Sierra® Slope Retention System: Installation in Service Since 1982

Canadian Pacific Railway
Waterdown, Ontario (Canada)

Tensar® Geogrid reinforcement is well suited to the repair of railway embankment landslips. The speed of installation in other structures ensures rapid and repair expenses resulting from track closures.

Application: A grade separation solution was to address cracks in an embankment shoulder adjacent to railroad tracks located along the Niagara Escarpment in Waterdown (now part of Hamilton, Ontario).

The Challenge: Canadian Pacific Railway (CPR) is a Class 1 North American railway that provides freight transportation services over a 14,000-mile network in Canada and the U.S. In 1982, the railway needed a quick and cost-effective repair to a heavy rail embankment landslip. The embankment, located below the ballast and railway subgrade, needed to withstand the sizeable surcharge of a locomotive.

Site Conditions: In 1958, high groundwater pressure had caused a slope failure. At this time, ballast fill was placed over the glacial till to reinstate the track; however, problems of track disturbance continued, and further run on periodically activated movement along the old shear surface. Following an exceptional thaw in December 1982, rail traffic was completely suspended before cracks were discovered within the embankment shoulder.

The Solution: Stochastic repair costs and the need for a speedy repair advanced the use of a reinforced soil structure. A Sierra® Slope System reinforced with Tensar® 400UX Geogrid was specified to repair the embankment cracks. The till placed 24 years earlier was excavated down to the bedrock, with bench-cut steps cut into the eroded soil. Geogrid was installed to promote slope drainage and help prevent surface frost heave as it lowered the water table. Also, the reinforced granular fill helped CPR achieve a higher factor of safety.

The geogrid's open structure enabled soil particles to interlock through the aperture, mobilizing the high strength of the grid and achieving efficient anchorage. To ensure local surface stability, each layer of geogrid was wrapped up the slope face, turned back, and secured into the fill. The slope face was reseeded and hydroseeded. The repair was successfully completed in 12 days.

Follow-up: A visual site inspection conducted by representatives of Canadian Pacific Railway and Tensar International revealed no evidence of subsequent failure. Conversations with long-term CPR track maintenance employees indicated no prior events as well.
Tensar International Corporation Offers Rail Engineers a Wide Variety of Solutions for Railway Applications

For more than three decades, Tensar International Corporation (TIC) has been providing single-source, mechanically stabilized earth (MSE) systems to industry companies in both the new transit and heavy rail markets. MSE systems by TIC are superior to many other grade separation systems because our MSE systems feature reinforcement with strong and durable Tensar® uniform (UX) Geogrids. Made of high-density polyethylene (HDPE), UX Geogrids have proven resistance to chemical, biological and environmental degradation, including hydrolysis. Tensar® UX Geogrids can be designed to long-term exposure to water, can be installed in high or low water table and can be designed from most chemically active soils. The Tensar UX Geogrids can be designed to accommodate a variety of rail applications, accommodate a Cooper E-80 or greater railway loading distribution, for rail applications accommodating a Cooper E-80 or greater railway loading distribution. Tensar® Geogrids are manufactured from high-density polyethylene (HDPE) that resists chemical, biological, and environmental degradation. In fact, this same polymer is used to protect other traditional steel reinforcing systems.

The solution is simple – if you are looking for a cost-effective grade separation system with a proven track record, Tensar has a system to meet your needs. Tensar Geogrid Separation solutions for railway applications offer a variety of opportunities to support the rail trackbeds, and can resist attack from most chemicals that may enter the backfill soils that support railway or making repairs to an existing one. Our rigorously proven systems are engineered to ensure their safety in knowing that our systems are engineered to meet your needs.

Safety is always a concern when constructing a new railway or making repairs to an existing one. Our rigorously proven systems are engineered to ensure their durability, their open aperture structure promotes excellent soil drainage with no buildup of pore water pressure from clogging. The solution is simple – if you are looking for a cost-effective grade separation system with a proven track record, Tensar has a system to meet your needs. Tensar Geogrid Separation solutions for railway applications offer a variety of opportunities to support the rail trackbeds, and can resist attack from most chemicals that may enter the backfill soils that support rail lines. In addition to the geogrids' durability, their open aperture structure promotes excellent soil drainage with no buildup of pore water pressure from clogging.

Additional assurance in the durability of Tensar Geogrids, an extendable reinforcement element, can be found in the “Association (AREMA) Manual for Railway Engineering. “American Railway Engineering and Maintenance-of-Way Engineers.” Additional assurance in the durability of Tensar Geogrids, their open aperture structure promotes excellent soil drainage with no buildup of pore water pressure from clogging.

Tensar® Systems Components for Railway Reinforced Systems

Components

<table>
<thead>
<tr>
<th>COMPONENTS</th>
<th>FUNCTION</th>
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</thead>
<tbody>
<tr>
<td>Tensar® Uniform (UX) and Reinforced (RX) Geogrids</td>
<td>Primary reinforcement material that is chemically and biologically stable. Secondary reinforcement material that is chemically and biologically stable. Includes five levels of reinforcement with four levels of HDPE geogrids, varying in strength and performance. Includes high performance fibers that mechanically connect the polymer geogrids to a hardened steel and a stone aggregate veneer, giving you a durable and cost-effective retaining wall.</td>
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<tr>
<td>Site-Specific Design Systems</td>
<td>Each system is a proven, mechanical interlock system to offer superior and cost-effective solutions for your project's unique design, environmental, and aesthetic conditions. Includes high performance fibers that mechanically connect the polymer geogrids to a hardened steel and a stone aggregate veneer, giving you a durable and cost-effective retaining wall.</td>
</tr>
<tr>
<td>Mechanical Connections</td>
<td>Each system has a proven, mechanical interlock system to offer superior and cost-effective solutions for your project's unique design, environmental, and aesthetic conditions. Includes high performance fibers that mechanically connect the polymer geogrids to a hardened steel and a stone aggregate veneer, giving you a durable and cost-effective retaining wall.</td>
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<tr>
<td>Engineering Services</td>
<td>Engineering services, design drawings and related site assistance available upon written request.</td>
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Benefits of Using Railway Site Solutions by Tensar International Corporation

Safety is always a concern when constructing a new railway or making repairs to an existing one. Our rigorously proven systems are engineered to meet your needs.

- Corrosion and Electromechanical Requirements – “Tensar” UV Geogrids are made of high-density polyethylene (HDPE) that resists chemical, biological and environmental degradation. In fact, this same polymer is used to protect other traditional steel reinforcing systems.
- Drainage and Hydrostatic Pressure – The open aperture structure of Tensar UX Geogrids promotes excellent soil drainage. The Tensar system is designed to meet your needs. Tensar Geogrid Separation solutions for railway applications offer a variety of opportunities to support the rail trackbeds, and can resist attack from most chemicals that may enter the backfill soils that support rail lines. In addition to the geogrids’ durability, their open aperture structure promotes excellent soil drainage with no buildup of pore water pressure from clogging.
- Backfill Stability – The Tensar system is a proven, mechanical interlock system to offer superior and cost-effective solutions for your project’s unique design, environmental, and aesthetic conditions. Includes high performance fibers that mechanically connect the polymer geogrids to a hardened steel and a stone aggregate veneer, giving you a durable and cost-effective retaining wall.
- Seismic Considerations – The high-strength fibers utilized within the Tensar system allows for increased pullout strength and mechanical face connections are increased to resist seismic events. Tensar Geogrid Separation solutions for railway applications for challenging grade separation systems have a record for withstanding seismic events. There are many reasons to choose Tensar Geogrid Separation solutions for railway applications for challenging grade separation systems. Our fully integrated structures are engineered for site and design versatility, long-term durability, increased structural reliability and sagged contract. With a network of licensed installers throughout the world, rail applications utilizing Tensar® Geogrid can be found in virtually every major city and country.

Proven Systems, Endless Facing Solutions

- Mesa® Retaining Wall Systems
- Sierra® Slope Retention System
- SierraScape® Retaining Wall System
- ARES® Retaining Wall Systems

- A proven single-source, Tensar Systems are a cost-effective alternative to metallic reinforced soils. Used in their own or in conjunction with other Tensar Systems, the ARES Systems can offer dependable wall solutions with significant durability.

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Tensar International Corporation Offers Rail Engineers a Wide Variety of Solutions for Railway Applications

For more than three decades, Tensar International Corporation (TIC) has been providing single-source mechanically stabilized earth (MSE) systems to today's companies in both the mass transit and heavy rail markets. MSE systems by TIC are superior to many other grade separation systems because our MSE systems feature reinforcement with strong and durable Tensar® Uniaxial (UX) Geogrids. Made of high-density polyethylene (HDPE), UX geogrids have proven resistance to chemical, biological and environmental degradation, including hydration. Tensar® UX Geogrids do not degrade from long-term exposure to water, can be installed in high or low soil water content and can rest against most chemicals that may enter the backfill soils that support them. In addition to the geogrid's durability, its open-aperture structure promotes excellent soil drainage with no buildup of pore water pressure from clogging.

Additional assurance in the durability of Tensar UX Geogrids, an extensive reinforcement element, can be found in the “Protection of Railway Engineering” by the American Railway Engineering Association (AREMA) Manual for Railway Engineering (UX) Geogrids. Made of high-density polyethylene (HDPE) that resists chemical, biological and environmental degradation. In fact, this same polymer is used to protect other traditional steel materials. Tensar® HDPE Geogrids do not degrade from long-term exposure to water, can be installed in high or low soil water content and can rest against most chemicals that may enter the backfill soils that support them. In addition to the geogrid's durability, its open-aperture structure promotes excellent soil drainage with no buildup of pore water pressure from clogging.

Mechanical Connection
Each system has a proven, mechanical connection to offer superior and cost-effective solutions for railway applications for challenging grade separation requirements. Tensar Grade Separation solutions for railway support structures accommodate seismic events. Tensar Grade Separation systems are engineered to withstand seismic loads, offer a variety of opportunities to support the rail trackbeds, and can resist attack from most chemicals that may enter the backfill soils that support them. In addition to the geogrid's durability, its open-aperture structure promotes excellent soil drainage with no buildup of pore water pressure from clogging.

Secondary Considerations
There are many reasons to choose Tensar Grade Separation solutions for railway applications for challenging grade separation requirements. Our fully integrated systems are engineered for site and design variability, long-term durability, increased structural integrity and weight savings.

With a network of licensed manufacturers throughout the world, rail applications utilizing Tensar® Geogrid can be found in over sixty countries. With a network of licensed manufacturers throughout the world, rail applications utilizing Tensar® Geogrid can be found in over sixty countries.

Benefits of Using Railway Site Solutions by Tensar International Corporation

Safety is always a concern when constructing a new railway or making repairs to an existing one. Our proven and patented railroad retaining systems for railway applications take into consideration a variety of safety factors, including:

• Corrosion and Environmental Requirements—Tensar® UX Geogrids are made of high-density polyethylene (HDPE) that resists chemical, biological and environmental degradation. In fact, this same polymer is used to protect other traditional steel materials.

• Drainage and Hydrostatic Pressure—The open aperture structure of Tensar UX Geogrid promotes excellent soil drainage, which can resist attack from most chemicals that may enter the backfill soils that support them. In addition to the geogrid's durability, its open-aperture structure promotes excellent soil drainage with no buildup of pore water pressure from clogging.

• Seismic Considerations—As wind and traffic loads, geological instability, and mechanical failure contribute to the failure of materials, this assures no loss in structural integrity due to vibrations, which is possible for systems that depend on friction.
Tensar® Grade Separation Systems are provided by, and When considering grade separations for rail applications, "American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual for Railway Engineering. "Additional assurance in the durability of Tensar Geogrids, the open aperture structure promotes excellent soil drainage with no buildup of pore water pressure from clogging.

For more than three decades, Tensar International Corporation has been providing single-source mechanically stabilized earth (MSE) systems to roadway companies in both the mass transit and heavy rail markets. MSE systems by TIC are superior to many other grade separation systems because our MSE systems feature reinforced systems. Presently, TIC® Geogrids have proven resistant to chemical, biological, and environmental degradation, including Hydrolysis. "Mechanically Stabilized Embankments, Pg. 8-7-2, 2002."

Corrosion and Electrochemical Requirements – "Tensar® UX Geogrids are made of high-density polyethylene (HDPE) that resists chemical, biological and environmental degradation. In fact, this same polymer is used to protect other metal reinforced systems."

Drainage and Hydrostatic Pressure – "The open aperture structure of Tensar UX Geogrids permits excellent soil drainage.

Railway Loads – "Tensar MSE solutions can be designed for rail applications, accommodating a Cooper 6-10 or greater railway loading distribution."

Vibro-Crushed – "Tensar Geogrid Separation solutions are reinforced with a polymer material, which is not affected by vibration at an electrical system.

Vibrations – "Tensar UX Geogrids open aperture structure and high joint strength provide high resistance to pullout while allowing for strong mechanical connection to the facing materials. This assures no loss in structural integrity due to vibrations, which is possible for systems that depend on friction.

Seismic Considerations – "Anchoring stands associated with high compression blocks and a patented mechanical connection to create a unified system. The performance of every component is integrated to reduce cost and increase structural reliability."

A fully integrated structure is engineered for site and design versatility, long-term durability, increased stability."

The Sierra System, a reinforced soil slope (RSS) solution, provides a structural, natural-looking alternative to precast MSE and cast-in-place retaining walls. The vegetative solution can also be integrated with other Tensar Systems, such as the MesaScape retaining wall system.

ARES® Retaining Wall Systems – A concrete panel system, ARE System are are cost-effective alternative to metallic reinforced walls. Used on their own or in combination with other Tensar Systems, the ARES Systems can offer dependable wall solutions with long-term durability.

Mesa® Retaining Wall Systems – The Mesa Series features geogrid reinforcement with high compressive blocks and a patented mechanical connection to create a unified system. The performance of every component is integrated to reduce cost and increase structural reliability."

Siesta® Slope Retention System – The SierraScape System provides a welded wire basket system that mechanically connects the polymer geogrid to a galvanized steel and a stone aggregate veneer, giving you a durable and cost-effective retaining wall.
Sierra® Slope Retention System: Installation in Service Since 1982

CANADIAN PACIFIC RAILWAY
WATERTOWN, ONTARIO (CANADA)

Tensar® Geogrid reinforcement is well suited to the repair of railway embankment landslips. The speed of installation of other interstices reduces disruption and repair expenses resulting from track closures.

Application: A grade separation solution was to address cracks in an embankment shoulder adjacent to rail tracks located along the Niagara Escarpment in Waterdown (now part of Hamilton), Ontario.

The Challenge: Canadian Pacific Railway (CPR) is a Class 1 North American railway that provides freight transportation services over a 14,000-mile network in Canada and the U.S. In 1982, the railway needed a quick and cost-effective repair to a heavy rail embankment landslip. The embankment, located below the ballast and railway subgrade, needed to withstand the sizeable surcharge of a locomotive.

Site Conditions: In 1958, high groundwater pressure had caused a slope failure. A subsequent ballast fill was placed over the glacial till to reinstate the track; however, problems of track disturbance continued, and further ran off periodically activated movement along the old shear surface. Following an exceptional thaw in December 1982, rail traffic was completely suspended before cracks were observed within the embankment shoulder.

The Solution: Geomorphology, repair costs and the need for a speedy repair advanced the use of a reinforced soil structure. A Sierra® Slope System reinforced with Tensar Uniaxial (UX) Geogrid was specified to repair the embankment cracks. The 24-year-old embankment was excavated down to the bedrock, with bench steps cut into the undisturbed soil. Granular fill was installed to promote slope drainage and help reduce surface frost heave at the lower part of the embankment. The geogrid's open structure enabled soil particles to interlock through the apertures, mobilizing the high strength of the grid and achieving efficient anchorage. To ensure local surface stability, each layer of geogrid was wrapped up the slope face, turned back and secured into the fill. The repair was successfully completed in 12 days.

Follow-up: A visual site inspection conducted in 2008 by representatives of Canadian Pacific Railway and Tensar International revealed no evidence of subsequent failure. Conversations with long-term CPR track maintenance employees indicated no prior events as well.

Distributed by:

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Canadian Pacific Railway
Waterdown, Ontario (Canada)

Tensar® Geosynthetics reinforcement is well suited to the repair of railway embankment landslips. The speed of installation often minimizes service disruptions and related expenses resulting from track closures.

**Application**
A grade separation solution was needed to address cracks in an embankment shoulder adjacent to railroad tracks located along the Niagara Escarpment in Waterdown, Ontario.

**The Challenge**
Canadian Pacific Railway (CPR) is a Class 1 North American railway that provides freight transportation services over a 14,000-mile network in Canada and the U.S. In 1982, the railway needed an effective and cost-efficient repair to a heavy rail embankment landslip. Site conditions were such that the embankment needed to withstand the sizeable surcharge of a locomotive.

**Site Conditions**
In 1958, high groundwater pressure had caused a slope failure. At the time of the incident, the problem of track disturbance continued, and further ovalization of the embankment surface was observed. Following an exceptional thaw in December 1982, rail traffic was temporarily suspended where cracks were discovered in the embankment shoulder.

**The Solution**
The geogrid's open structure enabled soil particles to interlock through the apertures, mobilizing the high strength of the grid and achieving efficient anchorage. To ensure local surface stability, each layer of geogrid was wrapped up the slope face, turned back and secured into the fill. The face was then re-planted and hydroseeded. The repair was successfully completed in 12 days.

**Follow-up**
In 2008, a visual site inspection conducted by representatives of Canadian Pacific Railway and Tensar International revealed no evidence of subsequent failure. Conversations with long-term CPR track maintenance employees indicated no prior events as well.