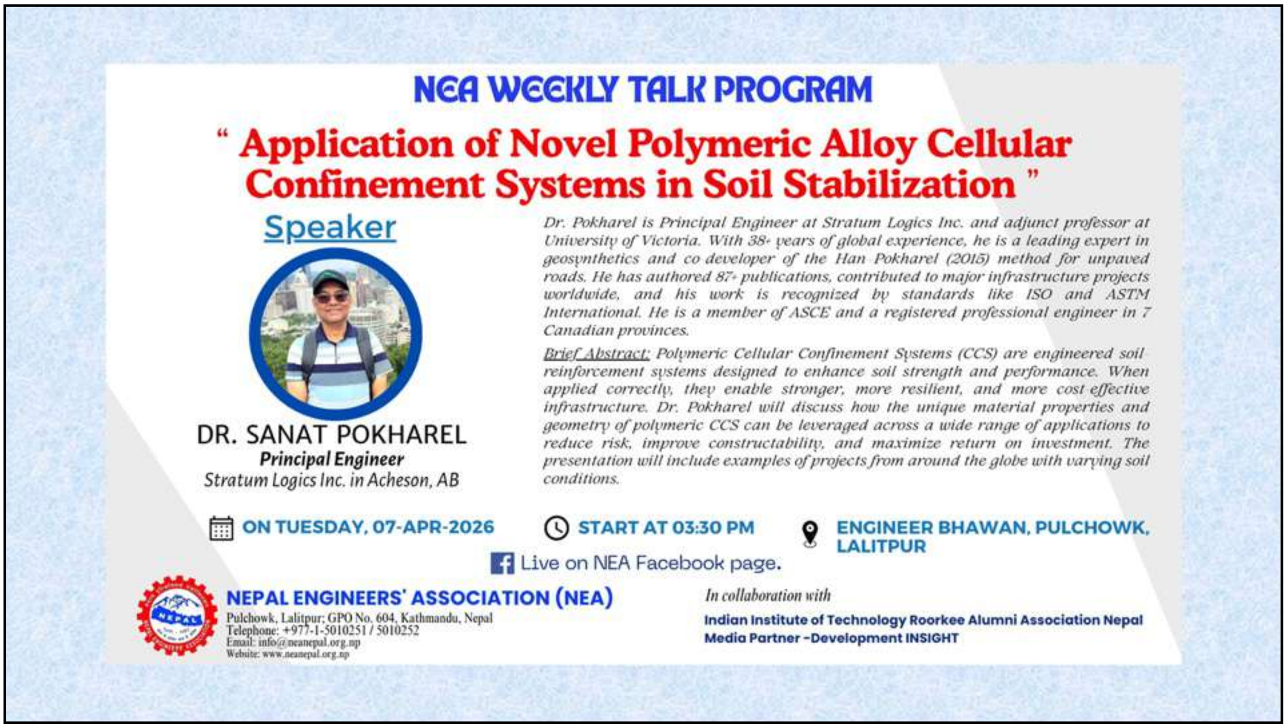
NEA WEEKLY TALK PROGRAM
" Application of Novel Polymeric Alloy Cellular Confinement Systems in Soil Stabilization "
Speaker
DR. SANAT POKHAREL
Principal Engineer
Stratum Logics Inc. in Acheson, AB
Dr. Pokharel is Principal Engineer at Stratum Logics Inc. and adjunct professor at University of Victoria. With 38+ years of global experience, he is a leading expert in geosynthetics and co developer of the Han Pokharel (2015) method for unpaved roads. He has authored 87+ publications, contributed to major infrastructure projects worldwide, and his work is recognized by standards like ISO and ASTM International. He is a member of ASCE and a registered professional engineer in 7 Canadian provinces.
Brief Abstract: Polymeric Cellular Confinement Systems (CCS) are engineered soil reinforcement systems designed to enhance soil strength and performance. When applied correctly, they enable stronger, more resilient, and more cost effective infrastructure. Dr. Pokharel will discuss how the unique material properties and geometry of polymeric CCS can be leveraged across a wide range of applications to reduce risk, improve constructability, and maximize return on investment. The presentation will include examples of projects from around the globe with varying soil conditions.
ON TUESDAY, 07-APR-2026
START AT 03:30 PM
ENGINEER BHAWAN, PULCHOWK, LALITPUR
Live on NEA Facebook page.
NEPAL ENGINEERS' ASSOCIATION (NEA)
Pulchowk, Lalitpur; GPO No. 604, Kathmandu, Nepal
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In collaboration with
Indian Institute of Technology Roorkee Alumni Association Nepal
Media Partner - Development INSIGHT

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NEPAL ENGINEERS' ASSOCIATION
IIT ROORKEE
Kathmandu April 7, 2026
STRATUM
APPLICATION OF NOVEL POLYMERIC ALLOY CELLULAR CONFINEMENT SYSTEM IN SOIL STABILIZATION
Sanat Pokharel, Ph.D. P.Eng.,
Principal Engineer, Stratum Logics Inc.
Professor Adjunct, University of Victoria

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Presentation Agenda: Technology, Material, Method and Design

- Geosynthetic Cellular Confinement System - Geocell
  - Development
  - Reinforcement Mechanism
    - Confinement
    - Wider stress distribution
    - Beam/Slab effect
    - Modulus improvement
    - Creep resistance
    - Vibration attenuation

- NPA Cellular Confinement system – Tough Cell
- Design with NPA Geocell –Tough Cell
- Case History: range of Projects

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Road Failures

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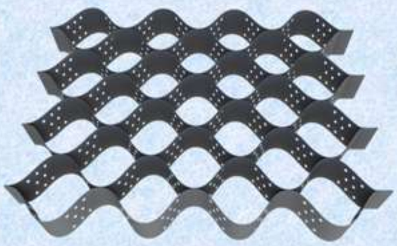
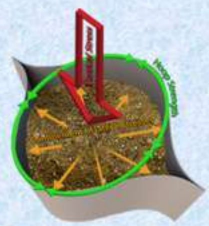
Geosynthetic Cellular Confinement System (Geocells)

- Expandable 3-D Cellular honeycomb-like structures
- Stabilize infill soil by confinement in a network of interconnected cells
- Developed by US Army Corps of Engineers in 1970s
- Different materials tried such as paper, metal, HDPE, etc.
- Latest in the series: **Neoloy Tough Cell**





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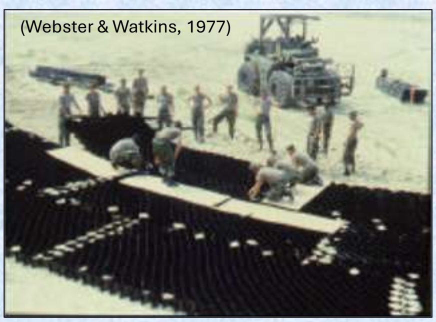
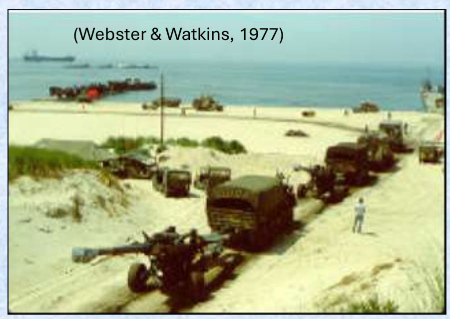
Development of CCS (Geocell) Technology



(Webster & Watkins, 1977)



(Webster & Watkins, 1977)

(Pokharel, 2013)

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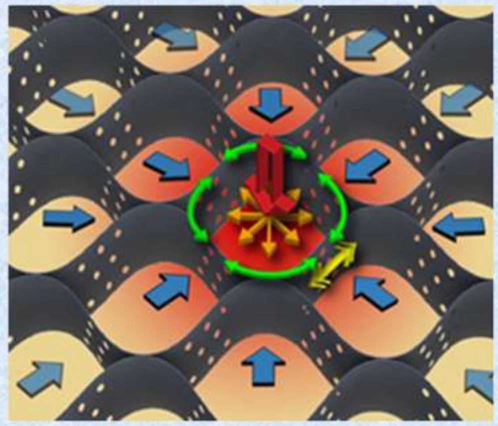
CCS Working Mechanisms



- Lateral and Vertical Confinement
- Thicker reinforced zone
- Wider Stress distribution
- Adds apparent cohesion to improve strength

- Hoop Resistance
- Wall friction
- Passive resistance
- Improved modulus

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NPA Tough Cell

- nano-composite alloy of polyester/polyamide nano-fibers, dispersed in polyolefin matrix.
- characterized by flexibility at low temperatures similar to HDPE and elastic behavior similar to engineering thermoplastic.
- lower thermal expansion coefficient, larger creep resistance, and higher tensile stiffness and strength than HDPE.
  - **Higher tensile strength**
  - **Higher elastic and dynamic modulus**
  - **Higher resistance to permanent deformation**
  - **Higher resistance to temperatures**
  - **Higher resistant environmental factors**

Property (SIM test, ASTM D6992)	Toughcell	Softcell
Allowable stress for long term design	>6.8 MPa	<2.5 MPa
Allowable load for long term design	>9.5 kN/m	<3.75 kN/m

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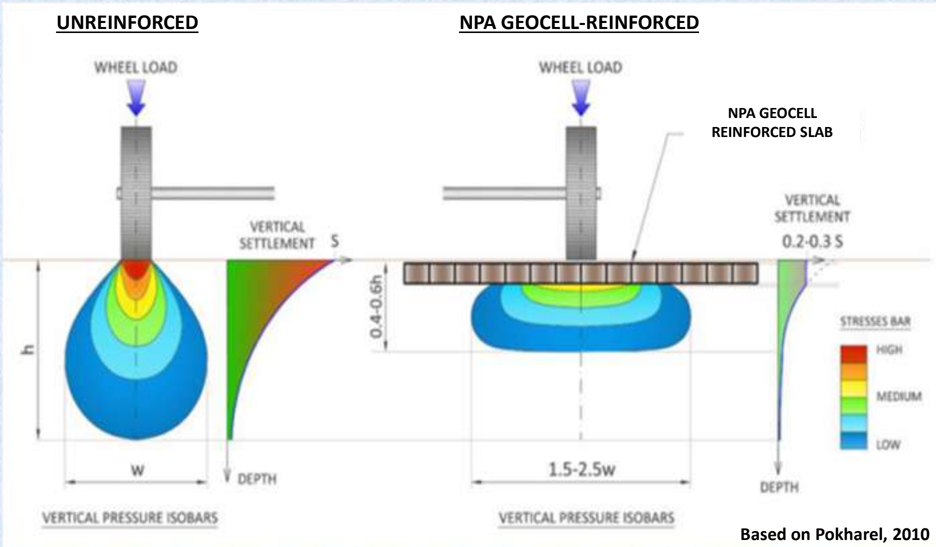
Stress Reduction - High Modulus NPA Geocell



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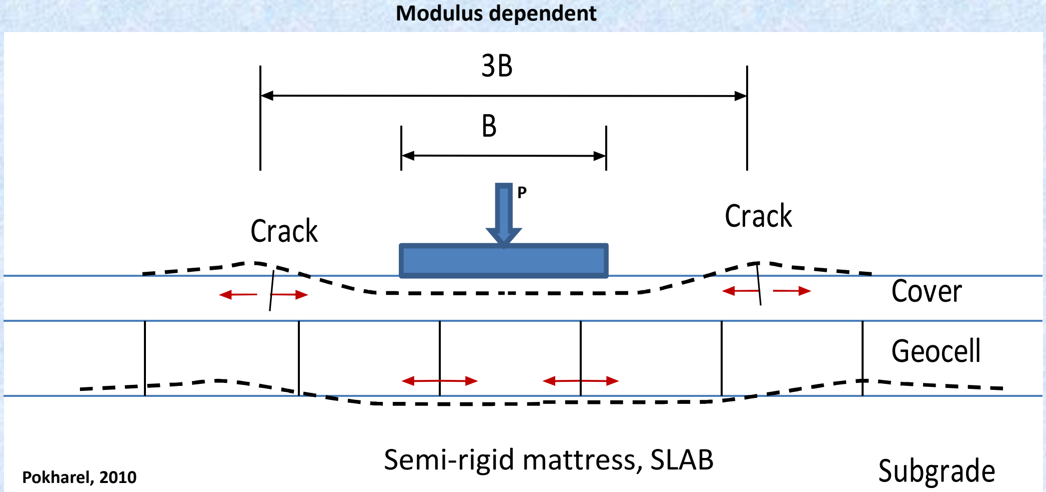
Beam / Slab Effect – High Modulus NPA Geocell

Modulus dependent



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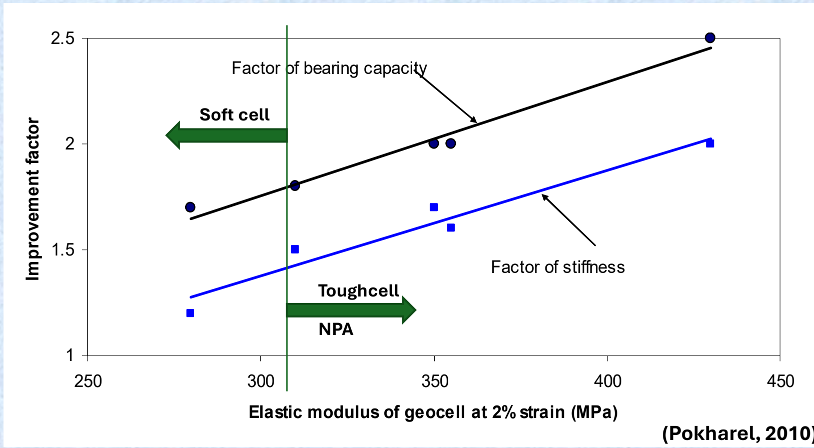
Modulus-Improvement Relationship



(Pokharel, 2010)

Relationship between the modulus of geocell sheet and the improvement factor for stiffness and bearing capacity

(Test on poorly graded sand infill and rigid subgrade)

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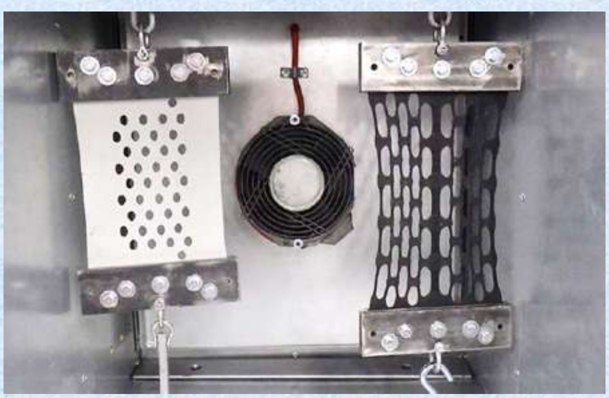
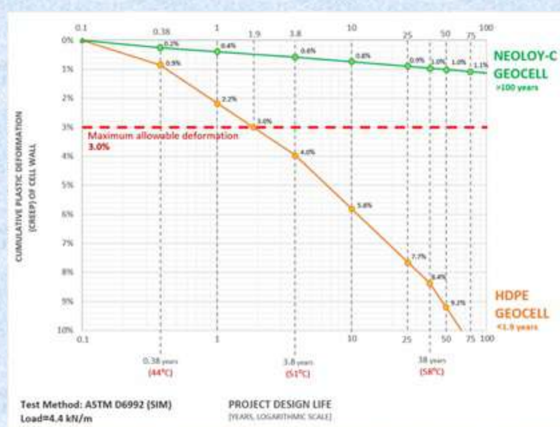
SIM TEST - Softcells vs Toughcells

The SIM (Stepped Isothermal Method) Accelerated Creep Test is the industry standard test for measuring tensile creep. It was first developed by the TRI – Texas Research Institute for NASA and the space industry – and then adopted by the Geosynthetic Research Institute (GRI, USA) (2000) and by the ASTM as standard D6992 (2003).



Comparison of Neoloy Geocell and HDPE (black)



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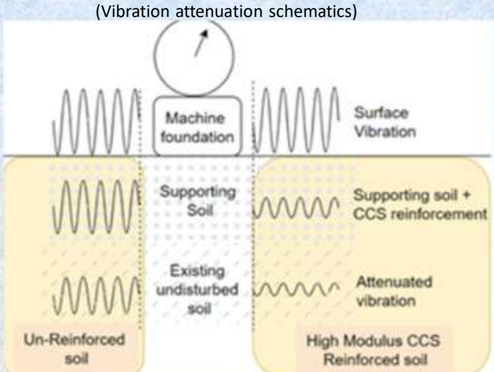
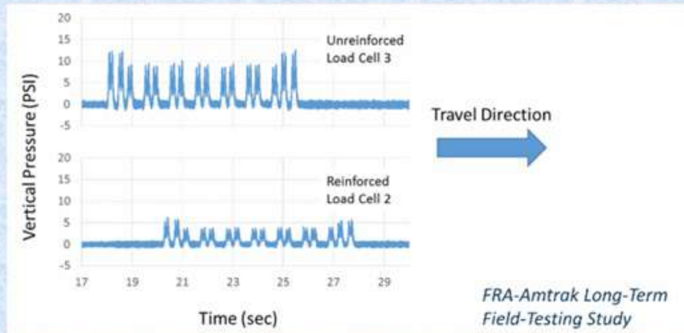
Vibration Attenuation / Dynamic Load

(Vibration attenuation schematics)



(Measured stress at the subgrade under dynamic high-speed train)



(Zarembski, Palese et al., 2017)

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Preferred Infill Material

For Load support - any free draining granular material with <12% fines

For vegetated slopes - Geocells can retain topsoil too

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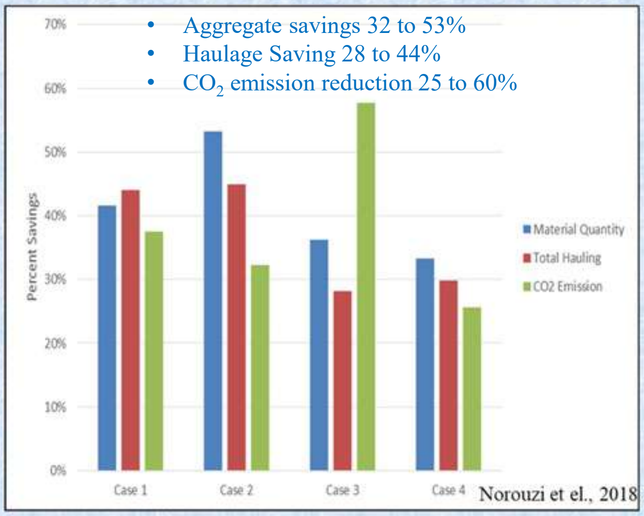
Cellular Confinement System- summary

What does Tough Cell do?

- Reduced stress on subgrade
- Increased bearing capacity
- Improved layer modulus
- Minimize creep-plastic deformation
- Freeze-thaw strength loss prevention
- Increased dynamic damping

Sustainability indicators- Alberta projects



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Development and validation of Design Method

Box tests

Moving wheel test

Medium size box

Large box

Accelerated Pavement Test

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Design Method Validation Field Research/ Test

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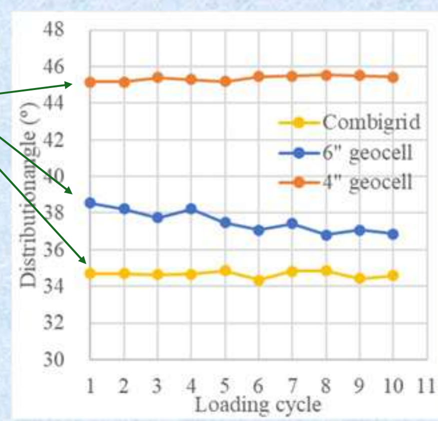
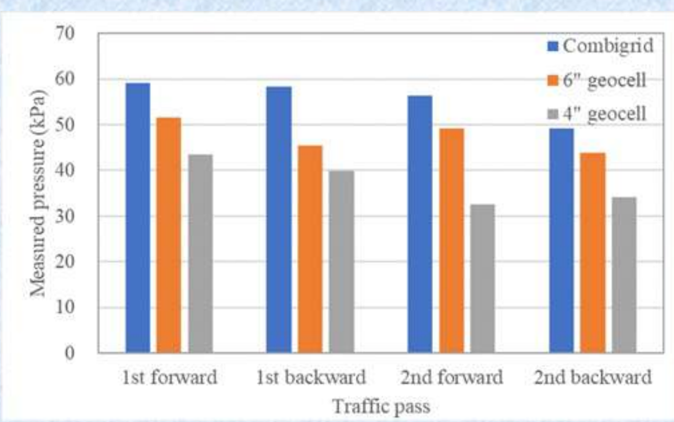
On going Research: Sturgeon Road Test

- The base course thicknesses
  - **100-330-P-D Toughcell = 300mm**
  - **150-330-P-C Toughcell = 300mm**
  - **Geocomposite section = 350mm**





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Research Publications, Approvals and Industry Validation

- Over 88 peer reviewed publications
- Over 500 projects designed with Tough Cell in Canada
  - Roads –paved/unpaved
  - Railway
  - Logging yard
  - Compressor Stations
  - Slopes, erosion control and Channels
  - Heavy haul road
- More than 150 publications worldwide on NPA Tough Cell and thousands of project worldwide

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Standards and Guidelines

- ❑ **ASTM D8269-21**
- ❑ **ISO standard 18228-5**
- ❑ **National standards**
  - ❑ Crow/SBRCUR standard, The Netherlands.
  - ❑ TG3 Technical guidelines, South Africa.
  - ❑ Alberta Transport approval.

- *"Geocells must have the right properties when it comes to dynamic stiffness, resistance to plastic deformation and tensile strength…"*
- extent of the reinforcing or stabilizing effect is determined by the **material from which the geocell product is made** and the geometry
- important material properties are **elastic stiffness** and **resistance to permanent deformation (creep)**.
- actual effectiveness of base reinforcement is reflected in the support improvement factor (SIF) and the modulus improvement factor (**MIF**)

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Standards and Guidelines

Organization: ASTM	ASTM D8269-21: Standard Guide for use of Geocells in Geotechnical and Roadway Projects
Published: 2018, World-wide	Title: ASTM D8269-21. Standard Guide for use of Geocells in Geotechnical and Roadway Projects, ASTM International, West Conshohocken, PA, 2018, www.astm.org. https://doi.org/10.1520/D8269-21.
	Brief: Covers the use of geocells in various geotechnical and roadway projects to standardize the use of this type of ground improvement technology in geotechnical-related applications: ○ Load support for unpaved and paved roads, railways, ports, heavy-duty pavements, container yards, and basal embankment stabilization ○ Retaining structures, free-standing structures, and fascia walls ○ Slope, channel, and geomembrane protection. For each application, the standard specifies the key geocell material properties and design guidelines. *See more details in Appendix 1* **PRS Neoloy® Tough-Cells meet or exceed the ASTM standards' properties to ensure long-term performance**

Organization: ISO	ISO/TR18228-5: Design Using Geosynthetics: Stabilisation
In publication 2022, World-wide	Title: ISO Standard WD TR 18228-5. (2022). Design using Geosynthetics – Part 5: Stabilization. International Organization for Standardization. Geneva, Switzerland.
	Brief: The ISO comprehensive Design Using Geosynthetics Standard chapter 5 is dedicated to the use and design of stabilization geosynthetics (3D geocells and 2D geogrids) in pavement structures. The geocells chapters includes: ○ General Description of Geocells Mechanism (4.3.2) ○ Unpaved Road Design Method with Geocells – Pokharel (6.2.3) ○ Railway (and roadway) design EV2 method with Geocells (6.5.4) ○ Key Properties for Geocells (7.3) ○ Testing Methods for Geocells (8.4) *See more details in Appendix 1* **PRS Neoloy® Tough-Cells meet or exceed the ISO standards' properties to ensure long-term performance**

ISO/TR 18228-5:2025(en)

K_1 is the coefficient defining the degradation of the load spreading angle with increasing number of passages;

$T_{2\%}$ is the tensile strength of the stabilizing geosynthetic at 2 % strain (kN/m);

r is the rut depth (m);

r_{cr} is the critical rut depth, reached when the full bearing capacity is mobilized (m).

Note that the base thickness h appears on both sides of the above equation, which can be therefore solved by iterations.

Refer to Reference [17] for information regarding the limits and applicability of the Leng-Gabr method.

6.2.3 Pokharel (2010) method for geocells

Based on studies of geocell stabilization mechanisms, numerical modelling and field trials, methods for design with geosynthetics were modified and adapted to geocells. The modifications include changing geosynthetic dependent parameters (such as torsional stiffness and tensile strength at 2 % strain) to geocell dependent parameters (such as elastic stiffness, creep resistance less than 2 % and tensile strength).

Pokharel[18] modified the Giroud and Han[2] design methodology for use with geocells. A specific set of geocell products, with specific properties were validated by laboratory cyclic plate loading tests and full-scale moving wheel tests. In the design methodology, a maximum allowable rutting is set (together with all other parameters) and the pavement thickness is determined by:

$$h = \frac{(0{,}868 + k' \log N)}{\eta[1 + 0{,}204(R_E - 1)]} \times \left(\sqrt{\frac{P}{\pi r^2 m 5{,}14 c_u}} - 1 \right) r \qquad (4)$$

where

h is the required base course thickness (m);

r is the radius of tire contact area (m);

N is the number of ESAL;

P is the wheel load (kN);

c_u is the undrained cohesion of the subgrade soil (kPa);

R_E is the modulus ratio of base course to subgrade soil;

m is the bearing capacity mobilization factor;

η is the conversion factor (0,689 for cyclic plate loading tests, 1,0 for field tests);

k' is the geocell calibration factor for the product used in design.

Giroud and Han[2] proposed a factor (k) that controls the rate of reduction in the stress distribution angle, which depends on the (r/h) ratio and the aperture stability modulus of the geogrid. Since the aperture stability modulus is not suitable for geocells, Pokharel[18] proposed a factor (k') to replace the CF (calibration factor) for the design of geocell bases over weak subgrade as shown in the equation above.

The reduction in the load distribution angle with the number of passes caused by the deterioration of the base course material under the repeated loading in the laboratory was observed by Gabr[22] for geogrid stabilization. Recent research showed that geocell confinement slows down the rate of deterioration and increases and maintains the modulus of the base course.

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Design Methods

- **Rut Criteria : Han and Pokharel (2015) method: Modified for Neoloy based geocells from Giroud and Han method for planar reinforcement.**

$$\text{Required thickness, } h = \frac{\left\{0.868 + k\left[\frac{r}{h}\right]^{1.5} \log N\right\}}{\{1 + 0.204(R_E - 1)\}} \times \left\{\sqrt{\frac{P}{\pi r^2\, m\, 5.14 c_u}} - 1\right\} r$$

- **Bearing Capacity Criteria: Terzaghi and Boussinesq formula**

$$q_{a,ult} = 1.3 N_c c_u + \gamma D N_q + 0.6 \gamma R N_\gamma$$

$$\sigma_{vt} = P\left[1 - \left(\frac{1}{1 + \left\{\frac{R}{Z_t}\right\}^2}\right)^{3/2}\right]$$

- **Beam on Elastic Foundation Analysis method if the applied load or cranes are supported on crane mats**

- **Hoop Strength of the Cells: Basic hoop stress formula from Physics**

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AASHTO Design method for Paved Road

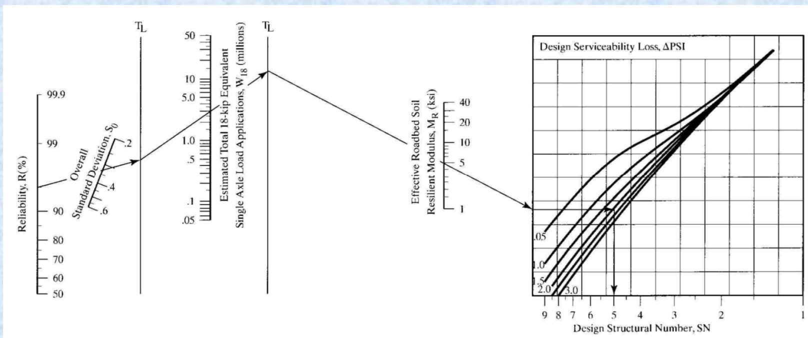
$SN = a_1D_1 + a_2m_2D_2 + a_3m_3D_3$

D_i= i^{th} layer thickness
m_i= i^{th} layer drainage coefficient
a_i= i^{th} layer coefficient
for unreinforced gravel base course ~ 0.14
for NPA-Geocell reinforced gravel base course ≥ 0.27

Modulus Improvement factors

Strength at yield (wide-width) = 22 kN/m

field tests and lab verification have shown MIF >4 for the NPA-Geocell reinforced GBC
3.5 is used for Type C



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Applications of Neoloy Tough Cell

Load Support
- Paved Road
- Unpaved Roads
- Crane and compressor station pads
- Haul roads / mine roads
- Railway Tracks
- Ports, shipyards and intermodal facilities
- Foundation Support
- Permafrost

Soil Stabilization / Slopes and Erosion Control
- Protects against slope failures and erosion
- Channel erosion protection
- The cell perforations facilitate drainage and root interlocks as well

Retaining walls
- Landslide protection
- Gravity retaining walls
- Reinforced Retaining Walls

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7th Street Nisku - Construction




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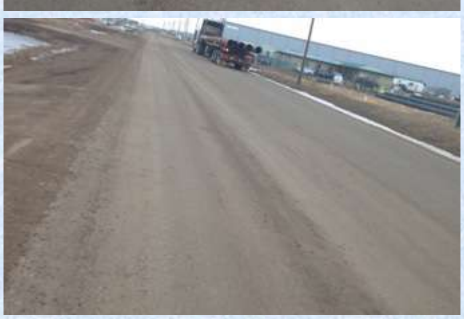
Observations

March 2015 NPA-Geocell

March 2015 CTB section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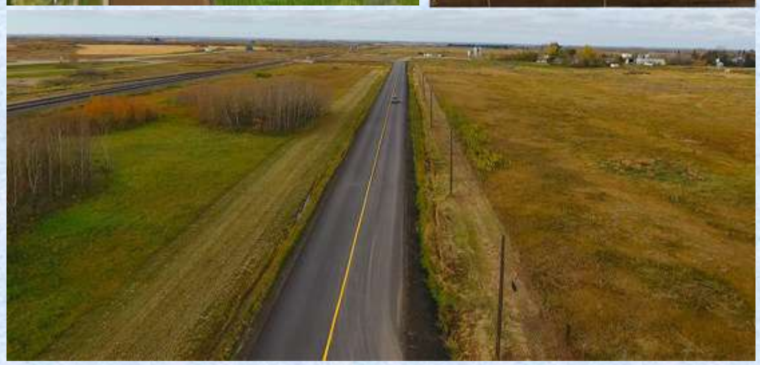
Village of Ryley – Paved Road

Existing condition

Rehabilitated with Tough Cell



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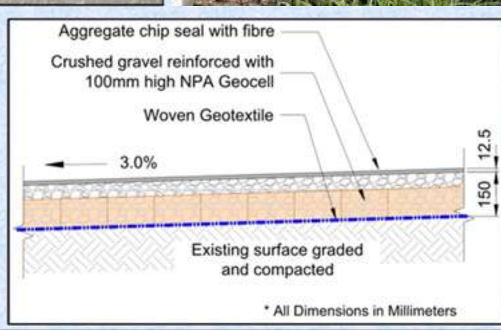
Mitchell Beach, Pigeon lake – Chip Sealed

Existing road surface in June 2013

Han and Pokharel (2015) design method ISO/TR18228-5



With chip-seal

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Performance of the Road

Two years

Five years

Seven years

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Hudson Bay Rail Track to Churchill - Flood Damage 2017

https://globalnews.ca/news/3523871/photos-show-widespread-damage-on-rail-line-to-churchill/

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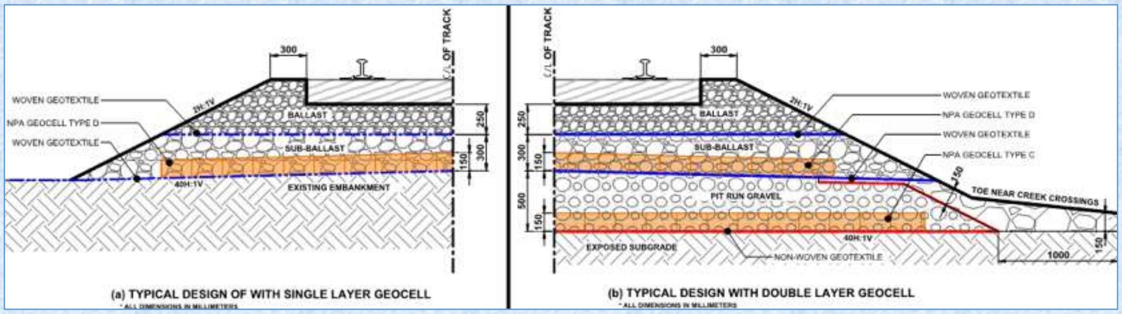
Rehabilitation design



- Only 5% of the applied load reaches the permafrost subgrade
- Washed debris material used with Toughcell at the sub ballast layer
- Vibration damage mitigation – a balanced fill height for thermal requirement and load support.

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Installation of Tough Cell – double layer

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Completion and Start of the Rail Service

Completed rail re-installation

First train arrival October 31st, 2018, in Churchill in two years

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In 2025

Non-stabilized section

Tough Cell stabilized section

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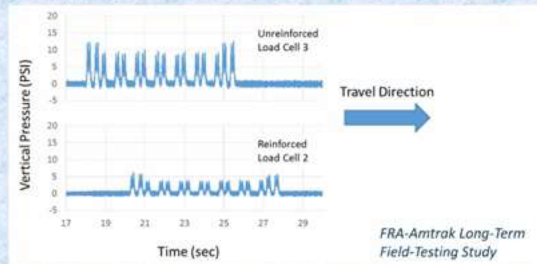
High Speed Track Stabilization, Amtrak USA

Decreased track maintenance cycle by 7 times



(Zarembski, Palese et al., 2017)

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Tough Cell on Unpaved and Haul Roads

Access to Buffalo Creek Compressor station 11.3kM road

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Haul Road Design with Petcoke Infill, Fort Hills, AB

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Performance

1.75m of gravel replaced by petcoke

Loads considered

- SMPT transport of new coke drum
  (3 units; each unit weighing 612,990lbs)
- CAT793 with 400 MT gross load

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Fort Hill Haul Road, OSR Phase II

Additional challenge was to maintain the downstream flow in the creek, upstream ponding not allowed.

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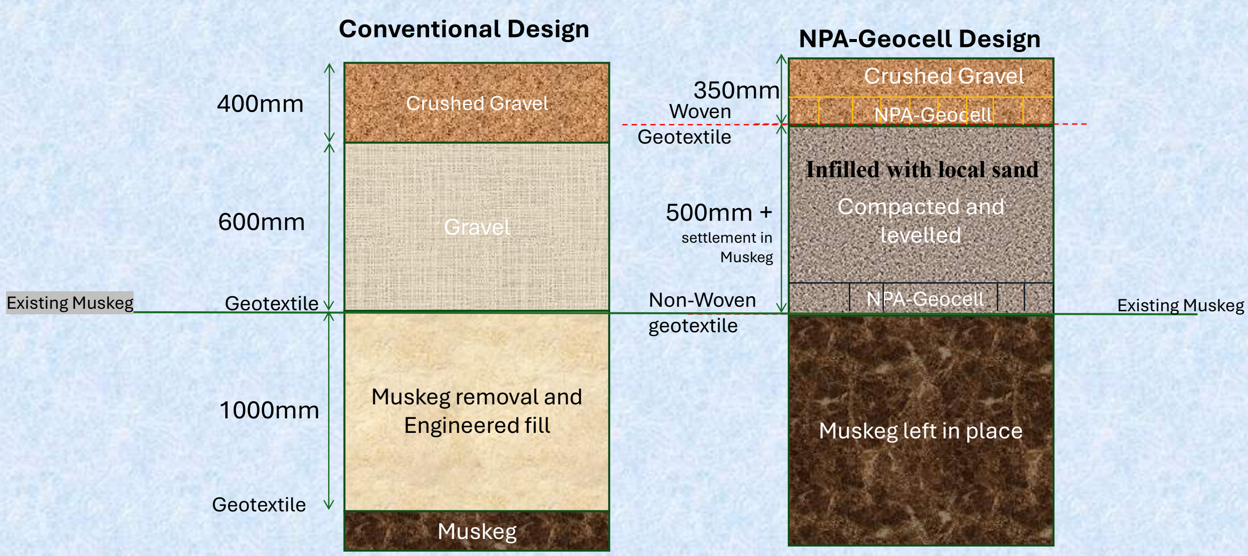
Fort Hills Haul Road, OSR Phase II

Load for design: CAT 797 (400 tons), CAT 793 (250 tons), CAT 777 (100 tons)



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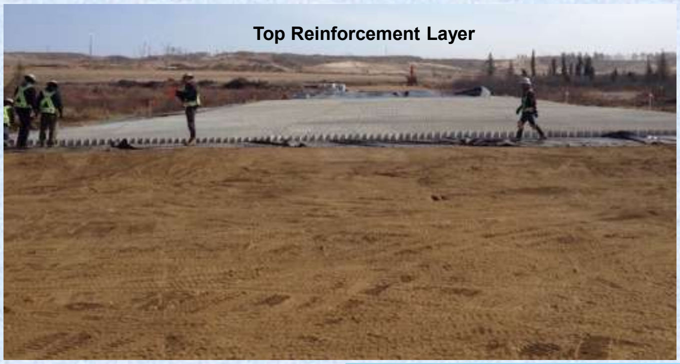
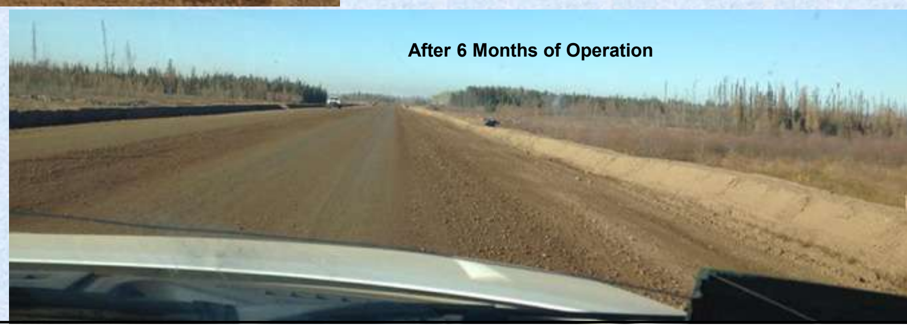
Fort Hill Haul Road, OSR Phase II



Nominated for the Client's President award for innovation and cost savings: 60% in cost and time savings



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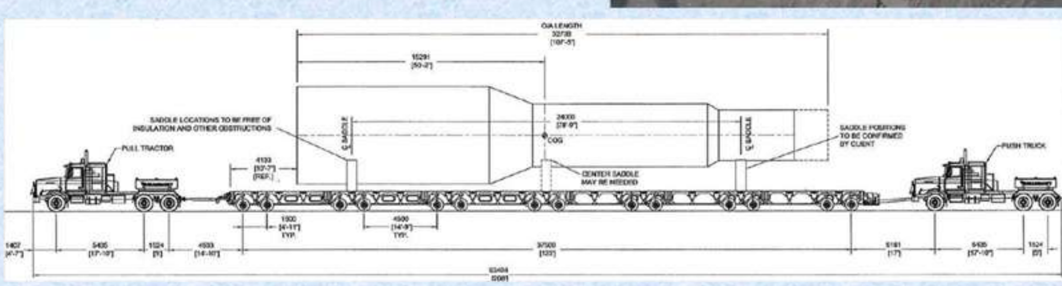
Causeway – Grizzly Oil Sands

<u>Access road in Algar Lake area 15km west off Highway 63</u>

- 205m stretch of access road
- Lowering of road level required
- Construction 4m below water table
- 6m deep Muskeg, CBR <1
- Design: Geomembrane with Clay cover and Neoweb-reinforced 40mm minus gravel as load support structure
- 14-Line 10' wide Hydraulic Scheuerle Trailer – 280,600 kg



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Liner, Gravel and NPA-Toughcell

After completion

After 3 months

Aquamaster PE 24 1563 N Liner + Clay cover + NPA-Geocell + gravel infill

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Unpaved Access Road, Christina Lake, MEG Energy

Traffic

Existing surface

Sand fill by end dumping

Aerial view

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Access Road

Loaded rock truck on completed road

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Mine Haul Road in the Arctic

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Blainville compressor Station, QC

NPA Toughcell Design for both access road and station pad

Properties	Type D	Type C
Dynamic Modulus (MPa)	>650	>525
Tensile Strength (kN/m)	>22	>19
Seam Weld Strength (kN/m)	>22	>19

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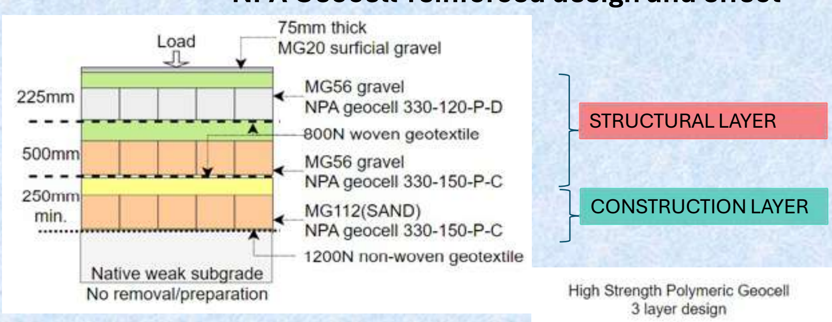
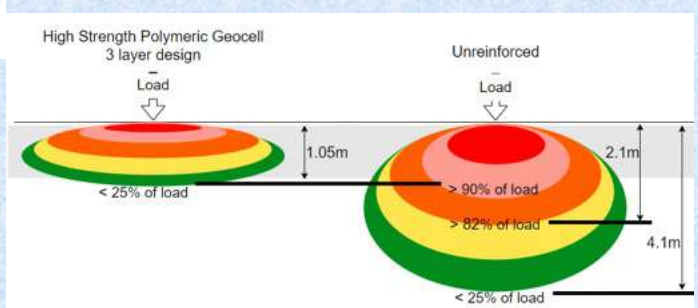
Blainville compressor Station, QC

NPA Geocell-reinforced design and effect





(Chatterjee et al. 2023)

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Blainville compressor Station, QC

PERFORMANCE

During construction

18 months later

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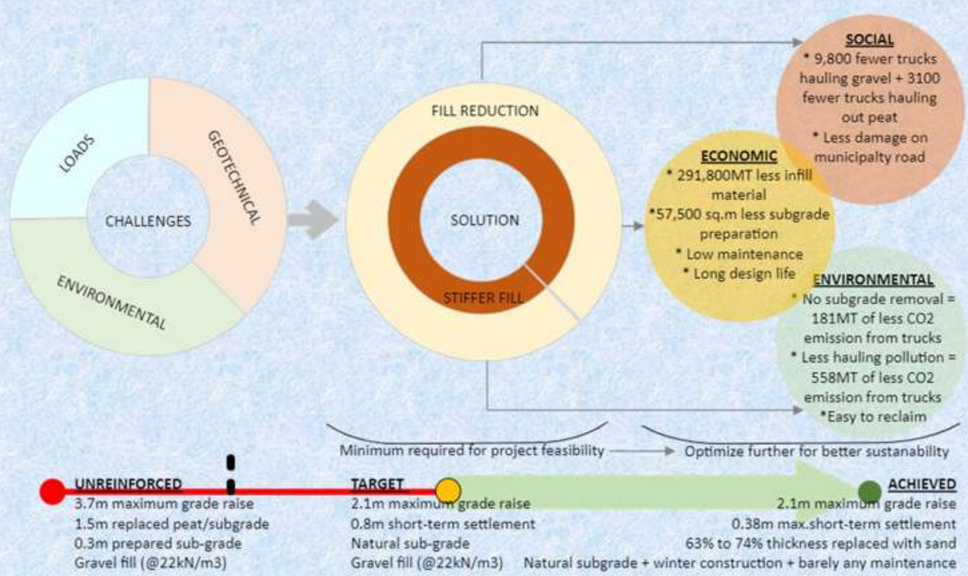
Value Added Engineering



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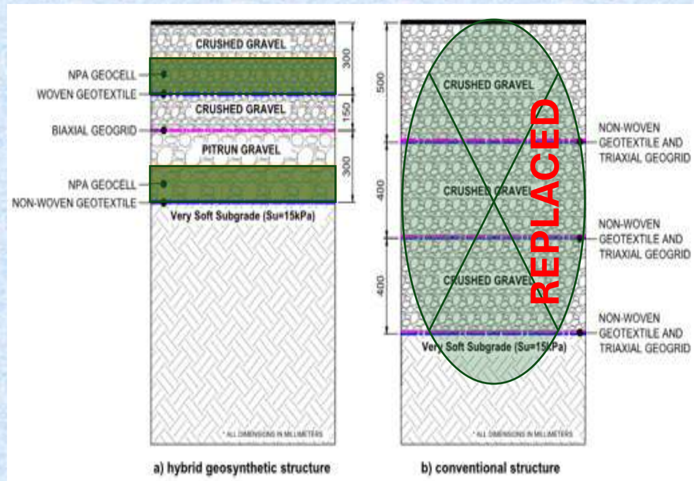
Otter Lake Compression Station: Hybrid Design with Tough Cell

Subgrade with total footprint of 27,000 m^2

Design comparison



- Design load
  - 215 tonne crane
  - Trailers carrying 140 tonne loads and
  - Highway trucks
- Innovative **HYBRID** design:
  - A layer of biaxial geogrid at the middle and
  - 2-layers of high strength polymeric Geocell with geotextile for separation
- Required gravel thickness
  - Cheaper pit run = 300 mm
  - Crushed = 450mm
- Designed to save crushed gravel and avoid excavation to possible extent

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Construction

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Performance

After completion

After one and a half year in operation

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Advantage of the design

Using the hybrid reinforcement structure:

- 22.8% savings in initial project cost,
- 100% savings in excavation,
- 42.3% savings in granular fill volume, and
- 45.7% savings in granular fill costs

Additional contribution to environmental benefits:

- The reduction in the volume of aggregate,
- The number of trips to haul material and
- Construction Time

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Logging Yard, CANFOR, Ft St John, BC

Canfor Logging Yard,
Fort Saint John. BC

The project eliminated all downtime related to log supply while improving mill production, employee morale, safety and reducing mobile equipment operating costs.

Savings per year on operation:
- Fuel savings $50k
- Loader maintenance $125k
- Tires & wearable parts $75k
- Avoided production loss $750k

Mel Jones
Plant manager,
Canfor Ft. St. John

CAT 988H before construction

Portion of completed surface

Toughcell installation

CAT 988H Loader on completed surface

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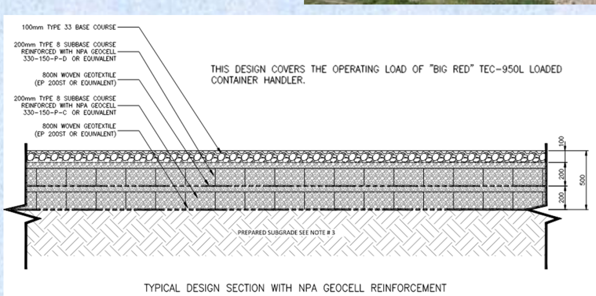
Mobil Grain Intermodal Facility, Regina



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Mobil Grain Intermodal Facility

In 2022 after 4 years of operation

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Crane Pad and Access, Langley

Trans Mountain Pipeline Spread 7A Wetland, Michels Canada

- Located in Langley, BC
- Temporary access for the pipeline construction through swampy lands
- NPA Geocell Reinforced foundation design over swamp using and mat on top

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Crane Pad and Access, Langley, BC

Trans Mountain Pipeline Spread 7A Wetland, Michels Canada

Construction

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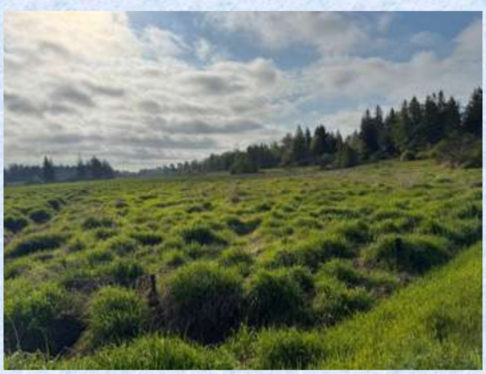
Trans Mountain Pipeline Spread 7A Wetland, Michels Canada, after reclamation in 2025 April



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Crane Foundation Support for Gantry, Egermont, AB



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Crane Foundation Support for Gantry, Egermont, AB

Refinery parts finishing long journey

Huge Sturgeon components finally hit road

DAVE COOPER
Edmonton Journal

After years in storage in Duluth, Minn., the heart of the new Sturgeon Refinery is finally on the road.

A dozen megaloads, which represent the disassembled vessel components weighing up to 510 tonnes each, are being hauled this week from a CN Rail siding north of Redwater down secondary roads to the refinery construction site northeast of Fort Saskatchewan.

The loads, up to eight metres wide and almost 80 metres long including the single pulling tract[illegible] two pushers, are travelling on

For Sturgeon Refinery - EDMONTON JOURNAL - February 5th 2014

Vessel weight 500ton
287 kPa bearing capacity required at the base

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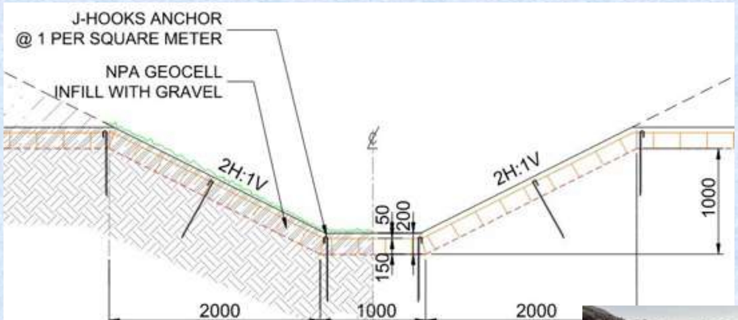
Channel protection and Lining, Drumheller, AB



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Channel Protection and Lining – Grand Cache, AB

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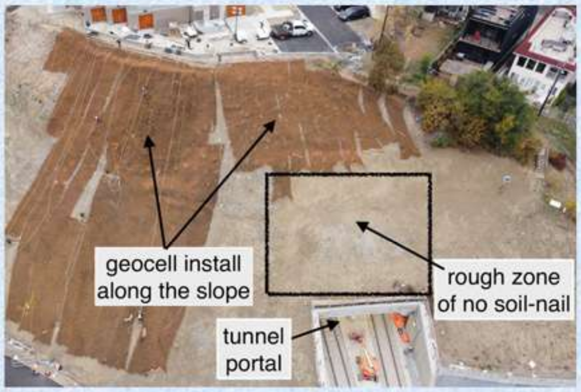
Slope and Erosion Protection LRT Tunnel Portal, Edmonton



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LRT Tunnel Portal, Edmonton - Performance

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Slope Protection

De-Beers, Victor mine, Ontario

Erosion control, City of Calgary

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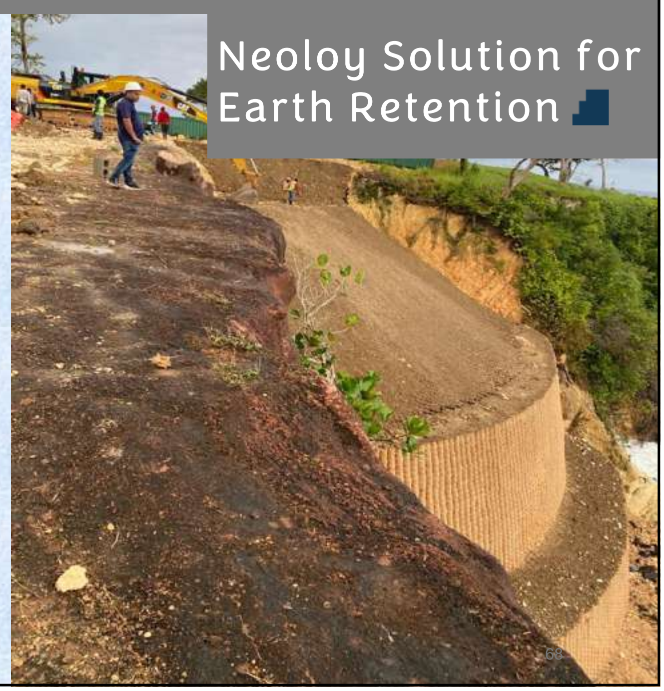
Dominican Republic

Neoloy Solution for Earth Retention



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EARTH RETENTION

PROJECT AT A GLANCE

Application
Reinforced and Gravity Retaining Wall

Subgrade/Soil
Gravel clay

Location
Zincirlikuyu, Istanbul, Turkey

Region
Middle East

Installation Date
Summer, 2009

Contractor
Prodezi Engineering-Consultancy

Client
Aşçıoğlu-Yimtaş JV

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Shipyard, Haifa

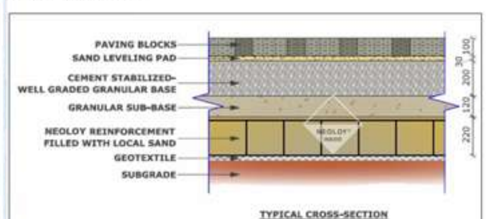
ISRAEL SHIPYARDS WHARF REHABILITATION

DESCRIPTION

The asphalt pavements of the large working platform docks at the Israel Shipyards suffer severe cracking and deterioration. These are caused by voids in the sand subgrade (which fill the dock's steel frame) as a result of the saturated marine conditions. Heavy loading from the Shipyard's 400-ton cranes, heavy machinery and container-reach stackers (can achieve up to 100 kg/cm2 pressure when lifting) combined with settlements and lowered bearing capacity caused failure of the platform surface and substructure layers.

The entire structural pavement needed to be replaced with a solution offering durable reinforcement over the unstable subgrade with sufficient bearing capacity for the entire range of Shipyard activities. The Shipyard was interested in fast and cost-efficient construction methods to reduce operational downtime and minimize work backlogs.

Pavement Structure



Concrete Paving Blocks
- 10 cm standard concrete paving blocks
- 3 cm sand leveling course

Cement stabilized base
- 20 cm height
- Mix according to Hydraulically Bound Mixture standards
- Strict on-site QC

Subbase
- 12 cm of Type I granular aggregate

Neoloy Tough Cells
- 20 cm height
- Local sand infill + 2 cm overfill
- Compaction

Geotextile
- 200 g/m2

Subgrade
- 2 x 20 cm layers
- Processing and compaction of sand – 15-ton non-vibratory compactor

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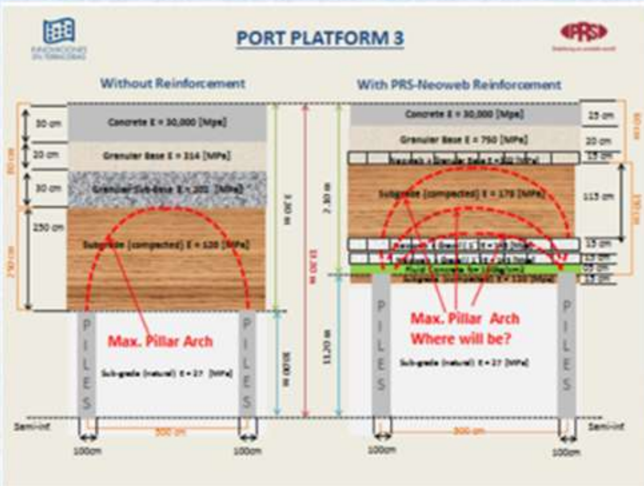
Shipyard, Manzanillo, Mexico



<u>LOAD TRANSFER PALTFORM - PAVEMENT STRUCTURE:</u>

- 25 cm — Concrete layer *(instead of 30 cm in conventional solution)*
- 20 cm — Granular Base layer *(modulus 750 MPa instead of 314 in conventional solution)*
- 12+3 cm — 12 cm Neoloy Tough Cell Base layer stabilization + 3 cm compacted overfill *(instead of 30 cm granular subbase layer)*
- 115 cm — Controlled subgrade (silty sand) *(modulus 178 MPa instead of 120 Mpa, and 115 cm instead of 230 cm in conventional solution)*
- 15 cm — Neoloy Tough Cell subgrade stabilization
- 15 cm — Neoloy Tough Cell subgrade stabilization
- 05 cm — Hydraulic cement – working platform
- 15 cm — Compacted subgrade

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Shipyard, Manzanillo, Mexico

MANZANILLO PORT LOAD TRANSFER PLATFORM, MEXICO

DESCRIPTION

A new 150,000 square meter multiple use terminal (MUT) was planned for Manzanillo port to handle 2.5 million tons of general purpose cargo and bulk minerals per year. The contractor was to build five 10,000 sqm platforms within a year utilizing the best available environmental- friendly and sustainable infrastructure. Construction was planned according to the highest international standards with a goal to exceed the planned handling capacity.

The only problem was the extreme site conditions for the terminal platform. The soil was saturated silty sand with a CBR <2%. Bulk handling of lead and zinc minerals, piled into mountains of ore on the dock could reach loads of 35 ton/m^2. The foundation for the terminal was constructed on vertical columns (piles); therefore, the reinforcement solution had to function as a load transfer platform (LTP) as well.

Due to the extreme site conditions and project requirements Ancora Engineering worked with PRS to develop a reliable design for a Tough Cell reinforced load transfer platform (LTP).

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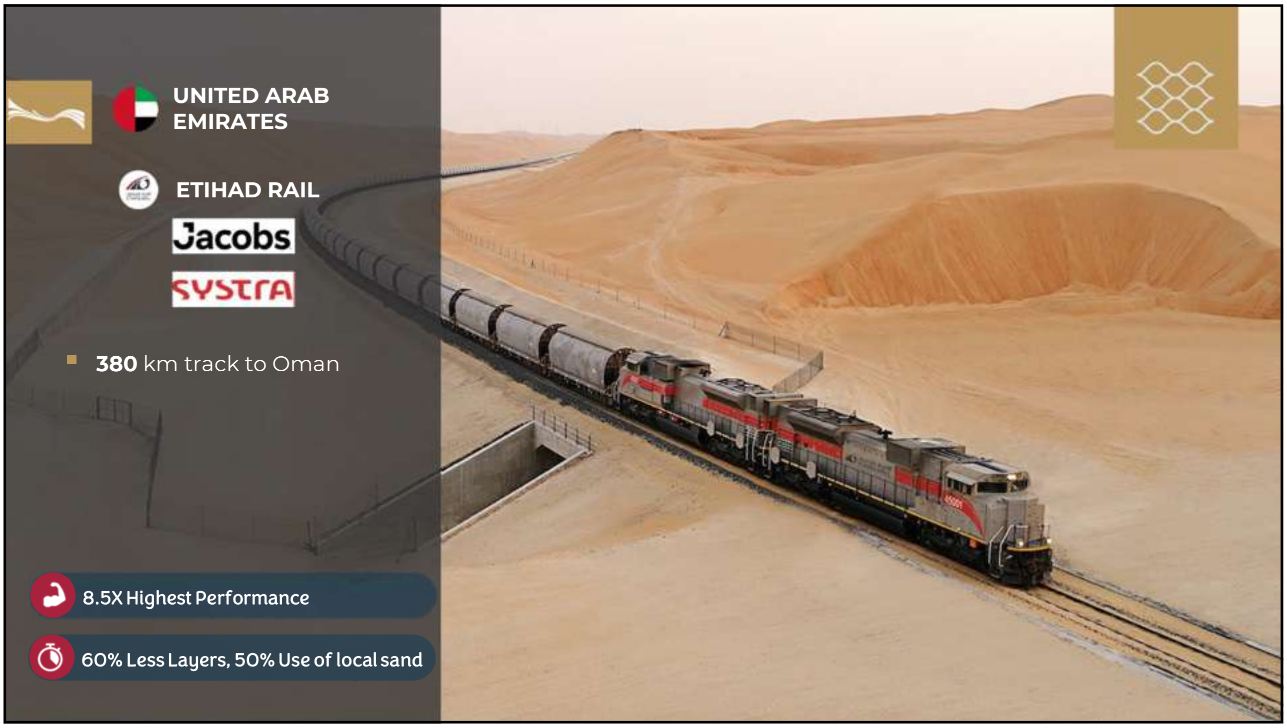
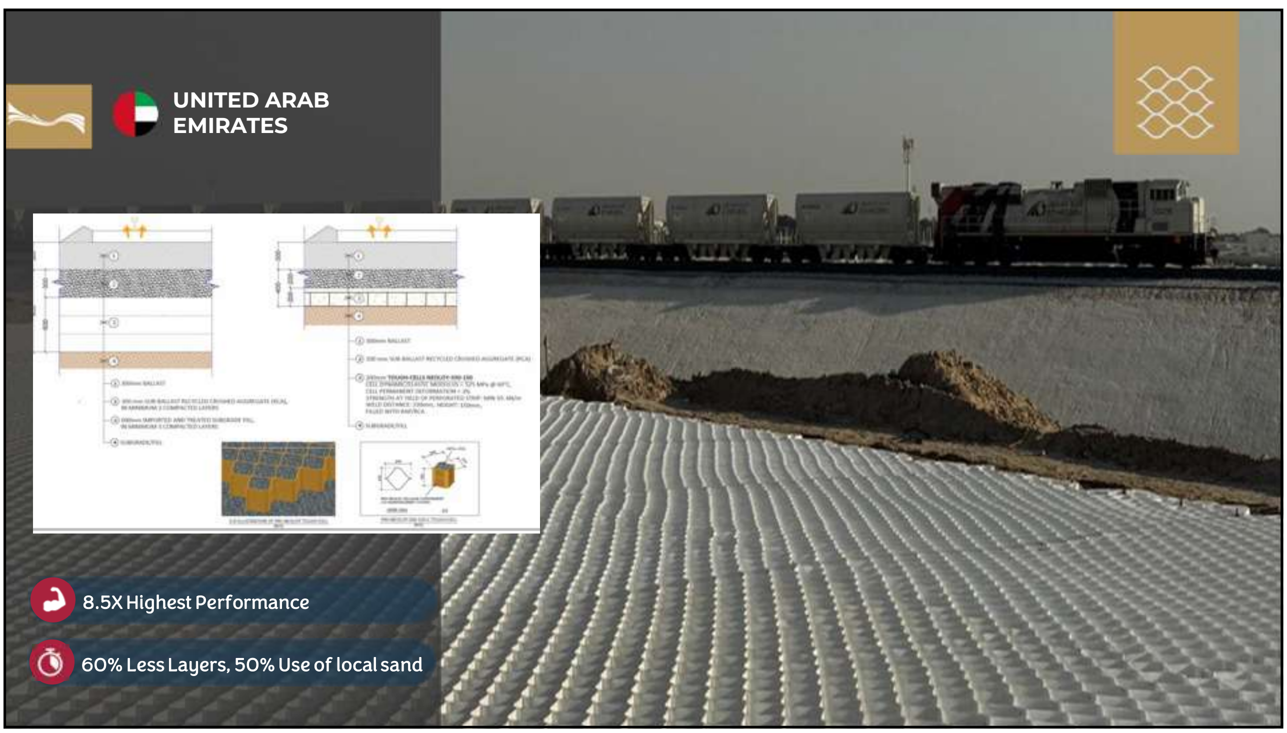

UNITED ARAB EMIRATES
ETIHAD RAIL
Jacobs
SYSTRA
380 km track to Oman
8.5X Highest Performance
60% Less Layers, 50% Use of local sand

73


UNITED ARAB EMIRATES
8.5X Highest Performance
60% Less Layers, 50% Use of local sand

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Mexico, Port
Neoloy Enables the
Lowest Settlements
For Ports
50% Cost Savings
Heavy load support – the "Mammoet"

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UK
Sea Wall,
Swansea,
Wales
Effective & durable sea wall
Cost-effective solution
Highly stable solution

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