GN Northern, Inc.
Consulting Engineers Environmental Scientists Construction Materials Testing

October 16, 2018

Swiftwater Custom Homes
Swiftwater Cellars Properties, LLC
PO Box 492
Roslyn, WA 98941

Attn.: Jeff Hansell,
CC: Paul Inwards, PE, Project Engineer, JUB Engineers, Inc.
Bryan Woodruff, RA, NCARB, AIA, Swaback, pllc

Subject: MEMO: Geosynthetic Mitigation Option of Sinkhole Hazard Risk
Winemaker's Cabins at Swiftwater Cellars
301 Rope Rider Drive, Cle Elum, Kittitas, Washington

GNN Project No. 217-871

References: GN Northern, Inc., December 4, 2017, *Coal Mine Hazards Assessment & Geotechnical Evaluation Report, Winemaker's Cabins at Swiftwater Cellars*, 301 Rope Rider Drive, Cle Elum, Kittitas, Washington, GNN Project No. 217-871.

GN Northern, Inc., June 4, 2018, *Supplemental Coal Mine Hazards Assessment, Winemaker's Cabins at Swiftwater Cellars*, 301 Rope Rider Drive, Cle Elum, Kittitas, Washington, GNN Project No. 217-871.

Gentlemen,

As requested, GN Northern (GNN) is pleased to present this memorandum regarding the use of geosynthetic reinforcement as an option for near-surface mitigation to reduce the risk of ground subsidence, surface distortion and displacement resulting from possible development of sinkholes beneath the proposed project caused by collapse of remaining historic coal mine workings.

Our services were completed in general accordance with our discussions and understanding during a conference call with representatives of Swiftwater Cellars Properties, LLC (SCP) and J-U-B Engineers (project civil design team) on August 29, 2018.

Based on the findings of our previous studies, portions of the project are underlain by historic abandoned coal mine workings that represent a significant hazard to proposed development at the surface from possible sinkhole development and associated subgrade settlement. Several factors must be considered for selection of an appropriate hazard mitigation method, including the degree or severity of the hazard, determination of the owner/developer's acceptable level of risk, and the subgrade support tolerance or level of importance & sensitivity of a proposed structure or improvement to be constructed above the hazard area and an appropriate setback from the mitigation areas.

As an alternative to appropriate abandonment through pressurized grout slurry backfilling of the existing mine workings or other methods to mitigate the noted risk, SCP wishes to consider the use of geotextile reinforcement installed near the surface. We understand that the proposed development layout has been revised to replace previously planned habitable residential building lots that were found to be located within areas identified as *Unbuildable Areas* due to *Moderate to Severe Mine Hazard*, with a proposed paved parking lot and private residential roadway with buried utilities.

It should be understood by all parties that near-surface reinforcement of upper site soils above the existing open mine works at depths does not mitigate or reduce the possibility of deep-seated collapse that would result in surficial disturbance and/or sinkhole development. This proposed near-surface improvement is a "safety-net" approach which considers the likelihood for short-term infrastructure disruption without significant risk to human health and safety until repairs could be completed.

Overview of Sinkhole Hazard Mitigation Using Geo-synthetic Reinforcement

In lieu of deep-seated improvement by backfilling the open mine works with grout slurry, the proposed project layout has been revised to allow for a near-surface approach to mitigation with the installation of geogrid reinforcement layers placed beneath proposed paved parking lots, roadway, and buried utilities. This relatively shallow mitigation approach will utilize placement of high-strength geogrids over the areas of mapped concern with a sufficient lateral extension beyond all sides of potential sinkhole formation areas. The intent of this mitigation method is for the geogrids to span the resulting void in the event of a collapse while supporting the ground above. The employment of this type of shallow improvement can be acceptable provided the proposed improvements above the geogrid reinforced areas are engineered and constructed with the understanding that some damage will occur in the event of a failure.

Considerations for Geo-synthetic Reinforcement Option

- ***Subsurface conditions beneath the proposed project pose a significant risk of ground subsidence resulting from collapse of remaining subterranean mine works. Appropriate mitigation measures are required to reduce the risk to human health, public safety, and property.***

- A near-surface approach to mitigating the hazard posed by potential development of sinkholes with the use of engineered geogrid reinforcement layers may be employed, provided:

  - The owner/developer understands and accepts the risk that damage may occur to site improvements/infrastructure in the event of subsurface collapse;
  - Habitable structures are not constructed within remediated high-risk areas designated as *Unbuildable Areas*;
  - Proposed improvements developed within remediated high-risk areas such as pavements, stormwater facilities, landscape features, and buried utilities should be designed and constructed to tolerate some degree of short-term subgrade settlement and distortion until repairs can be made without significant risk to human health and safety.

Geo-synthetic Reinforcement Design Approach

Any proposed site improvements located within portions of the project site that have been mapped as *Unbuildable Areas* due to *Moderate to Severe Mine Hazard*, shall be improved with the installation of geogrid layers as recommended herein. The general intent of the proposed mitigation design for this project is to provide a "safety-net" to prevent a full sinkhole cave-in in the event of a catastrophic failure at depth. Development above the proposed geogrid mitigated area will be restricted to paved parking, drive lanes, and buried utilities with sufficient tolerance to short-term subgrade settlement and distortion. The goal is to limit a significant life-safety concern while accepting that damage will occur to the infrastructure and repairs will be required.

Considering the proposed method of shallow mitigation with geogrid reinforcement within the mapped zone of area at risk, no home foundations shall be constructed above any portion of the extended buried geogrids. At some distance away from the outer edges of the geogrid reinforced area(s), development with residential structures (habitable structures) will commence as close as it is safe to do so. The geogrid design noted in the following paragraphs establishes the required geogrid extension. The buried geogrids may be wrapped around buried deadman anchors (ecology blocks or gabion units) to effectively reduce the lateral extension beyond the edge of the areas of concern to allow for more buildable real estate for the proposed development.

The design approach for geogrid reinforcement details the strength of the geogrids, minimum lateral extension ("*bond length*"), minimum required depth that the layers will need to be installed, and placement of engineered structural fill material both above and below the grid layers. With that in mind, and since the developer will want to construct habitable structures as close as possible to the mapped edges of the area of concern, the design goals for this project are:

- Selection of a specified ParaLink grid strength with an acceptable surface deformation limit that will allow for the shortest possible lateral extent (bond length) beyond the edge of concern.
- Minimum required depth of burial (thickness of upper fill) based on the selected soil and interface design parameters and selected ParaLink properties to allow for the shortest possible bond length.

A review of previous mine maps at the site indicate that mine shafts appear to typically measure approximately 20 feet in width. Based on the noted apparent width of historic mine shafts, we suggest an anticipated approximate diameter of possible surface sinkholes could be on the order of about 30 to 50 feet. We recommend that the proposed geogrid reinforcement layers should sufficiently span the entire area of concern and will require a minimum lateral offset equal to the ***net*** bond length required for the mitigation design beyon the outer edges of the mapped zone of *Unbuildable Areas*.

Geosynthetic Reinforcement Analysis

GNN consulted with Maccaferri for the preliminary design of the proposed mitigation using Maccaferri's ParaLink geogrids. The software used for the analysis is the MACBARS VOIDS for the design of a reinforced excavation section over sinkhole applications. A minimum excavation depth of 3 feet is required to provide enough weight of engineered backfill materials to ensure that the high strength geogrid can deform and to anchor the geogrid around the sinkhole.

To determine the optimal geogrid bond length, deformation limit of the new pavement surface were set at 3% and 5% with respect to the void diameter. The analysis considers a layer of crushed aggregate backfill below and above the ParaLink grids. The following design parameters were used to model the excavation and backfill properties for the proposed mitigation:

- Traffic Load: 150,000 ESAL
- Depth of Excavation/Height of Fill: 3 feet
- Unit Weight of Structural Backfill : 136 pcf
- Friction Angle of Fill Material in contact with Grids = 36°
- BackFill Type: Crushed rock engineered fill
- Design Life: 60 years

Void Properties

- Type of void: Axisymmetric cone
- Diameter of subsurface void: Approx. 20 feet

Preliminary Design and Construction Recommendations

Based on the results of the analysis for a preliminary design, we recommend installing two layers of uniaxial high strength geosynthetic layers such as Maccaferri ParaLink™ 1000 geogrid or ParaLink™ 1500 geogrid in 90 degree longitudinal and transvers layers (one perpendicular to the other) to reinforce subgrade soil within mapped *Unbuildable Areas* prior to construction of the proposed infrastructure improvements. Using ParaLink™ 1000 geogrid, the minimum reinforcement bond length (geogrid extension length beyond the edges of concern) of 42 feet on all sides is necessary to limit possible pavement surface deformation to 5%. Using ParaLink™ 1500 a minimum bond length of 47 feet is required to limit possible pavement surface deformation to 3%. Our preliminary design considers wrapping the geogrid edges around buried deadman anchors, such as concrete ecology blocks or gabions to reduce the total bond length extension by approximately 50% (net bond length). Note that the deformation limit of 3% equates to about 7.5" of settlement in the center of the void at the surface and 5% equates to about 1' (12") of settlement. See attached outputs of the engineering analyses for each geogrid option.

The grids shall be placed at a minimum depth of 3 feet below the design finish exterior grade. A minimum 5 feet overlap between adjacent geogrid sheets will be required to ensure reinforcement continuity. The geogrid layers will require a minimum 6-inch thick layer of imported crushed aggregate structural fill placed below, and a minimum 2 foot layer above to sufficiently sandwich the grids. See attached Figure 1, *Geogrid Reinforcement Option for Sinkhole Mitigation*.

Prior to placing the lower layer of imported crushed rock, the native subgrade exposed at the bottom of the overexcavation shall be moisture-conditioned as necessary and re-compacted to a minimum 95% of ASTM D1557 for a minimum depth of 8-inches. If the exposed subgrade soils include significant oversized materials and is non-testable, the surface shall proof-rolled with appropriate equipment to a dense and non-yielding condition. The recompacted subgrade shall be inspected by the geotechnical engineer prior to placement of imported structural fill. All imported structural fill placed above and below the geogrid layers shall consist of well-graded, crushed aggregate material meeting the grading requirements of WSDOT Standard Specification 9-03.9(3) (1-1/4 inch minus Base Course Material). Structural fill shall be placed in uniform lifts and compacted to a minimum 95% of the maximum dry density as determined by ASTM D1557.

A program of ongoing inspection and monitoring of all site improvements constructed above the areas of geogrid reinforcement, such as pavements, hardscapes, stormwater facilities, and utilities (above and below grade), should be implemented to allow for early indications/detection of possible subgrade distress and the need for ongoing maintenance and/or repair activities. The owner/developer will require a post-construct survey to serve as a baseline for ongoing monitoring.

Proposed habitable structures shall be setback a minimum lateral distance of 2-feet from the edge(s) of the geogrid reinforcement zone. A designated easement shall be established for those areas of the geogrid reinforcements that extend beyond property boundaries.

We recommend a minimum pavement section thickness of 3-inches of hot mix asphalt (HMA) within the parking areas and 4-inches for proposed roadways. The top 3-inches of the underlying imported crushed rock fill shall consist of ¾-inch top course material placed directly below the HMA.

If possible, all buried utilities should be designed to allow placement at a depth above the geogrid reinforcement layers. Proposed utility corridor alignments should be carefully laid out to allow for the narrowest possible perpendicular crossing of historically mapped mine shaft alignments at depth.

We recommend subsurface utilities be designed with flexible couplings and flexible pipe in order to tolerate future movement associated with potential sinkhole development. The gas utility supply company shall be consulted prior to design and installation of proposed pressurized gas lines that will traverse through the mitigated areas identified as *Unbuildable*. Critical buried utilities should include cut-off valves/switches or other appropriate means of shut-down, setback from both side of the reinforced zone, to accommodate possible damage from a collapse.

Routing of deeper utilities such as sanitary sewer shall be considered in the utility design scheme to be installed outside of the geogrid reinforced area to avoid compromising the integrity of the geogrids should repairs need to be done in the future.

This supplemental memorandum presenting an alternative near-surface option to mitigate the risk from possible sinkhole development serves as an addendum to GNN's 2017 Coal Mine Hazards Assessment & Geotechnical Evaluation Report and June 4, 2018, Supplemental Assessment. Except as modified in this memo, the findings, conclusions, and recommendations presented in the referenced GNN reports remain valid.

If you have any questions regarding this memo, please contact us at 509-248-9798.

Respectfully submitted,

GN Northern, Inc.

M. Yousuf Memon, PE
Geotechnical Engineer

Karl A. Harmon, LEG, PE
Senior Geologist/Engineer

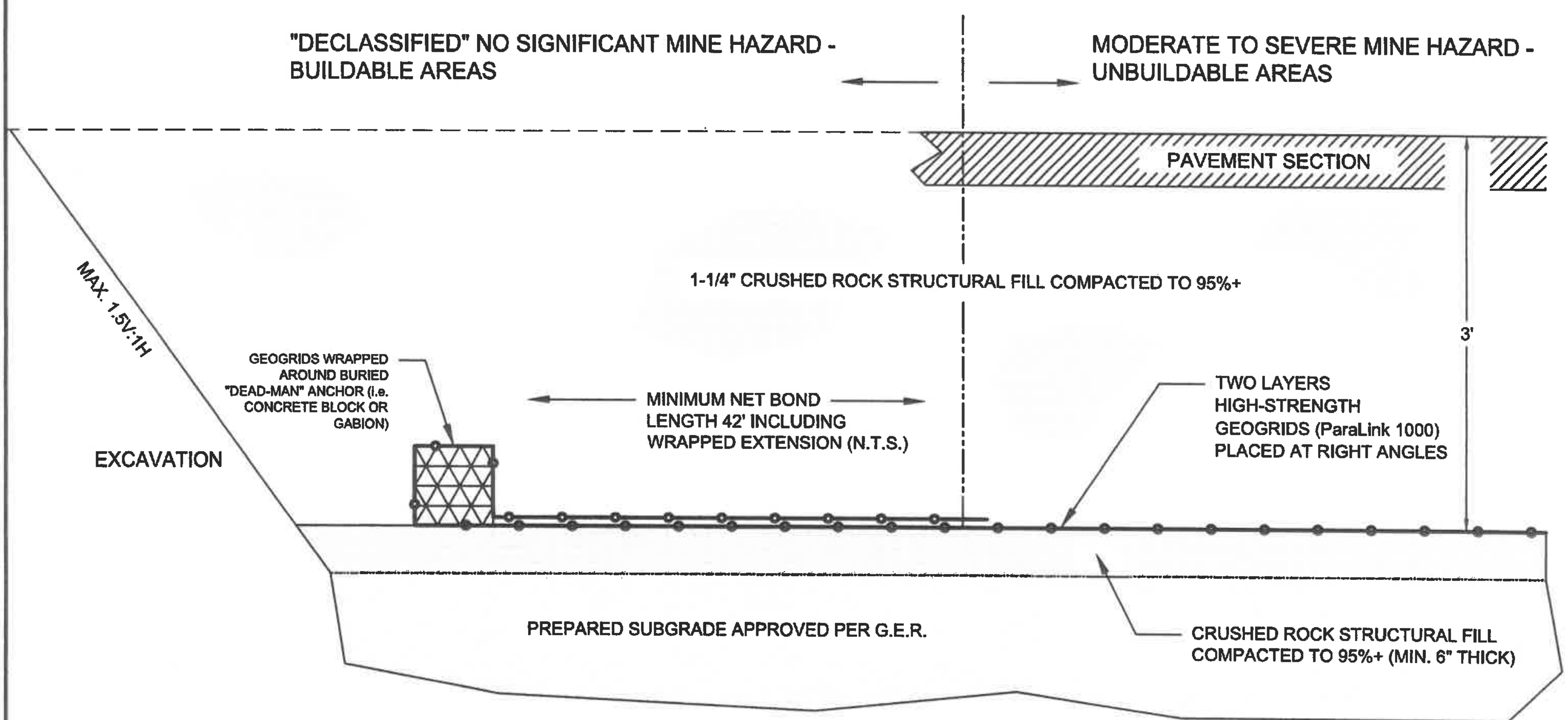
Attachments:

- Geogrid Reinforcement Option for Sinkhole Mitigation- Figure 1
- MACBARS VOIDS analyses outputs for Maccaferri ParaLink™1000 and 1500
- Project Example for Maccaferri ParaLink™ Geogrid for Void Application
- Typical Spec Sheet for Installation of ParaLink ™Geogrid for Void Application
- Technical Data Sheets (TDS) for Maccaferri ParaLink™ 1000, 1500 Geogrids

ATTACHMENTS

Geogrid Reinforcement Option for Sinkhole Mitigation- Figure 1

GEOGRID REINFORCEMENT OPTION FOR SINKHOLE MITIGATION



GN Northern, Inc.

* Consulting Engineers * Environmental Scientists
* Geologists * Construction Materials Testing

GN Northern, Inc.
Project No. 217-871
N.T.S.

GEOGRID REINFORCEMENT OPTION FOR SINKHOLE MITIGATION
Winemaker's Cabins at Swiftwater Cellars
301 Rope Rider Drive, Cle Elum, Washington

Date	Drawn By	Reviewed By	Figure
10/12/18	MBB	KAH	1

Northern, Inc.

MACBARS VOIDS analyses outputs for Maccaferri ParaLink™1000 and 1500

Project Information

Title: Sinkhole mitigation project - Cle Elum Washington
Number: US-Sinkhole mitigation project - Cle Elum,WA
Client: GN Northern, Inc.
Designer: SR

Description:

Embankment over voids

This software calculates the ultimate tensile strength of the reinforcement along and across the embankment over an area prone to subsidence.
All design calculations are in accordance with BS 8006:1995 Code of practice for strengthened/reinforced soils and other fills. This design software is based on the ParaLink range of high tensity geosynthetics with the partial factors of safety taken from the relevant British Board of Agrément Certificate [ParaLink Geocomposite Products Agrément Certificate No 03/4065].

Input

Geometry

Traffic load [kN/m²]	20
Height of embankment [m]	1
Unit weight of fill [kN/m³]	21.5
Friction angle of fill [°]	36
Fill type	Coarse gravel
Design life	60 years
Design temperature [°]	20
pH level	4.5 - 9.5
Type of void	Axisymmetric conditions
Design diameter of void [m]	6
Deformation limit [%]	5
Friction angle under ParaLink [°]	36
Mean height, across [m]	1.2
Mean height, along [m]	1.2

Reinforcement

Partial factors values	Paralink BBA Values
Design Strain [%]	3.1

Safety Factor	Ult.	Serv.
Manufacturing	1	1
Extrapolation of test data	1	1
Installation damage	1.03	1
Environmental	1.05	1
Ramifications of failure	1.1	1.1
Reduction factor creep	1.37	1

Safety Factor BS 8006

Load Factor	Ult.	Serv.
Embankment fill	1.3	1
Dead loads	1.2	1
Live loads	1.2	1

Stability Factor	Ult.	Serv.
Pullout	1.3	1
Sliding	1.3	1
Tan	1	1

Results

Design Calculation

Tult. Geogrid [kN/m]	957.47
Tserv. Geogrid [kN/m]	231.70
Bond length along the embankment [m]	12.6
Bond length across the embankment [m]	12.6
Max allowable strain in reinforcement [%]	6.42
Design strain	Ok

Geogrid Tult. 957.47 kN/m

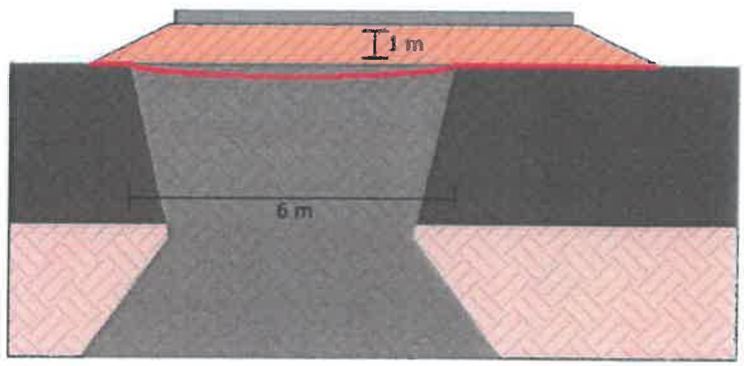
Reinforcement bond length

Across 12.6 m

Along 12.6 m

Max reinforcement strain 6.42 %

Design strain Ok



Client: **GN Northern, Inc. / US-Sinkhole mitigation project - Cle Elum,WA**

Project Information

Title: Sinkhole mitigation project - Cle Elum Washington
Number: US-Sinkhole mitigation project - Cle Elum,WA
Client: GN Northern, Inc.
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Description:

Embankment over voids

This software calculates the ultimate tensile strength of the reinforcement along and across the embankment over an area prone to subsidence.
All design calculations are in accordance with BS 8006:1995 Code of practice for strengthened/reinforced soils and other fills. This design software is based on the ParaLink range of high tensity geosynthetics with the partial factors of safety taken from the relevant British Board of Agrément Certificate [ParaLink Geocomposite Products Agrément Certificate No 03/4065].

Input

Geometry

Traffic load [kN/m²]	20
Height of embankment [m]	1
Unit weight of fill [kN/m³]	21.5
Friction angle of fill [°]	36
Fill type	Coarse gravel
Design life	60 years
Design temperature [°]	20
pH level	4.5 - 9.5
Type of void	Axisymmetric conditions
Design diameter of void [m]	6
Deformation limit [%]	3
Friction angle under ParaLink [°]	36
Mean height, across [m]	1.2
Mean height, along [m]	1.2

Reinforcement

Partial factors values	Paralink BBA Values
Design Strain [%]	2.3

Safety Factor	*Ult.*	*Serv.*
Manufacturing	1	1
Extrapolation of test data	1	1
Installation damage	1.03	1
Environmental	1.05	1
Ramifications of failure	1.1	1.1
Reduction factor creep	1.37	1

Safety Factor BS 8006

Load Factor	*Ult.*	*Serv.*
Embankment fill	1.3	1
Dead loads	1.2	1
Live loads	1.2	1

Stability Factor	*Ult.*	*Serv.*
Pullout	1.3	1
Sliding	1.3	1
Tan	1	1

Results

Design Calculation

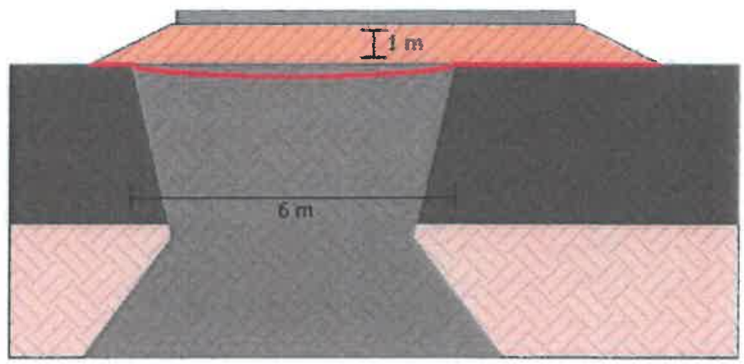
Tult. Geogrid [kN/m]	1,496.43
Tserv. Geogrid [kN/m]	263.49
Bond length along the embankment [m]	14.3
Bond length across the embankment [m]	14.3
Max allowable strain in reinforcement [%]	2.31
Design strain	Ok

Geogrid Tult. 1,496.43 kN/m

Reinforcement bond length
Across 14.3 m
Along 14.3 m

Max reinforcement strain 2.31 %

Design strain Ok



GNorthern, Inc.

Project Example for Void Application
Maccaferri ParaLink™ Geogrid

MACCAFERRI

CASE HISTORY

Ref: USA063 - Rev: 00, Issue Date: 05.11.2011

RE-ALIGNMENT OF CLEMSONVILLE ROAD

UNION BRIDGE, MARYLAND

SINKHOLE REMEDIATION
Product: Paralink® 1000

Guarding Against Sinkholes in Union Bridge

Sinkholes are a common problem in many parts of the world. Although not much can be done to prevent them from collapsing, catastrophic loss can be prevented. Geogrids from Maccaferri have been used successfully for sinkhole mitigation and site remediation designs around the world. Work in the historic town of Union Bridge, Maryland, exemplifies this geosynthetic reinforcement approach.

New development in Union Bridge is at times difficult for two reasons. First, the town is listed on the United States' National Register of Historic Places, so a premium is placed on preserving the city's traditional character and protecting the older structures and landscapes. Second, karst terrain is present, meaning that there is some surface instability and a heightened risk of sinkhole development. Sinkholes can develop in these soils gradually or suddenly, and are often caused by chemical dissolution of underlying carbonate rocks.

New building and infrastructure projects proceed with understandable caution. Reinforcement is frequently preferred.

Cementing Future Growth

One of the most important economic forces in Union Bridge is a major North American cement and construction materials company. To secure its future productivity in the town, the company sought to expand its limestone quarry; but to do so, it had to tackle the risks that quarry would cause for the town itself. An existing roadway would have to be realigned, and that meant that the roadway would now have to pass over a potential sinkhole zone. A solution was needed to mitigate potential damage.

Maccaferri was approached by the engineering consulting firm Hydro-Geo Services, Inc. to help solve the problem. With many years of international experience in sinkhole mitigation, Maccaferri worked with the project team to identify what would be the best solution for effective, economical results and safe, long-term performance. The embankment design of the new roadway leg needed to account for the possible development of a 15-ft.-diameter sinkhole.

A double-layer system design was selected, one that utilized Maccaferri's Paralink® 1000 kN geogrid in longitudinal and transversal layers for embankment reinforcement.

Concrete blocks were added along the perimeter to provide a uniform wrap and to increase friction between the bottom grid and the underlying soil. The grid was covered by a one foot layer of crushed aggregate. To ensure the integrity of the overall design, measures needed to be prescribed to prevent an embankment-weaking mixing of fines and the primary aggregate layer. A woven geotextile separation fabric was installed over the crushed aggregate to prevent this soil migration.

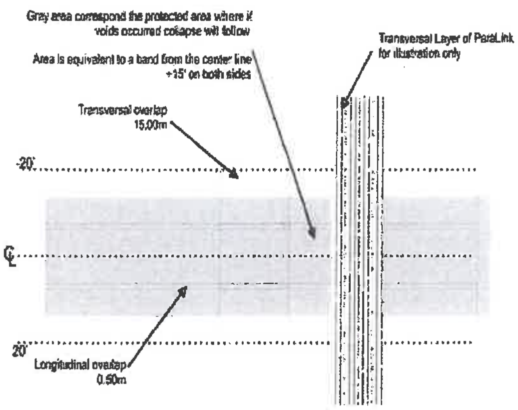
TBH/White Pine Construction installed more than 20,800 sq. yd. of Paralink® 1000, the project was executed in a timely fashion, and the roadway opened (in early 2011). The quarry works can continue to flourish, and with them so too does Union Bridge. The town's physical and economic infrastructures have both been reinforced.

Before Construction — Inset - Paralink® 1000

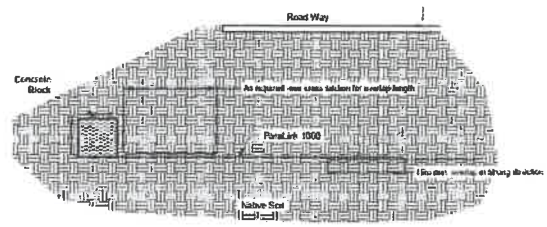
During construction - First layer installation

During construction - Second layer installation

MACCAFERRI



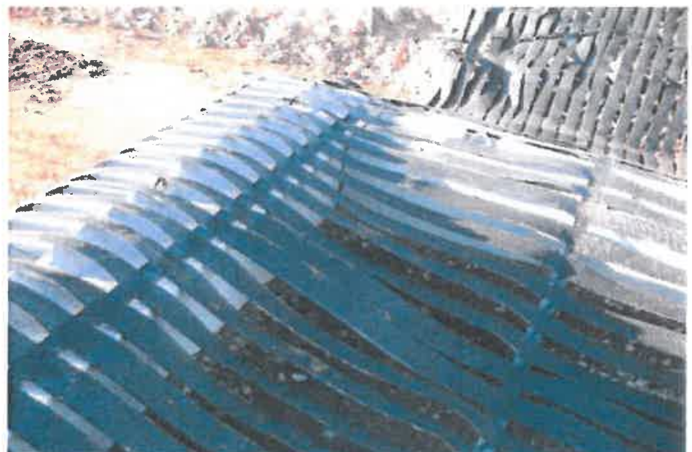
SECTION VIEW



TYPICAL CROSS SECTION

Project Details

Block installation / Backfilling



Wrapping the Blocks - 15' minimum

General Contractor

THOMAS, BENNETT, & HUNTER

Installer

WHITE PINE CONSTRUCTION

Consultant

HYDRO-GEO SERVICES / CLSI

Products Used

20,825 SY of PARALINK® 1000

Date of Construction

STARTED FALL 2010 / COMPLETION SPRING 2011

Paralink® Completely Installed

MACCAFERRI

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NJ, Iselin
NM, Albuquerque
OH, Westerville
PR, Caguas
TX, Lewisville

Northern, Inc.

Typical Spec Sheet for Installation of ParaLink ™Geogrid for Void Application

M

PARALINK®

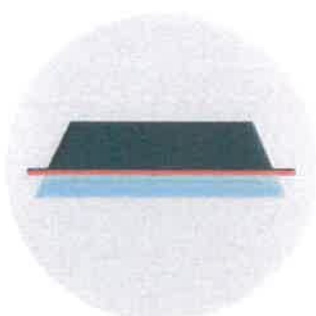
MACCAFERRI

THE WORLD'S STRONGEST GEOGRID

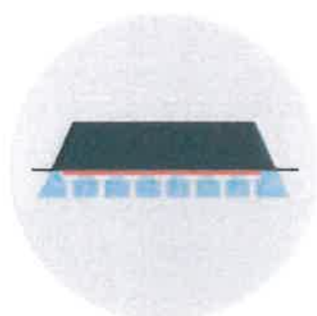
ParaLink® is an ultra strong reinforcement geogrid used in the most demanding civil engineering applications. They are amongst the most tried and tested geogrids in the world, offering a 100+ year design life. Most commonly, Paralink® is used in high performance basal reinforcement applications and in reinforced soil structures exposed to high loads.

Advantages of **ParaLink®**:

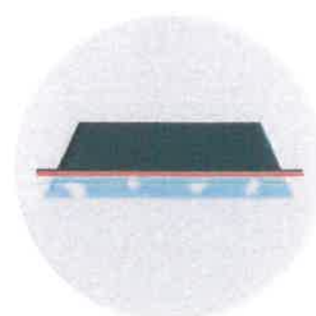
- High Tensile Strength - up to 1350kN/m
- High Modulus
- Easy to Install
- Low creep reduction factor
- Great chemical resistance with its LLDPE coating
- Low installation damage
- Economical - Eliminates some cost associated with additional piles, labor, and safety concerns
- Suitable for a range of soil types, including very aggressive environmental applications



Basal Reinforcement on Soft Foundations



Basal Reinforcement Over Piles



Basal Reinforcement Over Spanning Voids

PARALINK®

MANUFACTURED FOR DEMANDING ENVIRONMENTS

Maccaferri's **ParaLink®** is a unique high strength geogrid in use since 1977 with ultimate tensile strengths up to 1350 kN/m.

It is manufactured from molecular weight, high tenacity, multifilament polyester yarns placed in tension then co-extruded with polyethylene (LLDPE) to form polymeric strips. The polymeric strips are laid flat in the machine direction and a secondary member is laid and welded across the full width in the cross direction.

This generates a stable and strong geogrid. While polyester is the load bearing element maintaining minimal deformation, the polyethylene sheathing maintains both the integrity of the product and encases the yarns protection them from aggressive environments, such as high/low pH and harsh installation conditions.

Paralink® comes in a range of high tensile strengths for your most challenging projects. While the product is manufactured for reinforcement in a single direction, multiple layers of the product can be used for multi-directional support.

Close up a single direction installation of ParaLink®

CASE STUDY

REALIGNMENT OF CLEMSONVILLE RD. UNION BRIDGE, MARYLAND

Union Bridge, MD is home to a major cement and construction materials company. To secure its future, the company sought to expand its limestone quarry; but to do so, it had to tackle the risks that quarry would cause for the town itself. An existing roadway would have to be realigned and would pass over a potential sinkhole zone. A solution was needed to mitigate potential hazards.

The embankment design of the new roadway leg needed to account for the possible development of a 15-ft.-diameter sinkhole.

A double-layer system design was selected, utilizing more than 20,800 sq. yd. of Maccaferri's Paralink® 1000 kN geogrid in longitudinal and transversal layers for embankment reinforcement.

Concrete blocks were added along the perimeter to provide a uniform wrap and to increase friction between the bottom grid and the underlying soil. The grid was covered by a one foot layer of crushed aggregate. To ensure the integrity of the overall design, measures needed to be prescribed to prevent an embankment-weaking mixing of fines and the primary aggregate layer. A woven geotextile separation fabric was installed over the crushed aggregate to prevent this soil migration.

The project was successfully completed on-time and allowed work to continue in the bustling town. This project in the historic town of Union exemplifies Maccaferri's geosynthetic reinforcement approach.

(photo on reverse side)

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E: info@us.maccaferri.com

www.maccaferri.com/us

Northern, Inc.

Technical Data Sheets (TDS) for Maccaferri ParaLink™ 1000 and 1500 Geogrids

MACCAFERRI

TECHNICAL DATA SHEET

Rev: 02, Issue Date 08.19.2014

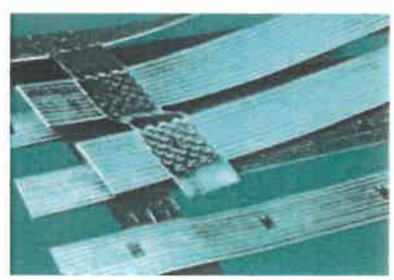
PARALINK™ 1000

ParaLink™ 1000 is manufactured from high tenacity, mutifilament polyester yarns aligned and co-extruded with polyethylene (LLDPE) to form polymeric strips. These strips are laid flat in the machine direction with a secondary strip laid and welded across the full width in the cross direction. **ParaLink™ 1000** is ideal for applications where reinforcement of soils is essential such as MSE walls, embankments over soft soil, sink holes, piled embankments, steep and shallow slopes, basal foundations and any other geotechnical application in which soils require enhancement. The heavy LLDPE coating enable **ParaLink™ 1000** to be used as reinforcement of contaminated or high aggressive materials for use in environmental applications.
The **ParaLink™** range has been tested internally and independently (NTPEP, BBA, Asqual) in accordance to published standards and will conform to the property values listed below.

PROPERTY	TEST METHOD	VALUES		NOTES
		Metric	English	
Mechanical				
Tensile Strength (ultimate)	ASTM D6637	**1013.2** kN/m	**69424** lb/ft	1
Elongation @ Ultimate strength	ASTM D6638	**9.5** %	**9.5** %	2
Creep Reduced Strength		**739.6** kN/m	**50674** lb/ft	1,3
Long Term Design Strength (LTDS)		**698.8** kN/m	**47879** lb/ft	1,4
Polymeric (core)				
Carboxyl End Group (CEG Max.)	GRI-GG7	**<30 mmol/kg**		
Molecular Weight (# average)	GRI-GG8	**>25000 M_w**		
Physical				
Grid aperture size (MD)		**940** mm	**37** inches	5,6
Grid aperture size (XMD)		**34** mm	**1.3** inches	5,6
Mass/Unit Area	ASTM D5261	**2620** g/m^2	**77.3** oz/yd^2	6
Roll Dimension	Width	**4.50** m	**14.8** ft	7
	Length	**50** m	**164** ft	7
Roll Area		**225** m^2	**270** yd^2	7
Roll Weight		**660** kg	**1450** lb	6

1. Minimum average roll values (MARV) are calculated as typical minus two standard deviations. Statistically, it yields a 97.7% degree of confidence that any samples taken from quality assurance testing will exceed the value reported.
2. The value reported is the typical value at the Tultimate; such strain can vary with a ±1 tolerance
3. Creep is calculated for a 75 years design life at 20°C; on request available data at 5, 50, 60, 100 & 120 years design life at 25 and 30°C
4. LTDS calculated for a standard temperature of 20°C, $4 \leq ph \leq 9.5$ in concrete sand soil $D_{90} \leq 4.0$ mm; $D_{50} < 1$ mm; installation damage factors for other soils and LTDS strength at different design life and temperature (see point 3) are available on request
5. The indicates measure is from edge pitch to edge pitch (opening mesh size); a tolerance of 5% on the reported value is admitted
6. Typical value
7. Width and length values per roll are nominal a tolerance of 5% on the reported value is admitted. Roll area is estimated and rounded up to the closest square yard

Maccaferri Inc. can engineer specific solutions in any of our products; please contact us if you may need a specific solution for your project.



Maccaferri reserves the right to amend product specifications without notice and specifiers are requested to check as to the validity of the pecifications they are using.

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MACCAFERRI

TECHNICAL DATA SHEET

Rev: 02, Issue Date 08.19.2014

PARALINK™ 1500

ParaLink™ 1500 is manufactured from high tenacity, mutifilament polyester yarns aligned and co-extruded with polyethylene (LLDPE) to form polymeric strips. These strips are laid flat in the machine direction with a secondary strip laid and welded across the full width in the cross direction. **ParaLink™ 1500** is ideal for applications where reinforcement of soils is essential such as MSE walls, embankments over soft soil, sink holes, piled embankments, steep and shallow slopes, basal foundations and any other geotechnical application in which soils require enhancement. The heavy LLDPE coating enable **ParaLink™ 1500** to be used as reinforcement of contaminated or high aggressive materials for use in environmental applications.
The **ParaLink™** range has been tested internally and independently (NTPEP, BBA, Asqual) in accordance to published standards and will conform to the property values listed below.

PROPERTY	TEST METHOD	VALUES		NOTES:
		Metric	English	
Mechanical				
Tensile Strength (ultimate)	ASTM D6637	**1500** kN/m	**102780** lb/ft	1
Elongation @ Ultimate strength	ASTM D6638	**9.5** %	**9.5** %	2
Creep Reduced Strength		**1095** kN/m	**75022** lb/ft	1,3
Long Term Design Strength (LTDS)		**1035** kN/m	**70883** lb/ft	1,4
Polymeric (core)				
Carboxyl End Group (CEG Max.)	GRI-GG7	<30 mmol/kg		
Molecular Weight (# average)	GRI-GG8	>25000 M_w		
Physical				
Grid aperture size (MD)		**940** mm	**37** inches	5,6
Grid aperture size (XMD)		**9** mm	**0.35** inches	5,6
Mass/Unit Area	ASTM D5261	**4012** g/m^2	**118** oz/yd^2	6
Roll Dimension	Width	**4.50** m	**14.8** ft	7
	Length	**50** m	**164** ft	7
Roll Area		**225** m^2	**270** yd^2	7
Roll Weight		**1000** kg	**2205** lb	6

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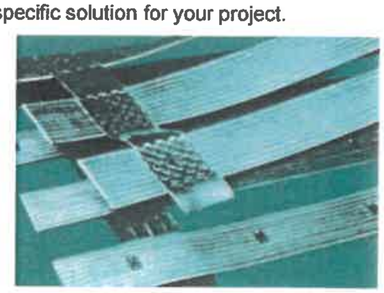

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