Guideline Specification – GS GCL4

Standard Thermally Locked Geosynthetic Clay Liner

GRI_GCL3 & EPA Compliant

Bentofix NSP

1.0 Introduction

Geosynthetic Clay Liners (GCLs) are manufactured, **reinforced** hydraulic barriers consisting of needle-punched natural sodium bentonite and geotextiles.

Needle-punched geosynthetic clay liners (GCLs) are fibre-reinforced composites that combine two durable outer layers and an intermediate, uniform core of high-swelling powder of sodium bentonite clay. This unique clay core acts as the barrier component, but its ultimate performance is dependent upon the durability and security provided by the outer layers. The uniform needle-punching forms a directionally independent, shear stress transferring sealing barrier. When the bentonite core hydrates with fresh water, the bentonite swells and forms a low-permeability gel layer, which outperforms traditional, thick compacted clay liners, due to the bentonite's ability to self-seal and re-heal.

Other features of needle-punched GCLs are product dependent and include (but are not limited to):

- High internal shear strength for steeper slopes.

- Durable geotextiles for the encapsulation of bentonite and long-term performance

- Excellent interface friction values

- Robust installation strength (if the nonwoven of the GCL is placed against cover soil material)

- Powdered bentonite for uniform clay distribution and immediate swelling. This high-quality powdered form of bentonite ensures a better seal and longer-term performance than granulated bentonite.

- Self-sealing of bentonite-impregnated overlaps

Geosynthetic Clay Liners (GCLs) are often used as a stand-alone liner or in combination with a geomembrane. They replace thick compacted clay liners due to many advantages, such as easy installation, low hydraulic conductivity, self-healing capabilities, capable of withstanding differential settlement, consistency, shear performance and cost effectiveness.

However, the designer should consider site specific conditions (soil material, slope angle, interface friction) and specify relevant characteristics to ensure a long-term and safe design.

This document is to assist design consultants with the technical specifications of GCLs, in particularly, the component geotextile and bentonite properties and the GCL physical and hydraulic properties. These specifications meet the recommendations from the **Geosynthetic Research Institute (GRI)** in the USA and the local **Environmental Protection Authority's (EPA) Best Practice Environmental Management (BPEM)** and **Department of Environmental and Resource Management (DERM)** policy.

2.0 Technical Specifications

2.1 Introduction

The Geosynthetic Clay Liner (GCL) shall consist of a continuous layer of powdered sodium bentonite, sandwiched between a needle-punched polypropylene (PP) geotextile as a cover layer and a slit film PP woven geotextile as the carrier layer. The components shall be needle-punched uniformly together across the entire GCL and thermally locked. The additional bentonite with the same quality as the core bentonite shall be impregnated into the outer 500 mm of the cover nonwoven geotextile during the manufacturing process to facilitate longitudinal impermeable overlaps.

2.2 Abbreviations

The abbreviations listed below, when used in this Specification, shall have the following meanings:

GRI	- Geosynthetic Research Institute in USA
EPA BPEM	- Environmental Protection Authority Best Practice Environmental Management
ASTM	- American Society for Testing of Materials
EN	- European Normalisation
ISO	- International Standards Organisation

2.3 Definitions

Geosynthetic Clay Liner (GCL) A factory manufactured hydraulic barrier consisting of sodium bentonite clay, sandwiched between, supported and encapsulated by two geotextiles, held together by needle punching.

Geotextile - A permeable woven, nonwoven fabric or a combination hereof used to contain the bentonite used in a GCL.

Sodium Bentonite - The high swelling clay component of GCLs consisting primarily of the mineral Montmorillonite.

Needle punching - A GCL manufacturing process whereby boards of barbed needles incorporate the staple fibres from a nonwoven geotextile, through a sodium bentonite clay layer, into the matrix of a second geotextile layer.

Minimum Average Roll Value (MARV) – is defined as the mean values of a particular lot less 2 standard deviations. Which when mathematically calculated provides 97.5% confidence.

Maximum Average Roll Value (MaxARV) - is defined as the mean values of a particular lot plus 2 standard deviations. Which when mathematically calculated provides 97.5% confidence.

Thermal Lock- a manufacturing process whereby entangled fibres are heat treated to increase internal shear capacity and mechanical strength of the GCL.

3.0 GCL Materials

The GCL product supplied to the project shall be in full accordance with the requirements of this section. Granular Bentonite and non-thermally locked GCLs shall not be used in this project.

The GCL shall be manufactured by mechanically bonding the geotextiles using a needle- punching process to enhance frictional and internal shear strength characteristics. In order to maintain these characteristics, no glues, adhesives or other non-mechanical bonding processes shall be used in lieu of the needle punched process. Additionally the GCL should be heat treated, causing a thermal lock process to the further enhance the properties of the GCL.

3.1 Description

Acceptable GCLs for this project include Bentofix® NSP4900 supplied by Global Synthetics Pty Ltd or any other needle punched GCL which fully meet all the requirements of this specification.

3.2 Alternative materials

Prior to considering an alternative GCL material, the Contractor shall submit certified test results and statements of quality from the proposed GCL supplier to the engineer, indicating without exception that the proposed GCL meets the requirements of this specification. Technical details of the GCL which shall be proposed to be used including the manufacturer's product specification name, location of manufacturer and a sample of the GCL.

The above requirements shall be delivered to the engineer a minimum of fifteen business days in advance of the bid.

3.3 GCL and Bentonite Physical properties

The GCL material shall be in accordance with the test methods and material physical properties as listed below in table 1 & 2. Table 1 furthermore defines minimum test frequencies for MQC.

Table 1 – Thermally Locked GCL Properties (3)

Technical Data	Test Method	Unit	Value	Test Frequency MQC
Geotextile layers: Cover layer (polypropylene nonwoven):				
Mass per unit area, cover nonwoven	EN ISO 9864/ ASTM D5261	g/m2	≥ 200	Every 2,500m2
Carrier layer (polypropylene woven) :				
Mass per unit, carrier woven (PP)	EN ISO 9864 / ASTM D5261	g/m2	≥ 100	Every 20,000m^2
Bentonite layer (sodium bentonite powder):				
Mass per unit area, powder sodium bentonite layer (@ 0% Moisture)	EN 14196	g/m²	≥ 3,700	Every 1,200m^2
Swell Index	ASTM-D-5890	ml/2g	≥ 24	Every 5,000m^2 (2)
Fluid Loss	ASTM-D-5891	ml/2g	≤ 18	Every 20,000m^2 (2)
Montmorillonite content	VDG P69 Methylene blue	mg/g	≥ 300	Every lot (2)
Geosynthetic Clay Liner (GCL):				
Mass per unit area, total GCL (@ 0% Moisture)	EN 14196 (ρ GBR-C)	g/m²	≥ 4,000	Every 1,200m^2
Thickness GCL, total	EN ISO 9863-1 (EN 964-1)	mm	≥ 5.4	Every 10,000m^2
Max. tensile strength, md / cmd (1)	EN ISO 10319 / ASTM-D-4595	kN/m	≥ 10.8/ 10.8	Every 10,000m^2
Elongation at break, md / cmd (1)	EN ISO 10319 / ASTM-D-4595	%	≥ 8 / 5	Every 10,000m^2
Peel strength	ASTM-D-6496	N/m	≥ 360	Every 5,000m^2
Static puncture strength	EN ISO 12236 / ASTM D6241	N	≥ 1800	Every 10,000m^2
Hydraulic Conductivity – k-value (permeability); k10	EN 16416 / ASTM-D-5887	m/s	≤ 2.5x10-^{11}	Every 25,000m^2
Index Flux; q10	EN 16416 / ASTM-D-5887	m³/m²/s	≤ 9 x10^{-9}	Every 25,000m^2
Roll dimensions / width x length	Manufacturer	m	5 x 40	

(1) md = machine direction, cmd = cross machine direction
(2) tested at the control of bentonite prior production of the GCL in the corresponding tonnes
(3) ≤ / ≥ Values are MARV or MaxARV values

Table 2 - Bentonite Properties

Bentonite Property	Range or Value
Montmorillonite content	≥ 80 wt. %(XRD)
Carbonate content	≤ 1-2 wt.%
Bentonite form	Natural Na-bentonite
Particle size	Powdered (e.g. 80% passing 75 micron sieve)
Cation exchange capacity	≥ 70 meq/100 g (or cmol/kg)
Free swell index	≥ 24 ml/2g
Fluid Loss	≤ 18 ml

Note: Values stated are MARVs or MaxARV

3.5 Dimensions

The minimum acceptable dimensions for the GCL panels shall be a 5m wide and 40m long. Short rolls (rolls less than 40 m long) may be supplied, but at a rate not more than 2 rolls per delivery truck or container load but with a minimum length of 15m.

3.6 Overlap Markings

An overlap guide-line delineating the overlap zone shall be imprinted with non-toxic ink on the edges of the GCL panel to ensure the accuracy of the seam. These lines shall be used during CQA to ensure the minimum overlap is achieved. The overlap guideline shall indicate where the edge of the panel must be placed in order to achieve a full 300mm of bentonite overlap for each GCL panel.

3.7 Impregnated Overlap Zone

The GCL supplied must have a minimum 500 wide edge zone with an additional minimum 500g/m^2 bentonite powder impregnated within the cover geotextile overlap zone. This will ensure that the overlap seam width of 300mm between adjacent panels maintains the effective hydraulic properties of the GCL.

4.0 Qualifications & Quality Control & Quality Assurance

The GCL Manufacturer, Installer and Construction Quality Assurance (CQA) inspector shall all be skilled in accordance with the following experience requirements. Any exceptions must be approved by the project engineer prior to the project bid.

4.1 GCL Manufacturer

The GCL manufacturer selected for use on this project shall have successfully produced at least 10,000,000 square meters (m^2) of needle punched GCL product and shall have an ISO 9001 (2008) accreditation. The components and the final GCL shall undergo regular and frequent testing in the manufacturer's laboratories according to the quality management standard ISO 9001(2008).

The manufacturer (upon request) shall provide its own in-house test documents covering the batch of rolls delivered to site.

4.2 GCL Installer

The installer shall provide to the engineer sufficient evidence of installation experience and competence with the specified geosynthetic materials.

The GCL installer shall demonstrate a minimum of 100,000 m^2 of GCL installation experience and shall provide sufficient evidence of installation experience and competence with other geosynthetics or shall demonstrate an acceptable level of training and supervision will be utilized in order to ensure the quality of the installation.

4.3 Manufacturing Quality Control (MQC)

The GCL shall be tested for compliance with this specification by the test methods and frequencies indicated on the material specification in Table 1 or as appropriate. GCL materials may be tested pre-approved at the manufacturing location.

Quality Control certificates shall be issued by the GCL manufacturer to the contractor, installer or project engineer, CQA inspector or other designated party for each delivery of material. The certifications shall be signed by the quality control manager of the GCL manufacturer or other responsible party.

4.4 Independent Testing

If requested the GCL quality shall be assured by independent third party testing. This shall be in accordance with the quality assurance standard DIN 18200 or approved equivalent. Proof of this testing shall be provided for approval by the relevant engineer before the contractor shall place any GCL within the project works.

5.0 Delivery, Storage & Handling

Prior to shipment, the manufacturer shall label each roll, both on the GCL roll and on the surface of the plastic protective sleeve. Labels shall be resistant to fading and moisture degradation to ensure legibility at the time of the installation. At a minimum the roll labels shall identify the following:

- Length and width of roll
- Total weight of roll
- Type of GCL material
- Manufacturers name
- Production Lot number and Individual Roll number

All GCL rolls shall be packaged in moisture resistant plastic sleeves. The cores (steel or plastic) shall be sufficiently strong to resist collapse during transit and handling.

The party responsible for unloading the GCL shall contact the manufacturer/supplier prior to shipment to determine the correct unloading methods and equipment if different from the pre-approved and specified methods.

Bentofix® Geosynthetic Clay Liner (GCL) must be supported during handling to ensure worker safety and prevent damage to the liner. Under approved circumstances only, shall the rolls be dragged, lifted from one end, lifted with only the forks of a lift truck or pushed to the ground from the delivery vehicle.

The CQA inspector shall verify that proper handling equipment is available which does not pose any danger to installation personnel or risk of damage or deformation to the liner material itself and those safety regulations on site are followed. Suitable handling equipment is described below:

Spreader bar assembly

A spreader bar assembly designed to carry the roll of GCL shall include both a core pipe or bar and a spreader bar beam. The core pipe shall be used to uniformly support the roll when inserted through the GCL core while the spreader bar beam will prevent chains or straps from chafing the roll edges.

Stinger

A stinger is a rigid pipe or rod with one end directly connected to a forklift or other handling equipment. If a stinger is used, it should be inserted to 75% of the full length into the roll to prevent excessive bending of the roll when lifted and be designed to carry the roll of GCL.

Lifting slings

Slings may be used to transport a GCL roll. Slings must uniformly support the GCL roll to prevent roll bending or deformation. It is generally recommended to place the straps at the one third points along the length of the roll. Great care must be exercised when this option is used. Lifting Slings must be supplied with appropriate compliance tags and SWL.

GCL Inspection upon delivery

Each roll shall be visually inspected when unloaded to determine if any packaging or material has been damaged during transit. Repairs to damaged GCL shall be performed in accordance with the manufacturer's guidelines.

- Rolls exhibiting damage shall be marked and set aside for closer examination during deployment.
- Minor rips or tears in the plastic packaging shall be repaired with moisture resistant tape prior to being placed in storage to prevent moisture damage.
- GCL rolls delivered to the project site shall be only those indicated on GCL manufacturing quality control certificates.

Storage and stockpiling

The GCL shall be delivered, stored and handled strictly in accordance with the manufacturer's instructions. Storage of the GCL rolls shall be the responsibility of the installer or other designated party. All GCL rolls shall be stock-piled and maintained dry in a flat location area away from high-traffic areas but sufficiently close to the active work area to minimize handling. The presence of free-flowing water within the packaging shall require that roll to be set aside for further examination to ascertain the extent of damage, if any.

- GCL should be stored no higher than five rolls high or limited to the height at which the handling apparatus may be safely handled by installation personnel. Stacks or tiers of rolls should be situated in a manner that prevents sliding or rolling by "chocking" the bottom layer of rolls.
- Rolls shall not be stacked on uneven or discontinuous surfaces in order to prevent bending, deformation, damage to the GCL or cause difficulty inserting the core pipe.
- An additional tarpaulin or plastic sheet shall be used over the stacked rolls to provide extra protection for GCL material stored outdoors.
- Bagged bentonite material shall be stored and covered next to GCL rolls unless other more protective measures are available. Bags shall be stored on pallets or other suitably dry surface which will prevent undue pre-hydration.

6.0 GCL Installation

The manufacturer/supplier shall provide an installation guide with detailed description of how the GCL shall be installed. Installation of the GCL shall be undertaken as per the manufacturer's guidelines, unless otherwise directed.

6.1 Hydration of Bentofix GCLs

Normally GCLs shall not be artificially hydrated. However, if the GCL could come into contact with liquids such as salt water, before it hydrates; the GCL shall be artificially hydrated beforehand. This shall be done after a porous soil cover layer has been installed.

6.2 Responsibility of the Contractor

The contractor shall be responsible for the quality of the installed GCL and shall submit with his tender the following items for approval:

- Technical details of the GCL which shall be proposed to be used including the manufacturer's product specification name, location of manufacturer and a sample of the GCL.
- Details of the manufacturer's instructions for the delivery, handling and storage of the GCL, preparation of the surface on which the GCL shall be laid, installation of the GCL including anchoring, jointing and working around pipes/structures and protective layer to the GCL.
- A method statement of the installation of the GCL including schematic panel layout drawings.

The contractor shall be responsible for ensuring that the GCL supplied complies with the requirements of this specification. He shall allow sufficient time for approval and shipping to site from the place of manufacture. Costs through delays because the contractor has not allowed sufficient time for the supply shall be borne by the contractor.

The following guideline specification is provided to assist design engineers with specification of Geosynthetic Clay Liners. This specification guideline is provided as an example only and requires the design engineer to customize it appropriately to suit site specific requirements. Global Synthetics assumes no liability with the use of this document.