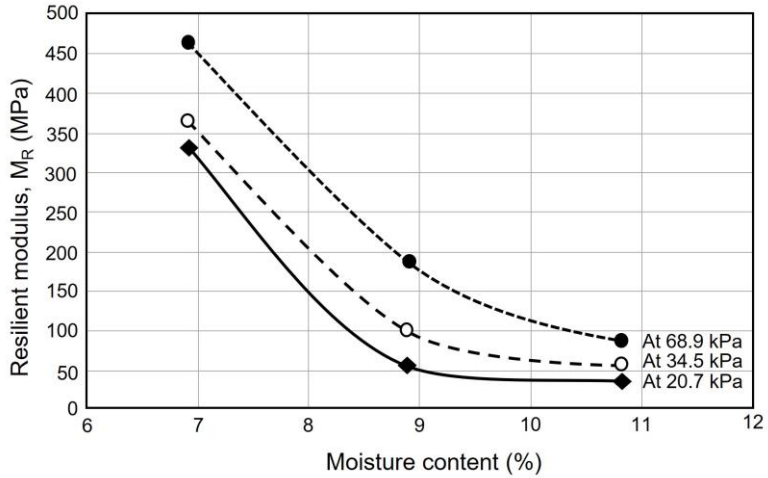
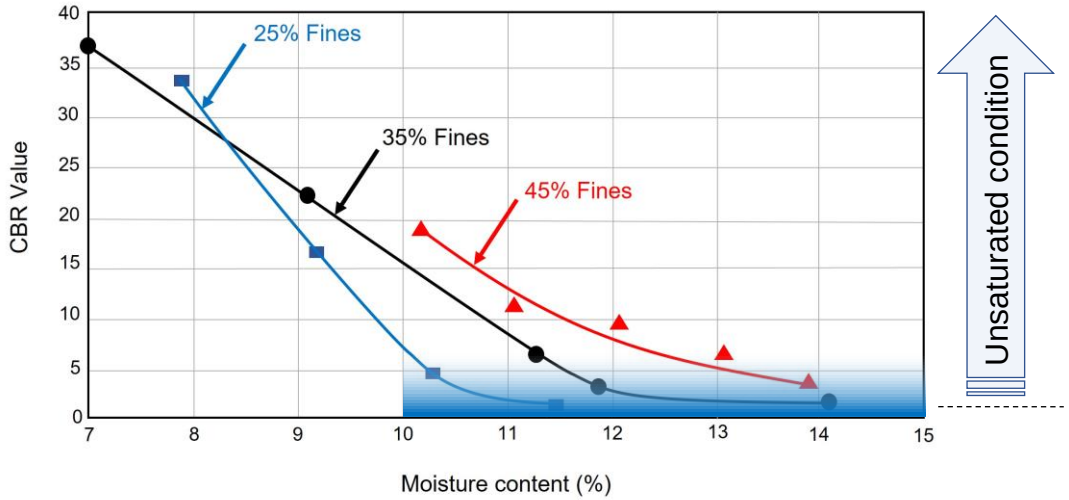
Introduction

- Roads and railways are generally constructed in the Vadose Zone; therefore, the subgrade and gravel layers above them typically exist under unsaturated conditions, except perhaps transiently during rainfall or floods
- An increase in moisture content will result in the weakening of gravel layers and subgrade
- For effective moisture management of the load bearing gravel layers and subgrade, the moisture management system provided needs to perform effectively under unsaturated conditions



Basecourse resilient modulus vs moisture content at various overburden (Lin et al., 2016)

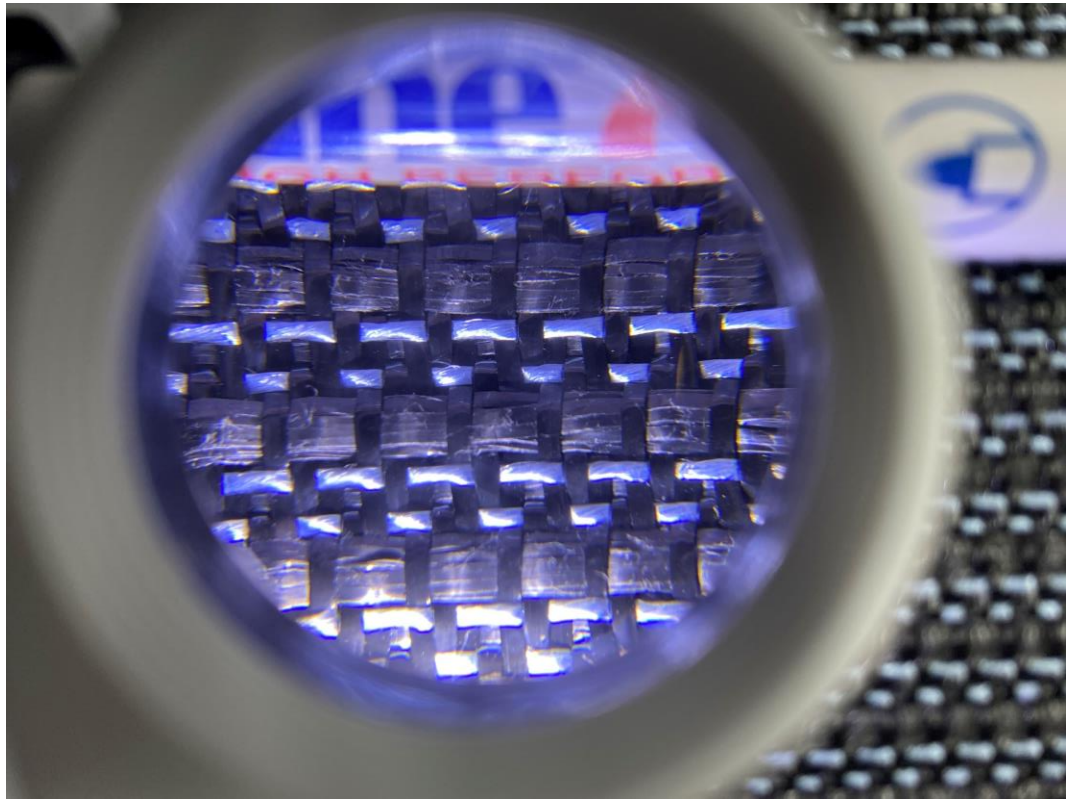


CBR vs moisture content for low plasticity soils with various percentage fines component content (Jenkins and Kerr, 1998)

The Innovative Moisture-Managing Reinforcement Geosynthetic

MMR Geosynthetic:

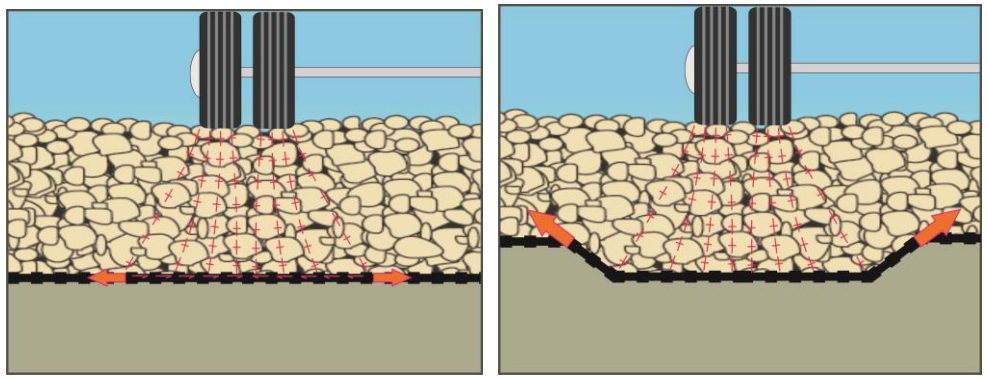
- Is a woven geotextile comprising of super high tenacity polypropylene yarn for mechanical properties and proprietary moisture wicking yarn for moisture management properties
- Has very high tensile strength at 2% strain for mechanical stabilization performance
- Has excellent moisture suction capability to reduce capillary water in soil and gravel, as well as to remove wicked moisture through lateral in-plane capillary flow for moisture management performance



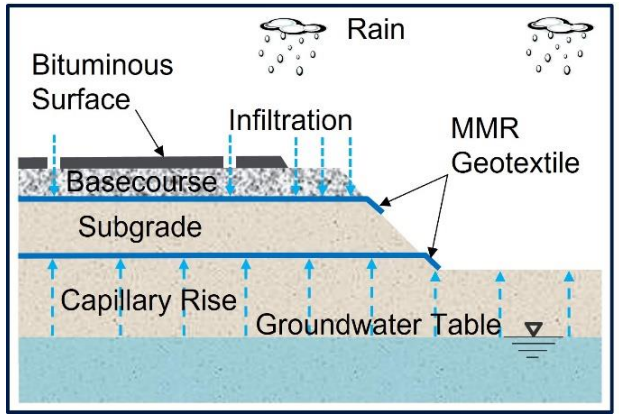
Mirafi® H_2Ri and Mirafi® H_2Rx

Reinforcement and Moisture Management Mechanisms of MMR Geosynthetic

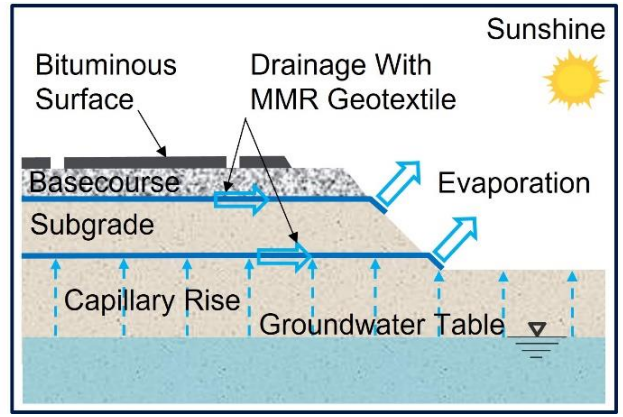
- The reactive tensile stiffness modulus of the geosynthetic, quantified by the tensile strength at 2% axial strain, play a significant role in suppressing deformation (Cuelho and Perkins, 2009; Cuelho et al, 2011)
- Wicking or Suction is a “new” geosynthetic function
- MMR Geosynthetic moves capillary water in-plane from a point of lower suction potential (wetter) to a point of higher suction potential (dryer)
- After rainfall the atmosphere RH drops; creating the suction differential for in-plane moisture flow out and removal through evaporation



The reactive tensile stiffness modulus of the geosynthetic restrains deformation (a geosynthetic function defined as reinforcement)



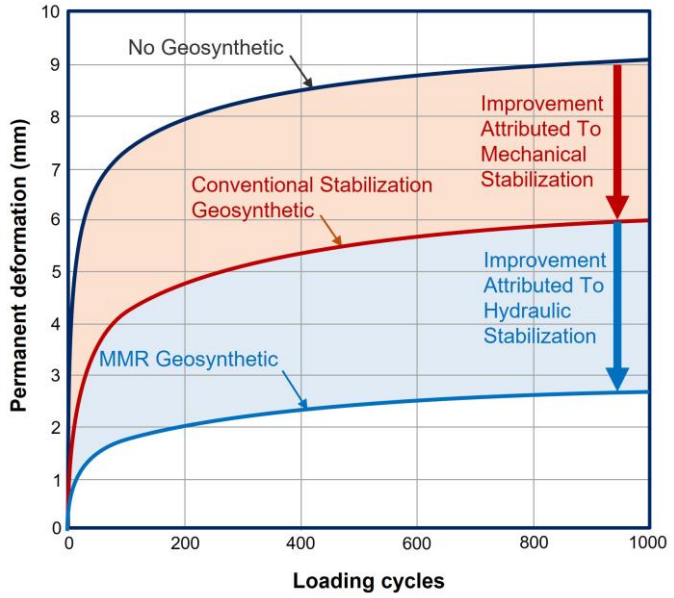
MMR Geosynthetic intercepts rainfall infiltration and capillary rise and drains out gravitational water



MMR Geosynthetic removes capillary water through internal suction and evaporation after rainfall event

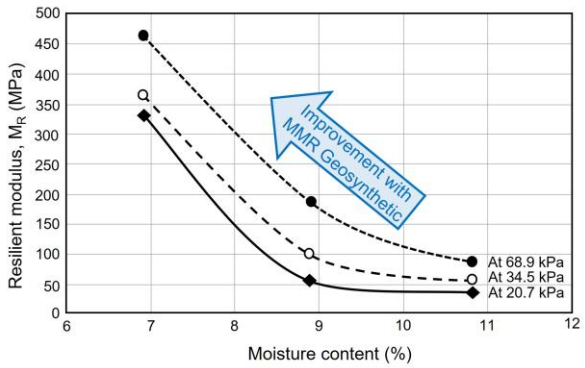
Mechanical and Hydraulic Stabilization of Gravel Structural Layers

- **<u>MMR Geosynthetic</u> improves the Basecourse Resilient Modulus and Performance**
  - Provides high tensile strength at 2% strain to mechanically strengthen the basecourse.
  - Provides internal suction to lower the equilibrium moisture content in the basecourse, thereby increasing the operational resilient modulus of the basecourse and hence performance.
  - After a rainfall event, quickly removes the excess moisture to restore the equilibrium moisture content of the basecourse.

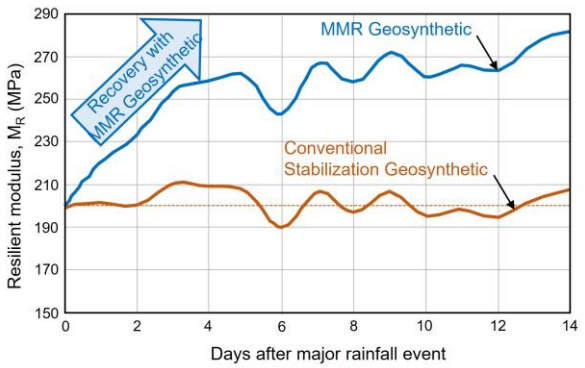


MMR Geosynthetic provides both:

- Mechanical Stabilization
- Hydraulic Stabilization



MMR Geosynthetic reduces basecourse MC to increase Resilient Modulus



After rainfall MMR Geosynthetic rapidly removes moisture to equilibrium MC

Kiwirail, Auckland to Whangarei

Rail track rehabilitation works within tunnels in 2021. Mirafi® H_2Rx for track mechanical stabilization and moisture removal.

Installed central spine trench drain prior to laying of Mirafi® H_2Rx

Mirafi® H_2Rx geotextile laid between subgrade and railway ballast

Mitigating Problems Unique to Expansive Clay Subgrades

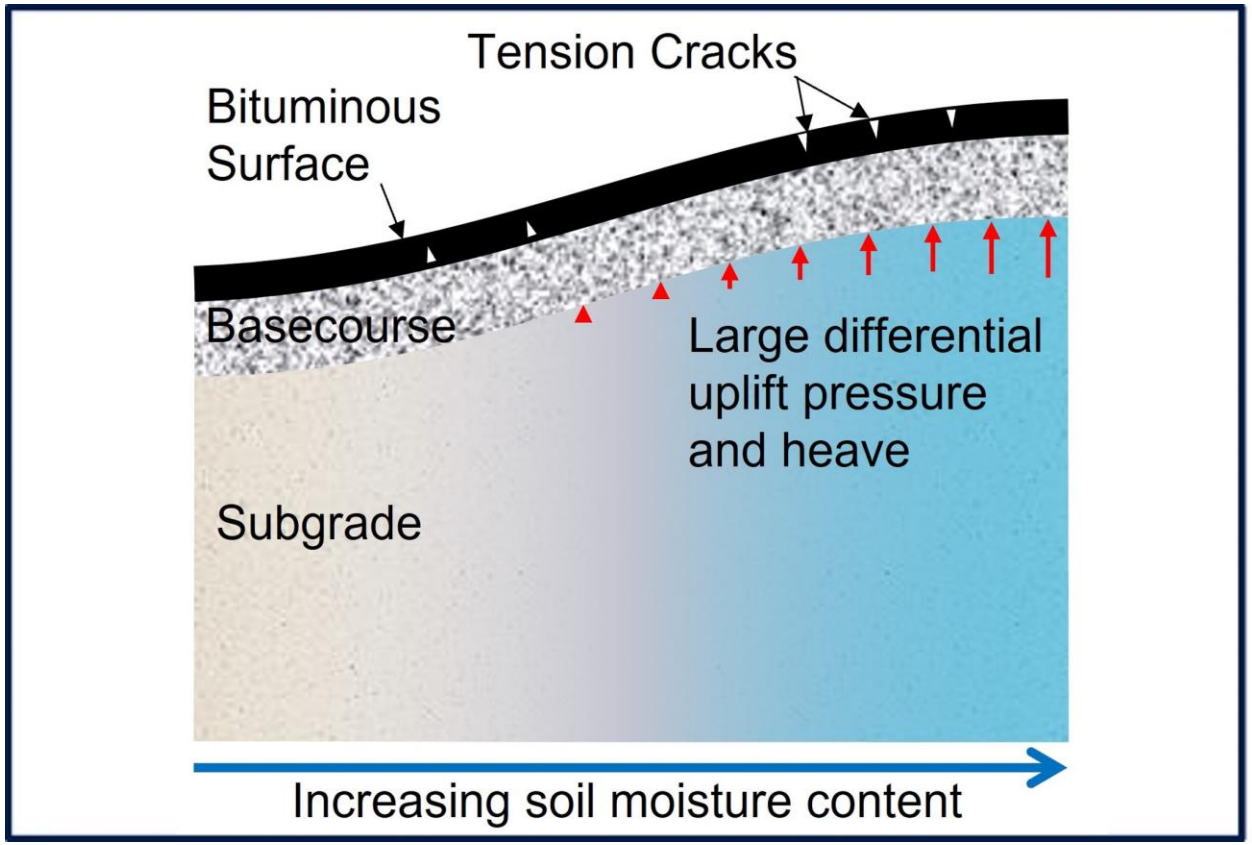
- **Expansive clays** exhibit significant change in volume in association with changes in moisture content, swelling when water is absorbed by the clay, shrinking and cracking when the clay dries out.
- The subgrade under the unpaved road shoulder receives more infiltration during rainy season, resulting in greater surface heave relative to the paved surface.
- Likewise, the subgrade under unpaved road shoulders dries out quicker during dry season, resulting in greater surface settlement relative to the paved surface.
- Over time, these cyclic heave and shrinkage distortions induce longitudinal pavement cracks near the pavement edges.

MMR Geosynthetic:

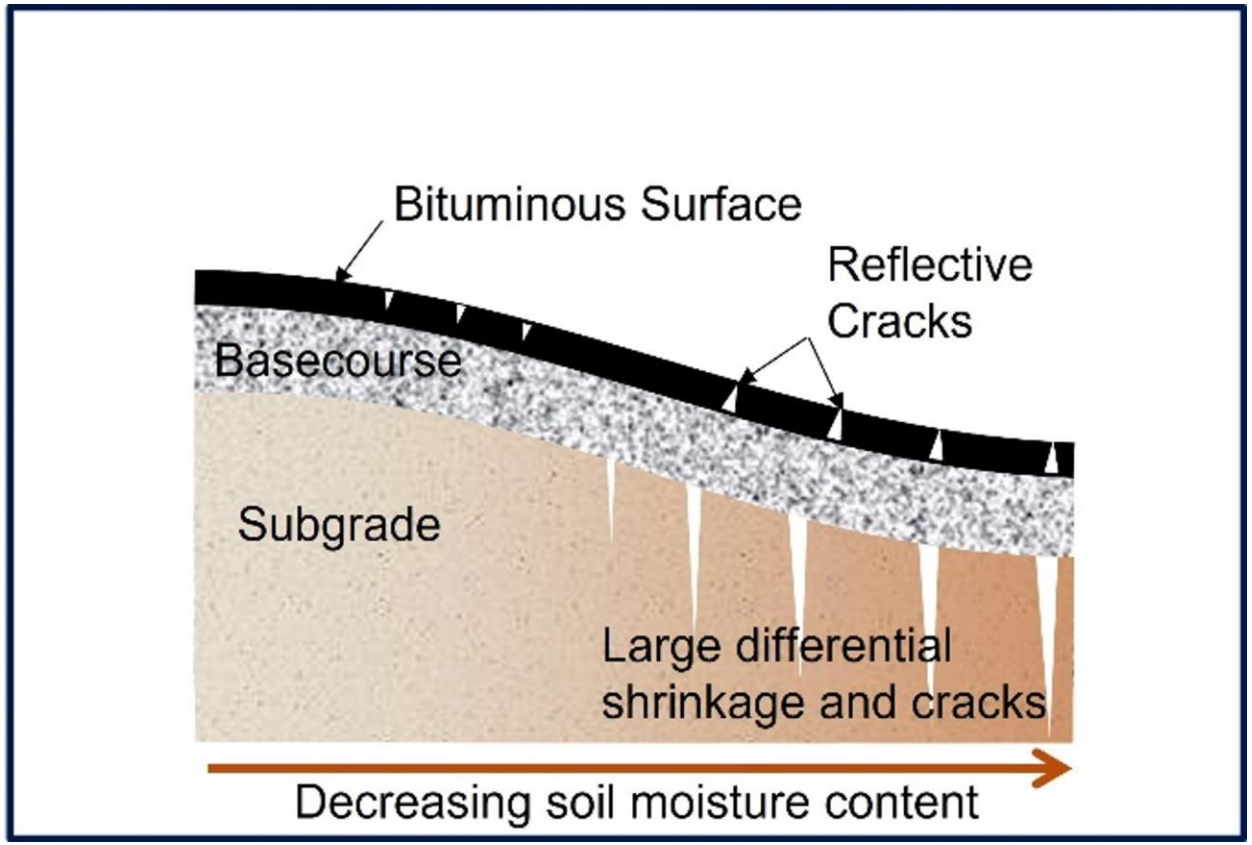
- **During the rainy season**, equalizes the expansive clay subgrade moisture content to reduce differential heave in the subgrade.
- **During the dry season**, equalizes the expansive clay subgrade moisture content to reduce differential shrinkage and cracking in the subgrade.
- Provides mechanical stabilization to prevent the development of longitudinal cracks in the pavement surface resulting from cyclic edge heave and settlement.
- Provides mechanical stabilization to prevent the reflection of subgrade contraction cracks to the pavement surface.

Mitigating Problems Unique to Expansive Clay Subgrades

For highly expansive clay subgrade, very large edge heave during the rainy season

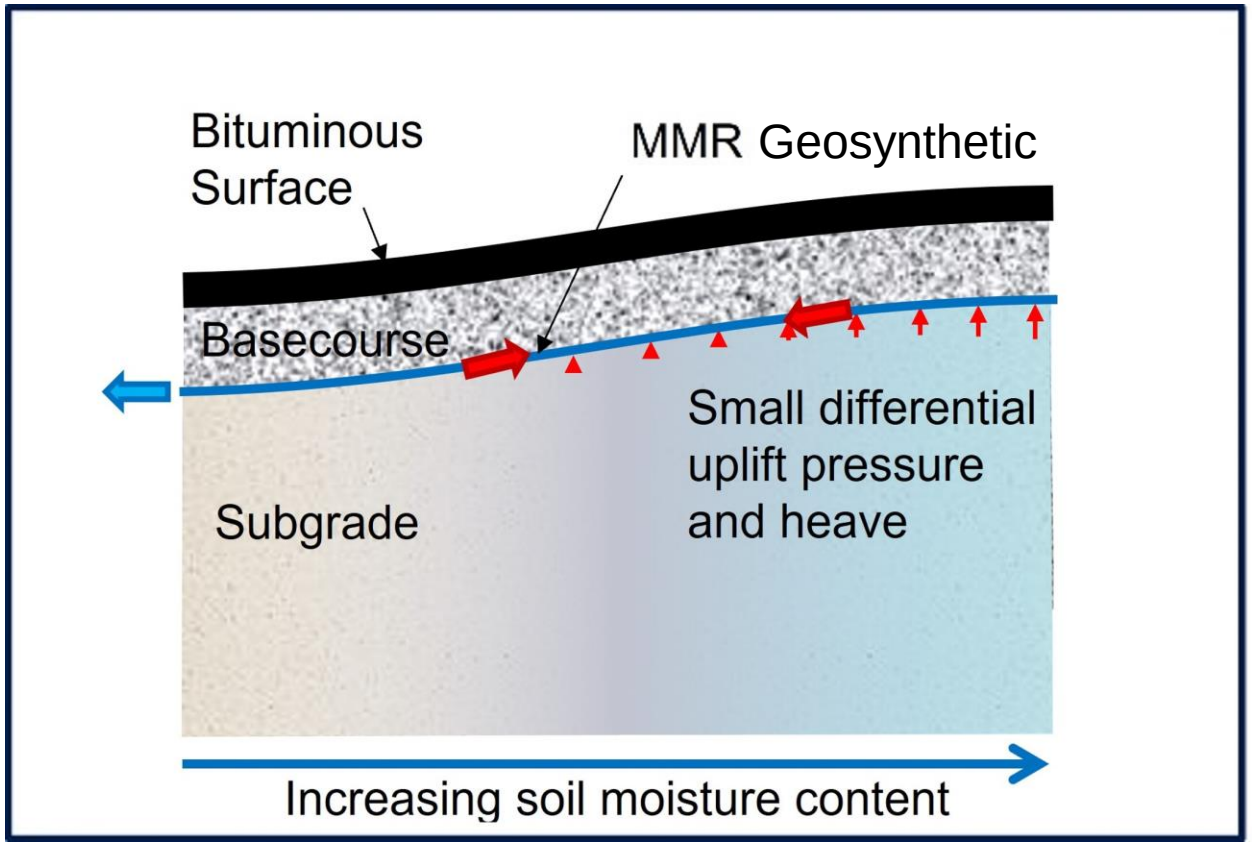


For highly expansive clay subgrade, very large edge subgrade shrinkage and cracking during the dry season

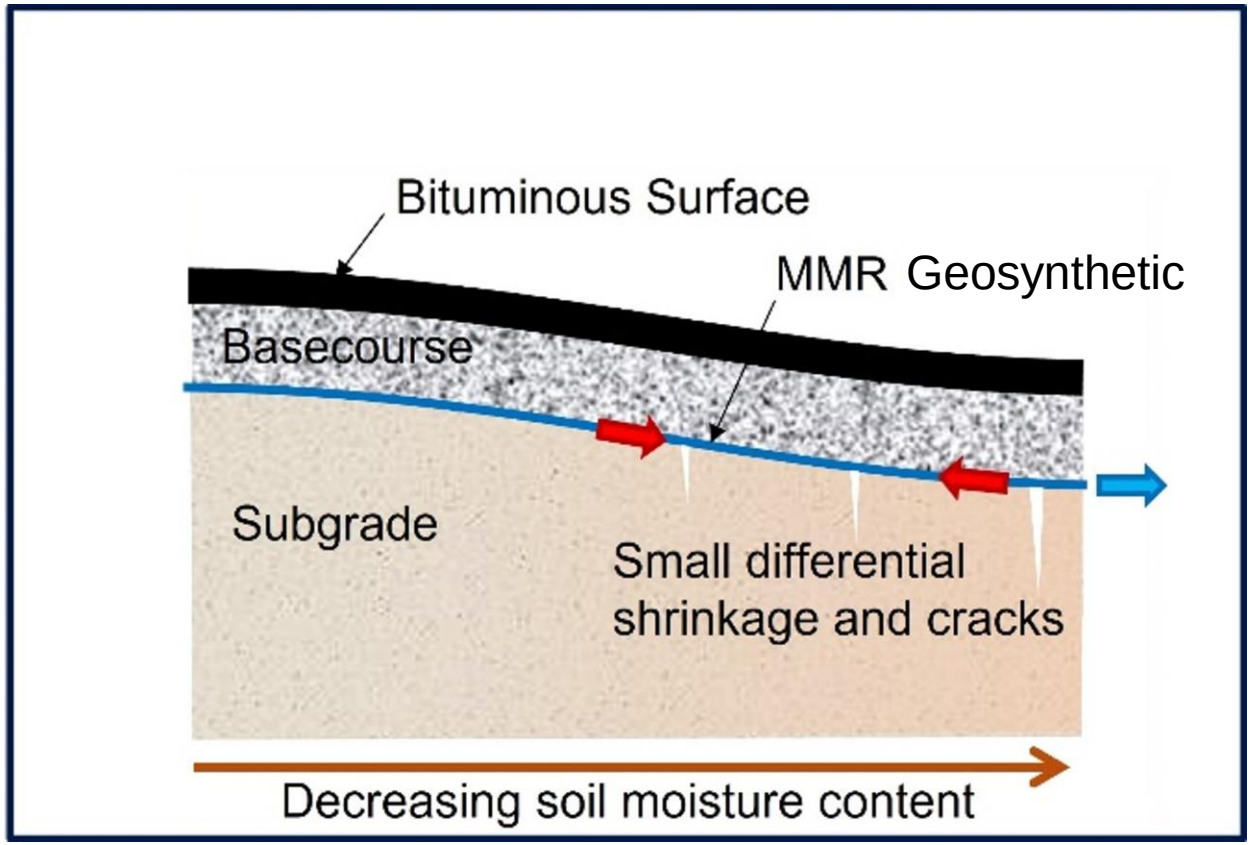


Mitigating Problems Unique to Expansive Clay Subgrades

MMR Geosynthetic equalizes the subgrade moisture to reduce differential heave and provide mechanical stabilization to prevent surface crack formation



MMR Geosynthetic equalizes the subgrade moisture to reduce subgrade shrinkage, cracking and provide mechanical stabilization to prevent surface crack formation

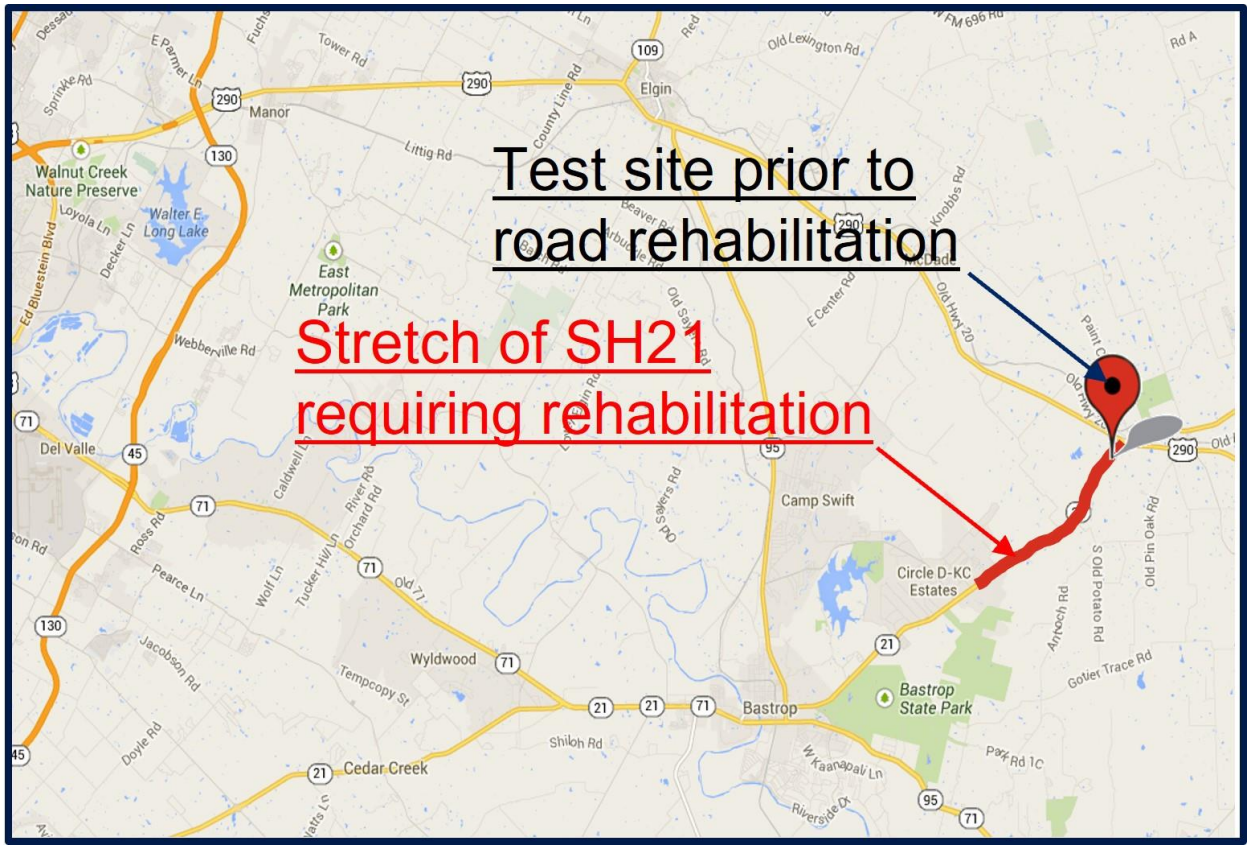


State Highway 21, Texas

A 10km section of SH21 in Texas founded on expansive clay subgrade was rehabilitated using MMR Geosynthetic (Zornberg et al, 2017).

Longitudinal edge cracks progressively formed from the edge towards the centre of road

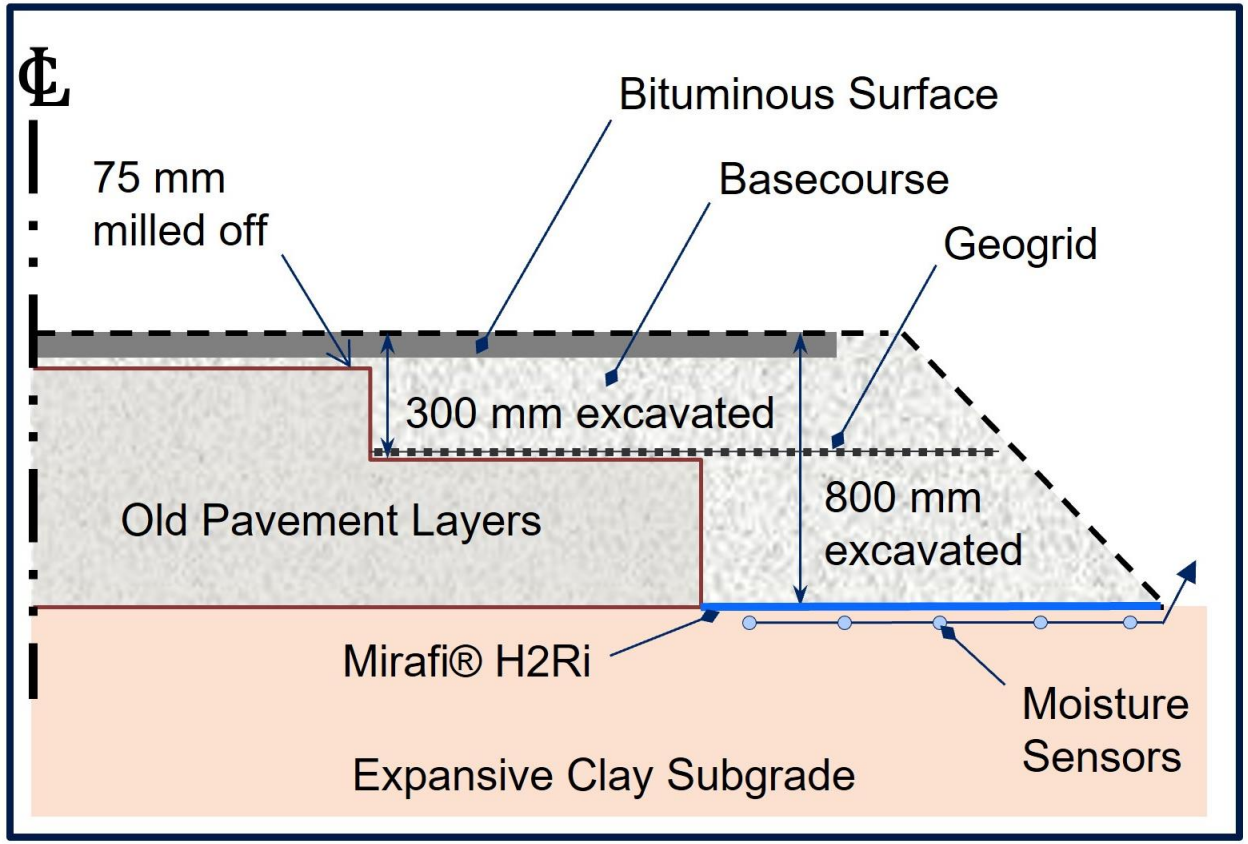
Map showing stretch of SH21 requiring rehabilitation and location of test site



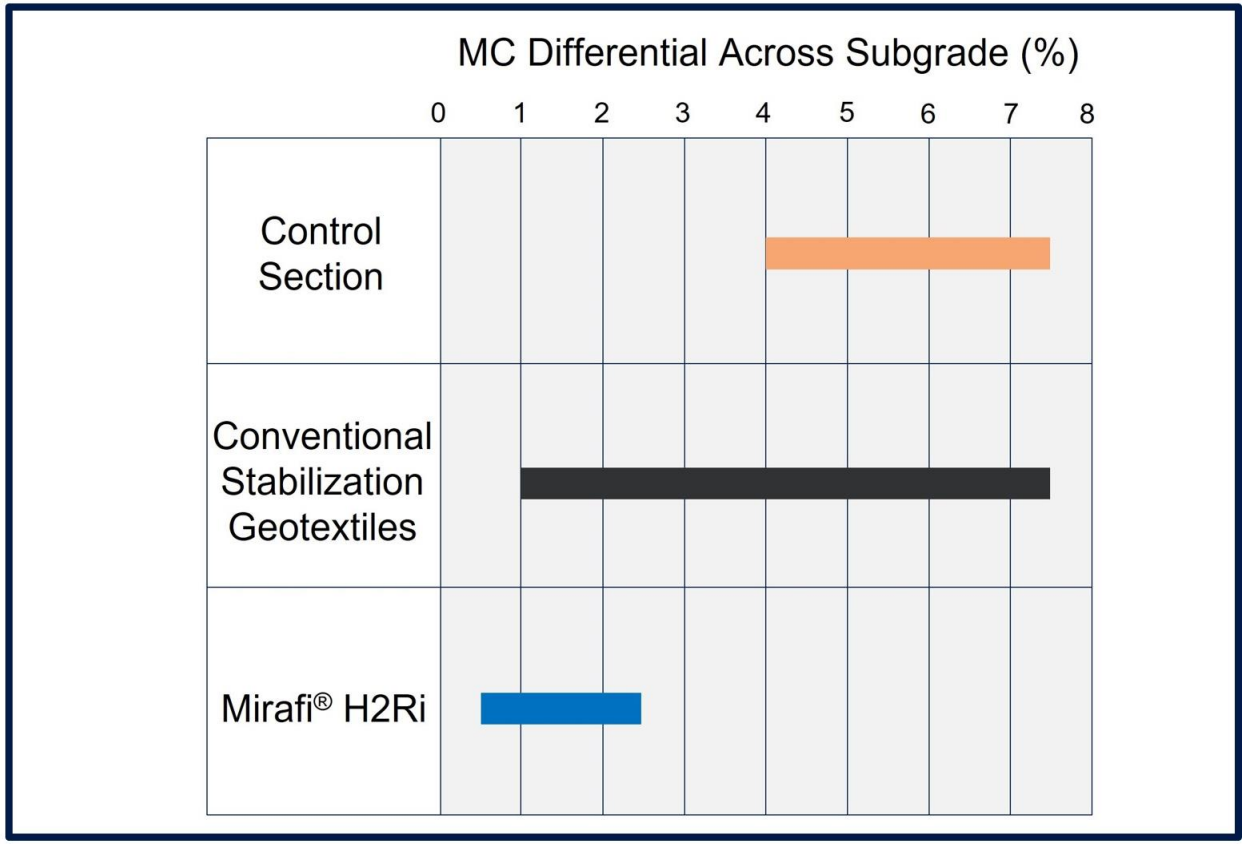
State Highway 21, Texas

Prior to full rehabilitation works, an on-site instrumented trial was conducted to demonstrate the effectiveness of Mirafi® H2Ri in equalizing the soil moisture content at the subgrade.

Cross-section diagram showing pavement repair and location of moisture sensors in the instrumented section



The range of moisture content differentials at various times for different geotextiles laid over the subgrade



Mitigating Problems Unique to Frost Action in Subgrades

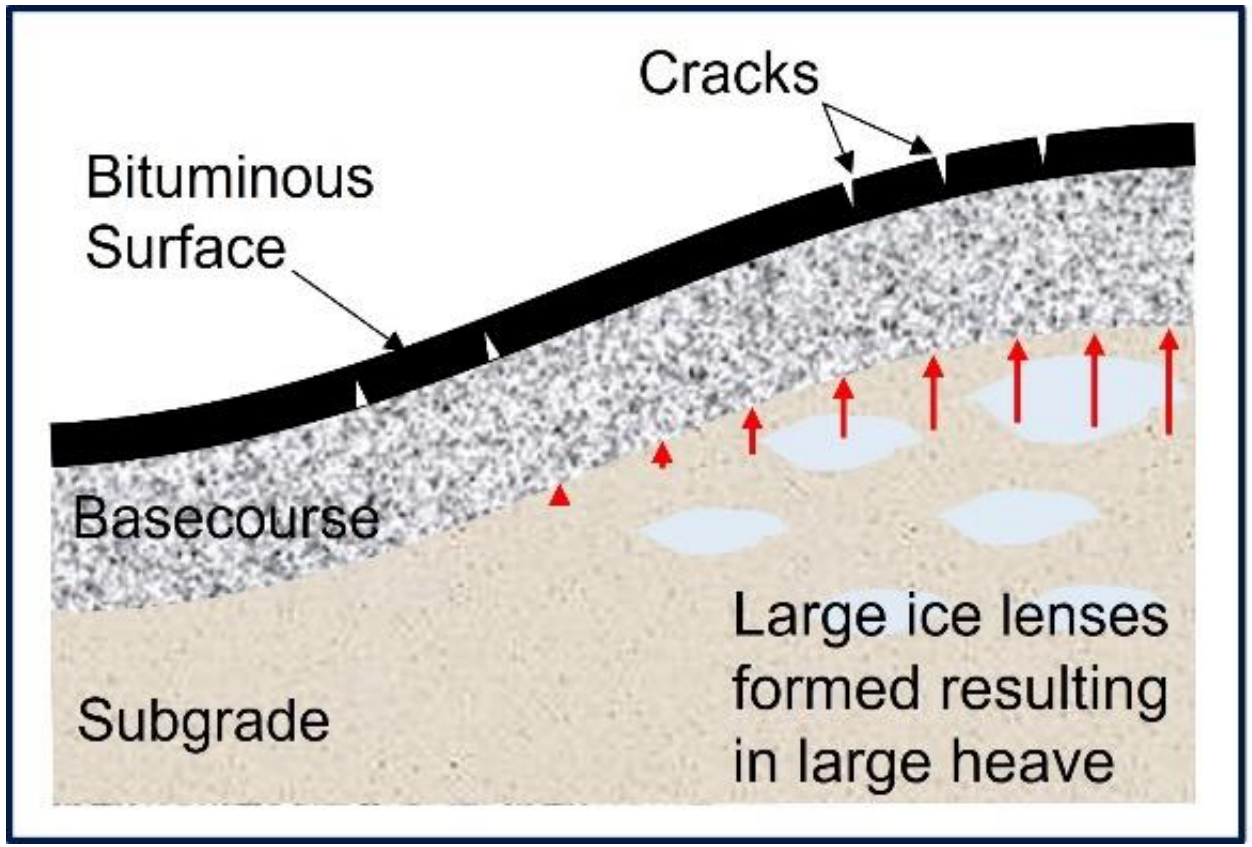
- **Frost action** is the process of alternate freezing and thawing of moisture.
- **Three conditions must exist together** before frost action can occur in soil:
  - a soil material that is frost susceptible (typically silts, silty clays and fine sands),
  - a sufficiently cold climate to allow freezing temperatures to penetrate below the ground surface, and
  - a supply of water (from capillary rise, aquifer and moisture existing in soil pores) into the freezing zone.

MMR Geosynthetic:

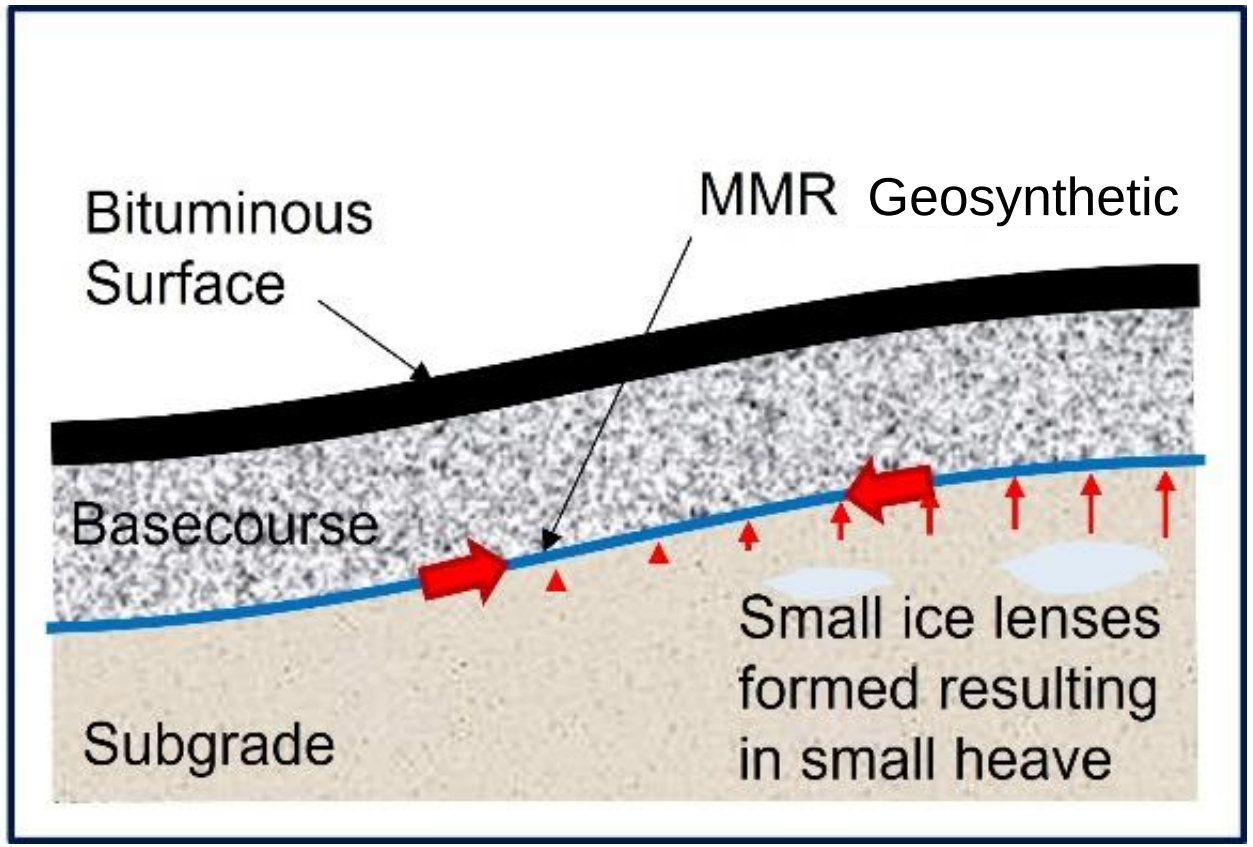
- **During rainfall prior to ground freeze**, intercepts infiltration and drains laterally thereby preventing ingress into the frost susceptible subgrade soil, and consequently reduces the availability of water in soil that helps intensify the formation of ice lenses and ground heave during the ground freeze.
- **During ground freeze**, provides biaxial tensile restraint to minimize the formation of pavement surface heaves.
- **During ground thaw**, provides mechanical stabilization of the road structure over the weakened subgrade.
- **During ground thaw**, intercepts any rising ice-melt water and drains horizontally to the roadside, thereby preventing pavement frost boil.

Mitigating Problems Unique to Frost Action in Subgrades

Pavement heave and cracking due to ice lens formation in the subgrade during the freezing season

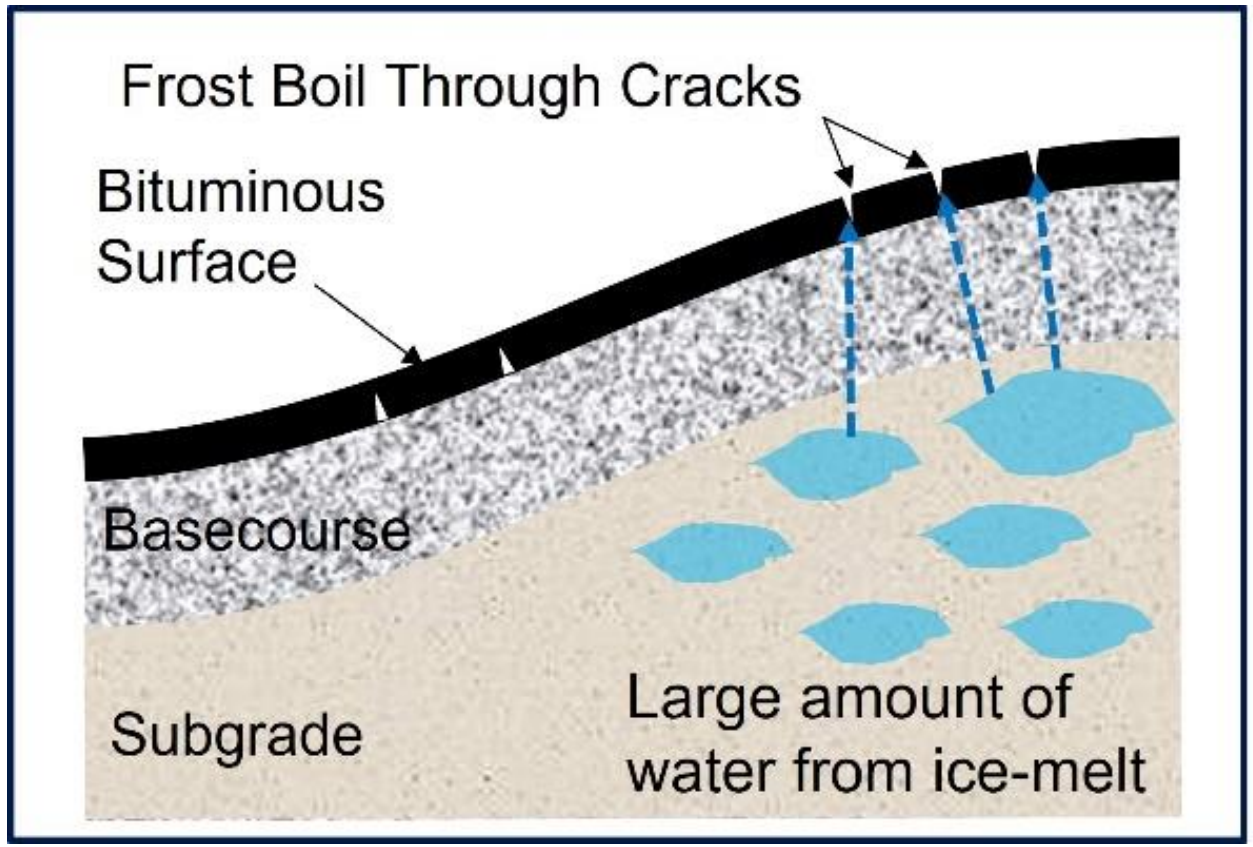


MMR Geosynthetic removes rainfall ingress to prevent soaking of the subgrade for reduced ice lens formation during the freezing season

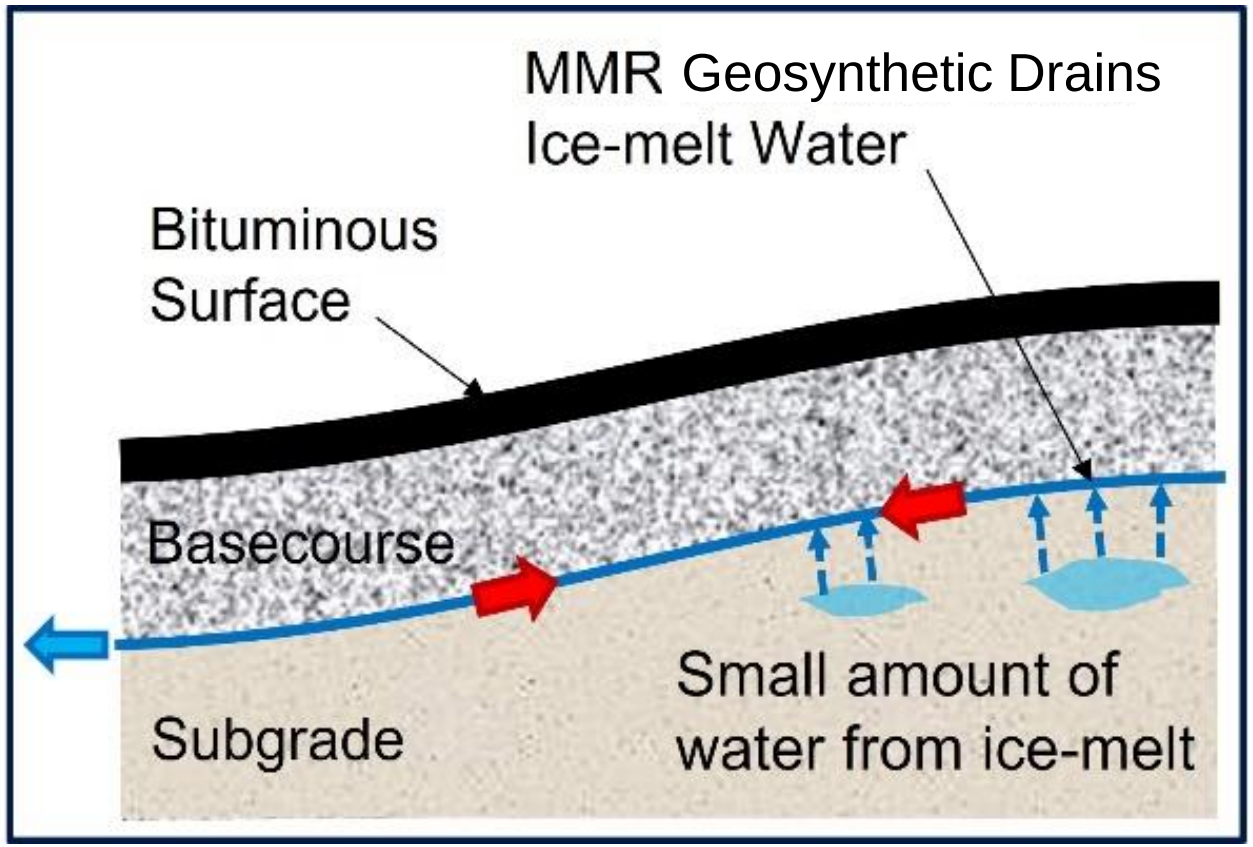


Mitigating Problems Unique to Frost Action in Subgrades

Subgrade weakens due to melting ice and the ice-melt water mixed with soil fines escapes through the cracked surface when the frozen ground thaws



MMR Geosynthetic removes ice-melt water to reduce weakening of subgrade, provide mechanical stabilization to prevent surface crack formation and prevent frost boil



Dalton Highway, Alaska

A 20km section of Dalton Highway in Alaska is prone to frost action in the subgrade. After a site trial proved the effectiveness of MMR geotextile in eliminating frost boils, construction began in Aug 2012.

Frost boils prior to laying of bituminous surfacing layer commonly occurring along the highway

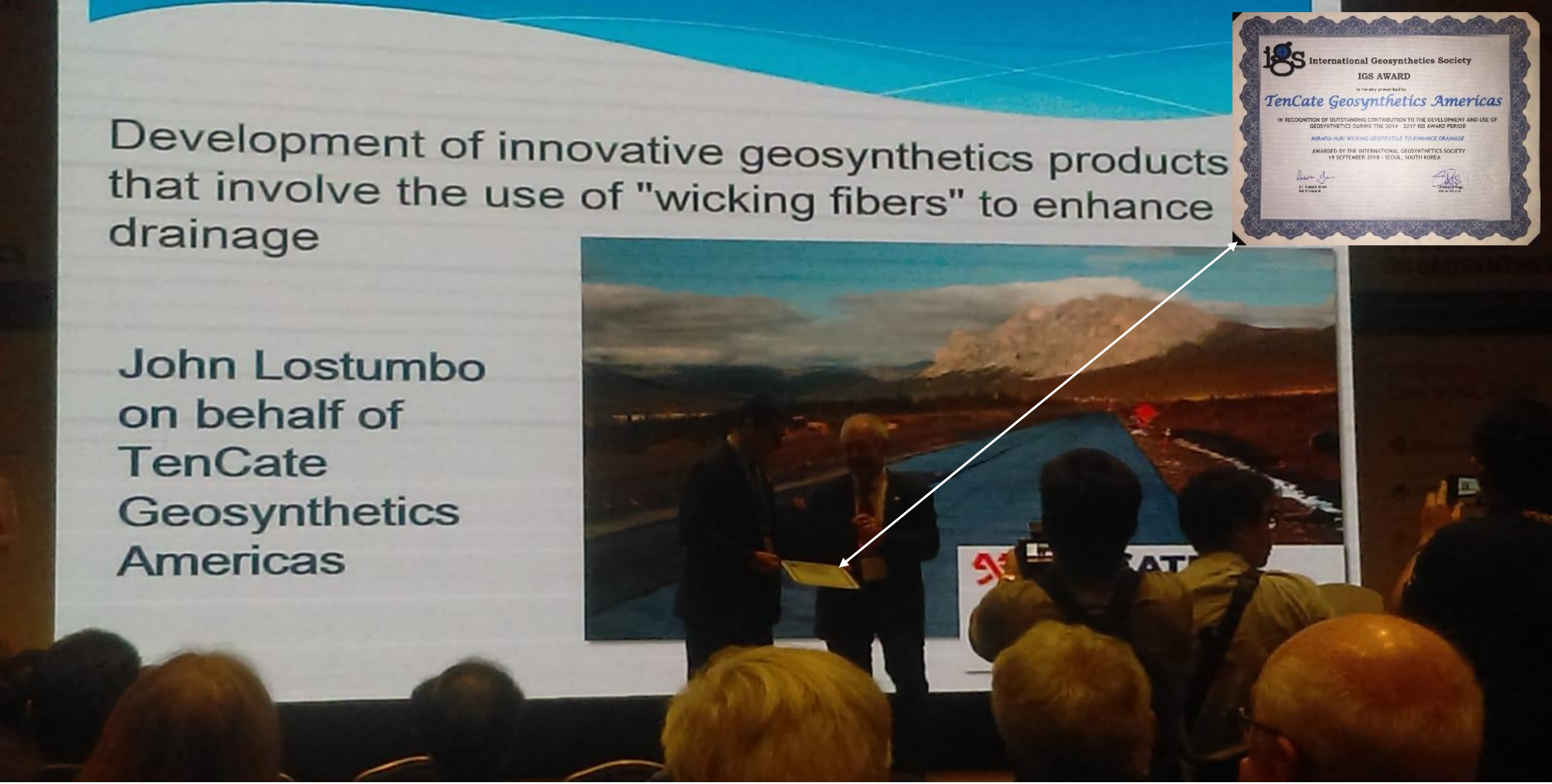
Placement of basecourse material over laid out Mirafi® H_2Ri geotextile

Dalton Highway, Alaska

The moisture-managing reinforcement solution resulted in an estimated savings of USD2.5 million over the conforming conventional solution (AKDOT&PF, 2016).

The basecourse placed above the Mirafi® H_2Ri geotextile was evidently dryer

Inspection of road surface after paving over


Development of innovative geosynthetics products that involve the use of "wicking fibers" to enhance drainage
John Lostumbo on behalf of TenCate Geosynthetics Americas
International Geosynthetics Society
IGS AWARD
TenCate Geosynthetics Americas
IN RECOGNITION OF OUTSTANDING CONTRIBUTION TO THE DEVELOPMENT AND USE OF GEOSYNTHETICS DURING THE 2014 - 2017 IGS AWARD PERIOD
MIRAFI® H2Ri WICKING GEOTEXTILE TO ENHANCE DRAINAGE
AWARDED BY THE INTERNATIONAL GEOSYNTHETICS SOCIETY
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