



**SPECIFICATION TITLE: GIGSA 1200 W(GCL) - 2008  
PRO-FORMA STANDARDISED  
SPECIFICATION FOR REINFORCED  
NEEDLEPUNCHED GEOSYNTHETIC  
CLAY LINERS (GCLs)**

**REV. : A**  
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**ORIGINATOR : GIGSA GCL Committee**

## **PREFACE**

This document aims to supplement the standardised specifications suite for civil engineering construction works that is currently in use in South Africa – SANS 1200. The preface of SANS 1200 is adopted as follows:

“The prime purpose in the production of these standardised specifications was to arrive at a set of standard and unambiguous documents acceptable to employer, engineering and contractor bodies and thereby to save money through lower contract prices and to reduce the number of engineering hours spent in administering contracts by establishing, for all classes, of civil engineering construction, practical standards of workmanship and administrative control that would be adequate but not excessive and which all parties would, in due course, become familiar with.”

The standardised specifications are so framed that the responsible engineer, instead of spending time on researching and framing clauses to cover basic, routine, standard, and often quasi-legal matters, can devote his energy and time to thorough pre-contract investigation, to design, and to the framing of specification clauses that are of special application to the project concerned.

Furthermore, the document follows the format and content requirements as set in SANS 0120: Part 1- 1986.

## **DISCLAIMER**

Neither the Geosynthetic Interest Group of South Africa (GIGSA), nor any of its parent or related institutes, warrants or indemnifies any materials manufactured or installed according to this specification either at this time or in the future. Users of this document should note that this document and the standards referred to herein are subject to revision from time to time, and the user should ensure that the latest revisions are utilised.

## **GIGSA GCL COMMITTEE**

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**PS GCL**

**GEOSYNTHETIC CLAY LINER**

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## **PS GCL: GEOSYNTHETIC CLAY LINER**

### **PS GCL1: SCOPE**

This specification covers the requirements for furnishing materials, equipment, and services necessary and incidental to complete reinforced geosynthetic clay liner (GCL) installations. Non-reinforced GCLs are available in the marketplace, but are not covered by this document. GCLs are also termed Clay Geosynthetic Barriers (CGBs).

### **PS GCL 2: INTERPRETATIONS**

#### **PS GCL 2.1: Supporting Specifications**

The publications below and in appendix A form part of this specification to the extent referenced. Where a particular publication is referred to, that publication shall, unless otherwise stated, be the edition in effect 30 (thirty) days prior to the date of issue of this specification. Any contradictions between publications shall be submitted to the Engineer for decision.

The sections pertaining to a needlepunched GCL in the GRI-GCL3 specification are adopted and accepted by this standard as the manufacturing quality control specification. This should be read in conjunction with this standard.

### **GRI-GCL3: Test Methods, Required Properties, and Testing Frequencies of Geosynthetic Clay Liners (GCLs)**

GRI Standards are constantly being updated by the Geosynthetic Research Institute (GRI) and many of the documents are freely available online at website address: [www.geosynthetic-institute.org/specs.htm](http://www.geosynthetic-institute.org/specs.htm).

EN-ISO or any other standard which can be shown to be equivalent to the standards specified may be acceptable.

#### **PS GCL 2.2: Units**

The values stated in SI (metric) units are to be regarded as the standard.

#### **PS GCL 2.3: Safety**

This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

#### **PS GCL 2.4: Definitions relating to Geosynthetic Clay Liners**

For the purposes of this specification, the following definitions shall apply:

**Carrier Layer:** The material that forms the base layer of a needlepunched GCL. This consists of a woven or nonwoven geotextile, or a combination of these.

**Cover Layer:** The material that forms the top layer of a needlepunched GCL. This consists of a nonwoven geotextile.

**Geofilm:** a thin polymeric film which is essentially impermeable.

**Geosynthetic:** A planar, polymeric (synthetic or natural) material used in conjunction with soil/rock and/or any other geotechnical material in civil engineering applications.

**Geosynthetic Clay Liner** (also known as Clay Geosynthetic Barriers): An assembled structure of geosynthetic materials and low hydraulic conductivity earth materials (clay or bentonite), in the form of a manufactured sheet, used in contact with soil/rock and/or any other geotechnical material in civil engineering applications.

**Geotextile, non-woven:** A geotextile in the form of a manufactured sheet or web of directionally or randomly orientated fibres, filaments or other elements, mechanically and/or thermally and/or chemically bonded.

**Geotextile, woven:** A geotextile produced by interlacing, usually at right angles, two or more sets of yarns, fibres, filaments, tapes or other elements.

**Reinforced GCL:** A GCL in which the carrier and cover layers are mechanically linked through the bentonite component to provide internal shear strength to the GCL.

**Bentonite:** a distinct type of fine-grained clay soil typically containing not less than 80% Montmorillonite clay, usually characterized by high swelling upon wetting.

**PS GCL 2.5: Definitions Relating to Quality Programmes**

Refer to the GRI-GCL 3 specification for definitions relating to quality programmes.

**PS GCL 3: MATERIALS AND MANUFACTURING OF GCLs**

**PS GCL 3.1: Qualification of GCL Manufacturer**

GCLs will be manufactured in accordance with GRI-GCL3.

Details of the Manufacturer shall be provided by the GCL Installer in the Data Sheets forming part of the Tender.

The Manufacturer must demonstrate sufficient production capacity to supply product meeting the specifications within the time frame required.

The engineer may request:

- A reference list of projects where the material under consideration has been used, including area installed, date of installation, and client.
- Manufacturing Quality Control manuals and related documentation

**PS GCL 3.2: GCL Plant Audit**

**PS GCL 3.2.1: Scope**

The Engineer may perform an audit of the manufacturing and quality control procedures used by the Manufacturer, specifically for the production of the GCLs to be used for installation at the Employer's facility. .

**PS GCL 3.2.2: Quality Control**

The manufacturer shall make available to the Employer and Engineer, Manufacturing Quality Control (MQC) manuals, which outline all quality procedures, to be implemented for the manufacture of the GCLs.

The Manufacturer shall provide certification for laboratory testing equipment. The Engineer may verify that, during select runs of material, all MQC procedures are performed.

**PS GCL 3.2.3: Manufacturing Process**

In general, the Manufacturer shall provide access for the Engineer to all equipment used to manufacture the GCLs. This does not include divulging trade secrets, formulations and procedures that are not commonly known as basic manufacturing processes.

The Engineer shall be furnished with the relevant test results, in accordance with this specification, and the QC certificates.

**PS GCL 3.3: Manufacturing of Geosynthetic Clay Liner (GCL)**

**PS GCL 3.3.1: Manufacturing and Materials**

Refer to the GRI-GCL3 specification for the manufacturing quality control requirements of reinforced needlepunched GCLs.

Special Note: The Engineer shall be informed and give approval if the source of bentonite is changed from the originally offered GCL product.

**PS GCL 3.2.2: Quality Control Submissions**

Manufacturing Quality Control documentation from the manufacturer of each type of GCL supplied must be submitted for approval. Submittals must be made before the materials are purchased and delivered to site. Submittals to include:

- dates of manufacture
- batch numbers and roll numbers, length and width
- documentation of the manufacturer's specific quality control program, which shall provide test data indicating the actual test values per roll or per batch, as may be applicable as called for in GRI – GCL3.

**PS GCL 4: PACKAGING, TRANSPORTATION, HANDLING AND STORAGE**

The products shall be packaged, transported, unloaded and stored in accordance with the manufacturer's instructions, subject to the engineer's approval, and generally in accordance with ASTM Standard D 5888, "Standard Guide for Storage and Handling of Geosynthetic Clay Liners".

**PS GCL 4.1: Packaging and Identification**

All GCL rolls shall be packaged in opaque moisture and ultraviolet resistant plastic sleeves. The roll cores shall be sufficiently strong to resist collapse during transit and handling. The Engineer has the right to reject any roll if the core has collapsed or if the roll is damaged in any other way.

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

- Product name, grade and manufacturer
- Length and width of roll
- Gross mass of roll
- Production lot/batch number and individual roll number
- Manufacturers quality approval label
- Label with handling guidelines

**PS GCL 4.2: Auxiliary Products**

Any accessory bentonite used for sealing seams, penetrations, or repairs, shall be high-quality powdered or granular sodium bentonite from a recognized producer and must comply with the same specifications as the GCL itself, as contained in GRI-GCL3.

**PS GCL 4.3: Transportation**

To transport GCL rolls, an appropriate core pipe must be used to support the weight of the roll. During transportation, a roll may not deflect by more than half its diameter.

**PS GCL 4.4: Handling of Materials**

The method of unloading and handling of GCL rolls shall be as specified below. Any deviation from these procedures shall be pre-approved by the Engineer in writing.

GCLs must be supported during handling to ensure worker safety and to prevent damage to the product. Stacking should always allow easy access to at least one end of each roll for handling equipment as well as for roll identification. The construction quality assurance officer shall verify that proper handling equipment exists which does not pose any danger to installation personnel or risk of damage or deformation to the liner material itself.

Under no circumstances may the rolls be dragged, lifted from one end, lifted in the middle of the roll, lifted with only the forks of a forklift, or dropped to the ground from the delivery vehicle.

**Spreader Bar Assembly:** A spreader bar assembly shall include 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. Lifting the rolls should be done with a sufficiently strong pipe/bar that can easily fit in the roll core. This can be accomplished with a 63mm to 75mm outside diameter steel pipe/bar, with a wall thickness capable of providing sufficient beam strength to support the weight of the roll without bending, which, depending on the GCL type, can be up to 1200kg or more.

**Carpet Spike (or “stinger”):** A carpet spike is a rigid pipe or rod with one end directly connected to a forklift or other handling equipment and the other end rounded off to allow easy insertion into roll material cores. If a carpet spike is used, it must be at least  $\frac{3}{4}$  the width of the roll and inserted to its full length into the roll core to prevent excessive bending of the roll when lifted.

**Roller Cradles:** Roller cradles consist of two rollers, which both support the GCL roll and allow it to unroll freely without significant deflection.

**PS GCL 4.5: Inspection upon Delivery**

Each roll shall be visually inspected when unloaded to determine if any packaging or material has been damaged during transit. Possible product conditions and actions are listed below:

- Rolls, including the roll cores, exhibiting damage shall be marked and set aside for closer examination during installation. Minor rips or tears in the plastic packaging shall be repaired with moisture resistant tape before being placed in storage to prevent moisture damage.
- The presence of free-flowing water (more than small amount of condensate from bentonite itself) within any roll packaging shall require that the roll be set aside for further examination to ascertain the extent of any damage.
- GCL rolls delivered to the project site shall be those indicated on GCL manufacturing quality control certificates.
- Repairs to damaged GCL rolls shall be performed in accordance with **PS GCL 5.3.6** of this specification, during installation.

The Engineer reserves the right to reject any roll at any stage prior to installation should it exhibit any of the above damages or non-conformance.

**PS GCL 4.6: Storage**

Storage of the GCL rolls shall be the responsibility of the Installer party. All GCL rolls shall be stockpiled and maintained dry in a well-drained flat area away from high-traffic areas but sufficiently close to the active work area to minimize handling. Rolls should be stacked off the ground using “sleepers” of some kind.

Rolls shall not be stacked on uneven or discontinuous surfaces, in order to prevent bending, deformation, product thinning and damage to the GCL or cause difficulty during handling.

GCL roll stacks shall be limited to the height at which installation personnel can safely manoeuvre the handling apparatus. Stacks or tiers of rolls must be situated in a manner that prevents sliding or rolling by chocking the bottom layer of the rolls.

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 in a dry location free from the influences of weather conditions. Bags shall be stored on pallets or other suitably dry surfaces that will prevent pre-hydration.

**PS GCL 5: CONSTRUCTION**

**PS GCL 5.1: Construction Quality Control**

**PS GCL 5.1.1: Construction Quality Control (CQC) Plan**

The CQC Plan shall be submitted to the Engineer at least 5 days before construction commences. It shall include:

- A site staff organogram indicating authority and responsibilities
- Panel Layout Drawing(s)
- A Method Statement detailing the Contractor's proposed construction procedure of the specific elements of the GCL installation including activities preceding and following the installation (i.e. surface preparation and cover placement). No work related to such elements shall commence before the method statement has been submitted and agreed upon.
- A Delivery note checklist template
- Acceptance and non-conformance templates for subgrade, panel placement, seaming and repairs.

**PS GCL 5.1.2: Qualification of the GCL Contractor**

The GCL shall be installed by a competent Contractor. If the Contractor has no prior experience installing GCLs, adequate training should be provided by the GCL supplier to the satisfaction of the Engineer. The cost of the training shall be taken into account in the payment items (see section 9.2).

**PS GCL 5.1.3: Notification of Changes**

After acceptance of the CQC Plan, the Contractor shall notify the Engineer in writing prior to any proposed change. Proposed changes are subject to acceptance by the Engineer.

**PS GCL 5.2: Construction Quality Assurance**

**PS GCL 5.2.1: Duties of Engineer's Construction Quality Assurance**

**Engineer's Personnel**

The personnel of the Engineer include:

- The CQA Officer, who may be the same person as the Engineer's representative;
- The Engineer's representative who is located at the site; and
- Any other staff or assistant who may be used on the site.

The general duties of a qualified and experienced CQA Officer are set out below.

The CQA Officer shall review all site-specific documentation, proposed panel layouts, Contractor's GCL construction programme and methods, and the Contractor's CQC Plan and he shall attend the Site Meetings where necessary and may be required to produce a final report.

### **PS GCL 5.3: Installation**

#### **PS GCL 5.3.1: Panel Layout**

Prior to commencing GCL installation the Contractor shall prepare and submit to the Engineer for approval a proposed panel layout drawing, drawn to scale, showing the proposed deployment pattern and sequence. The location of overlaps and details thereof must also be shown. No deployment of GCL shall commence until the Engineer has approved the panel layout. This deployment plan may be requested by the Engineer at the tender stage.

In preparing the panel layout, the Contractor shall take into account the construction schedule, access restrictions and the following limitations placed on seam locations:

- To the maximum extent possible, overlaps shall be parallel to the slope (down the slope).
- The number of transverse seams (perpendicular to slope) on slopes shall be minimized. Where such seams are unavoidable, the details of these seams must be approved by the Engineer.
- Seams at inside and outside corners, odd-shaped geometric configurations, seam convergences, and small panels shall be avoided if possible.

Each panel and penetration shall be given a simple and logical identification code consistent with the panel layout drawing. The panel identification should include the panel batch and roll number. The panel layout drawing shall be updated from time to time to reflect the actual deployment configuration.

On completion of the installation, the Contractor shall prepare and submit to the Engineer as-built drawings to scale showing the final panel layout.

#### **PS GCL 5.3.2: Subsurface Preparation**

Prior to deployment of GCL over the prepared subgrade, the GCL Contractor shall inspect, with the earthworks contractor, construction quality assurance, all surfaces on and trenches in which the GCL is to be placed. The Contractor shall certify in writing that the subgrade is acceptable for the installation of the GCL. Surfaces not in compliance with the Specifications shall be rectified by the Contractor and be subjected to inspection and acceptance before the GCL is deployed. The responsibility for maintenance of the accepted areas is described in the Project Specification.

The subgrade should be firm and unyielding, with no abrupt elevation changes, voids or open cracks, and free from standing water.

The subgrade surface should be smooth and consist primarily of fine-grained soil that is free of sharp and protruding edges, construction debris and other foreign matter. Protrusions should not exceed 5mm.

Compaction of the subgrade should be in accordance with project specifications, and should be carried out in such a way that wheel ruts, footprints and other abrupt grade changes are removed. As a minimum, the level of compaction should be such that installation equipment or other construction vehicles that traffic the area of deployment do not cause significant rutting.

Where a GCL is installed over a geosynthetic underlay, this underlay should not be trafficked by unsuitable vehicles as described in section 5.3.9, and walking on the underlay must be kept to an absolute minimum.

### **PS GCL 5.3.3: Anchor Trench**

In some cases the GCL can be anchored in the same trench as any adjacent geosynthetic liner components (if used). Dimensions and location of the trench should be provided on the project drawing. The front edge of the trench is to be rounded, so as to prevent stress concentrations on the GCL. Care should be taken to preserve the integrity of the sides of the trench during GCL installation.

The GCL is to be placed in the trench such that it covers the entire trench floor, but does not extend up the rear trench wall. When the GCL is placed in position, the anchor trench must be loosely backfilled up to 150mm or loaded with appropriate ballast to prevent movement until compaction commences. The anchor trench is to be backfilled and compacted with selected material in layers not exceeding 150mm thick.

### **PS GCL 5.3.4: Deployment**

The GCL shall be installed on the approved areas shown on the drawings, or as directed by the Engineer, using methods and procedures that ensure a minimum of handling. The orientation of the GCL, i.e., which side faces up, shall be in accordance with the drawings, or as instructed by the Engineer.

When possible, GCL deployment should begin at the higher elevations and proceed to the lower elevations. At no time shall GCL rolls be released and allowed to unroll freely under gravity. Damaged, faulty or suspect areas shall be marked for repair. The method used to unroll the GCL shall not damage any underlying geosynthetics or allow stones, mud, or debris to be trapped under the GCL. Care shall be taken to prevent damage to the bottom surface of the GCL when it is finally positioned across the subgrade or underlying geosynthetic.

The GCL shall be placed one panel at a time in a relaxed condition with the required overlap so that it is in intimate contact with the underlying surface at all locations and free of tension or stress upon completion of the installation. All necessary precautions, including installing extra material, shall be taken to avoid bridging of the material. Cutting and trimming of GCL placed over geomembranes shall be undertaken with hooked-blade knives or other approved cutter. Special care shall be taken to protect other geosynthetic materials from damage that could be caused when cutting.

It is important to ensure that the GCL is not left exposed to the elements and therefore the subsequent covering activities must be co-ordinated accordingly with the GCL installation.

The Contractor shall only deploy as much GCL that can be covered in a reasonably short time in the event of precipitation or as can be covered by the end of the working day with soil cover, geomembrane, or temporary plastic sheeting.

The layout and sequence of panel placement is determined by the direction of water run-off. Panels are laid out according to previously approved panel layout drawings. Generally, the installation is started at the up-wind side and at the highest elevation so that any rainfall runs off the lower part of the impoundment, preventing pooled water from hydrating the GCL.

If unplanned premature hydration occurs the Engineer shall be notified. If the extent of the premature hydration is such that, when an average weight person walking over the GCL causes "toothpasting" to occur, the hydrated GCL may need to be replaced at the discretion of the Engineer in accordance with the requirements of section PS GCL 5.3.6.

The extent of the damage of the prematurely hydrated GCL section can be assessed taking the following into account:

- Separation and damage of the geotextiles
- Depth of indentations (and corresponding bentonite thinning) where it has been walked or driven on.
- The integrity of the overlaps and other bentonite enhanced seams.

A sharp utility knife should be used for cutting the GCL if required, e.g. around penetrations. Frequent blade changes are recommended to avoid damage to the geosynthetic components of the GCL during the cutting process. Removed blades should not be discarded on or under the installed GCL. Cutting should be done on an adequately sized, preferably wooden, cutting board.

### **PS GCL 5.3.5: Seaming**

#### **General**

GCL seams shall be used where called for on the Drawings, shown on the approved panel layout, or as directed by the Engineer. The seam shall be created by overlapping adjacent edges and enhancing the seam as recommended by the manufacturer, or as instructed by the Engineer.

The overlap zone shall be kept clean and shall not be contaminated with loose soil or other debris. There shall be no folds in the overlap zone and no traffic or walking shall occur on the completed seam. No end overlaps shall be positioned in sumps or inverts.

#### **Overlap**

Overlaps shall be to the engineer's requirements and shingled in the direction of anticipated water flow.

If the GCL does not incorporate a mechanism to ensure longitudinal overlap sealing overlap areas will require on site overlap bentonite sealing. Edges are pulled back and bentonite of the same source to that used in the product should be poured continuously along all seam edges. The amount of bentonite must be specified by the Engineer.

Horizontal seams on steep slopes (greater than 1V:6H) should be avoided. However, these may be required for long slopes, in which case the horizontal seams shall be constructed as directed by the Engineer.

When the GCL is cut to fit into small areas, in corners or around structures adjacent panels should be overlapped a minimum 300mm or as directed by the Engineer, adding abundant bentonite in overlapped areas, if the overlapped area does not cover a bentonite enhanced longitudinal edge.

### **PS GCL 5.3.6: Repairs**

#### **General**

Any portion of the GCL or seam showing a defect shall be repaired. Reasons for requiring repairs to the GCL installation include, but are not limited to:

- A hole, cut, or tear
- Insufficient overlap
- Bridging
- GCL material defects
- A hard object underneath the GCL
- Unconfined and unhydrated GCL material exposure to harmful liquids during installation. This could include hydrocarbon fuels, chemicals, pesticides or non-compatible leachate, as determined by the Engineer.
- Premature hydration

#### **Repair Methods**

Agreement on the appropriate repair method shall be reached between the Contractor and the Engineer. Repairs shall be undertaken using one or a combination of the following methods:

##### *Patching*

Patching shall be used to repair holes, cuts or tears, insufficient overlap, bridging, GCL material defects, and to remove hard objects underneath the GCL. Patching shall comprise installing a new piece of GCL of the same material type and thickness extending at least 500 mm beyond the affected area in each direction. This 500 mm area must be augmented with bentonite powder/granules or paste per the supplier's normal jointing requirements for patches and to the Engineer's approval. Patch seams shall be created as described in **PS GCL 5.3.5**. Patches on slopes steeper than 1V:6H shall be minimized, and in this case the Engineer shall approve the location and size of such a patch. In addition to bentonite augmentation around the edge of patches on slopes steeper than 1V:6H the patch shall be temporarily secured such that it is not displaced during cover placement. Patches may be tucked under the damaged area to limit patch movement.

No patches shall overlap. If this is required to make a repair, the entire area, including all previous patches in the near vicinity, shall be covered with a single large patch. The Engineer shall approve deviations from this requirement.

Note: Bentonite paste, especially when used in combination with a geomembrane, may develop cracks if desiccation occurs which may not close when rehydrated.

### PS GCL 5.3.7: Sealing Around Penetrations and Structures

The GCL shall be sealed around penetrations and structures embedded in the sub-grade. Bentonite powder/granules or bentonite paste shall be used liberally to seal the GCL to these structures in accordance with the drawings. An example detail is shown in Figure 1.

When the GCL is placed over an earthen subgrade, a “notch” should be excavated into the sub-grade around the penetration. The notch should then be filled with bentonite or bentonite paste. A secondary collar of GCL should be placed round the penetration with a minimum overlap of 300mm.

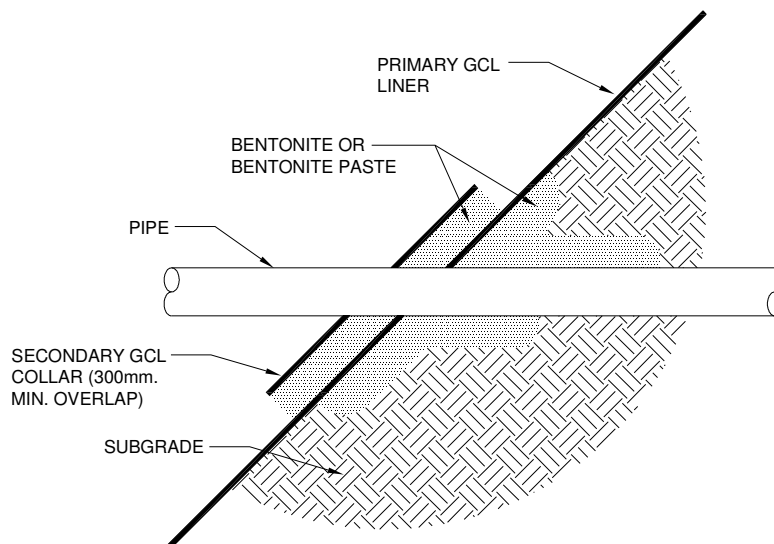


Figure 1: Typical pipe penetration section detail (after ASTM D 6102)

### PS GCL 5.3.8: Hydration

The GCL should always be placed against a moist soil layer to ensure adequate hydration after placement. Pre-hydration of the GCL should be considered very carefully by the Engineer and only used in unique project conditions, such as highly saline environments, relatively short-term applications or low quality cover soils.

### PS GCL 5.3.9: Cover Placement

#### Soil Cover

Prior to the commencement of soil cover placement, the Contractor shall agree with the Engineer the procedure to be used for placement of soil cover, routes to be taken by construction equipment, and additional temporary cover that may be required on high traffic routes.

Cover soil specification to be approved by the Engineer taking into account the compatibility of the GCL and cover soil. As a minimum the soil shall be free from sharp stones, roots, construction debris, etc. that may damage the GCL.

Where soil cover is placed directly onto the GCL, the soil cover shall be placed in one layer to the thickness and density specified on the Drawings immediately following deployment and acceptance of the GCL. Equipment and procedures that minimize stress on the GCL and prevent soil from entering the seam overlaps. On flatter surfaces soil placement should be in the direction of the overlaps. On slopes, soil cover should be placed in an up-slope direction to minimize tensile forces on the GCL, while at the same time preventing soil from opening the seams. In some cases, however, it may be preferable (at the discretion of the Engineer) to place cover downhill. This must be done carefully with the machinery wheels on adequately thick soil cover.

No vehicles should be allowed to traffic the area directly above the GCL unless at least 300mm separation exists between the GCL and the vehicle to adequately distribute the vehicle load for a short period of time of pass-over. If frequent traffic is expected over a GCL lined area it is recommended to increase the soil cover to at least 600mm as directed by the Engineer.

The soil cover shall be placed to within at least 750 mm of the leading edge of the GCL. Before the end of the working day, the remaining exposed GCL shall be covered with temporary plastic sheeting that is anchored under the leading edge of the soil cover and folded at least 300 mm under the leading edge of the GCL. The protected end of the GCL shall be held in place with temporary ballast until installation resumes.

#### **Geomembrane Cover**

Where a geomembrane is placed directly onto the GCL, the geomembrane shall be placed immediately following deployment and acceptance of the GCL using equipment and procedures that minimize stress on the GCL. This may be accomplished by using lightweight, rubber-tired equipment such as a 4-wheel all-terrain vehicle (ATV). This vehicle can be driven directly on the GCL, provided the ATV makes no sudden stops, starts, or turns. If such instances do occur, the CQA officer shall be notified immediately. The CQA officer shall then inspect the possible damage and may instruct repair in accordance with PS GCL 5.3.6. When a textured geomembrane is installed over the GCL, the contractor shall take necessary measures to ensure the integrity of the installed GCL is not compromised in any way. This could necessitate the use of temporary slip-sheets to minimize friction between the GCL and geomembrane.

Low ground pressure devices such as ATVs or tractors to facilitate deployment over other geosynthetic layers should be used if no other method is possible. The machines should exert less than 50kN/m<sup>2</sup> carrying a driver weighing approximately 80kg.

The geomembrane shall be placed as close to the leading edge of the GCL without creating unnecessary additional seams in the geomembrane.

#### **PS GCL 6: TOLERANCES**

Manufacturing tolerances to be in accordance with GRI-GCL 3 and any associated standards.

The maximum permissible deviations for overlaps in joints, patches and seams shall be 10% of the specified overlap.

**PS GCL 7: TESTING**

The GCL material shall be tested for compliance with the specifications listed in Table 1 (a) in GRI GCL 3 (Reinforced GCL GT related) by the test methods and frequencies indicated. Sampling of GCL is to be in accordance with ASTM D6072.

Immediately upon manufacture, Conformance Testing may, at the discretion of the Engineer, be carried out by an independent accredited laboratory (MQA laboratory). Common important conformance tests are listed in Table 1. Further tests, such as GCL shear strength (ASTM D 6243), may be required by the Engineer for specific projects. The testing frequency shall be at the discretion of the Engineer but the frequency shown in Table 1 (a) in GRI GCL 3 (Reinforced GCL GT related) can be used as a guideline. The Engineer shall approve the laboratory before any testing is done. The Engineer has the right to reject any roll or production batch if the samples do not pass conformance testing.

The Contractor shall supply with his tender, a Construction Quality Control Plan which clearly indicates documentation ensuring compliance with the necessary material specifications, and control points requiring quality control checking during construction/installation.

The engineer may request test results produced by a certified laboratory independent of the manufacturer to verify the claimed properties, prior to approval of the product(s) offered. All MQC and CQC testing and reporting thereon are described in the GRI-GCL 3 specification.

**Table 1. Key specifications for Geosynthetic Clay Liners (after Table 1 (a) form GRI-GCL3).**

<b>Material Property</b>	<b>ASTM Test method</b>
Bentonite Swell Index	D 5890
Bentonite Dry Mass/ Unit Area	D 5993
GCL Peel Strength	D 6496
GCL Index Flux	D 5887

**PS GCL 8: DOCUMENTATION**

**PS GCL 8.1 General**

An effective construction quality assurance plan depends largely on recognition of all construction activities that must be monitored, and on assigning responsibility for the monitoring of each activity. This is most effectively accomplished and verified by the documentation of quality assurance activities. The Engineer will ensure that all quality assurance requirements have been addressed and satisfied.

**PS GCL 8.2 Prior to installation**

The Installer/Contractor is to provide the following to the Engineer before installation on site:

- Manufacturers conformance certificates
- A drawing indicating the position and numbers of each individual panel that will be installed (Panel layout)
- A Method Statement describing the method of installation and quality control documentation to be completed
- A Project Quality Plan with organization chart and detailing inspection procedures

**PS GCL 8.3 During installation**

The Installer/Contractor is to complete the following:

- Material receipt with roll numbers
- Subgrade surface acceptance documentation
- Panel layout – Panels installed and repair positions
- Panel Placement Form showing the location of all panels and joints
- Project Quality Plan – Signatures
- Certificate of Acceptance

The Engineers representative is to complete the following daily reports:

- Field notes, including memoranda of meetings and/or discussions with the Contractor and GCL Installer.
- Construction problems and solution data sheets
- Project Quality Plan – Signatures
- Data on weather conditions
- Safety Matters
- Soil cover details
- Signature of Completion Certificate

**PS GCL 8.4 After installation**

The Installer/Contractor is to provide the following within 14 days to the Engineer.

- A complete Data Pack containing all completed and signed documentation as described in 9.2 and 9.3 (Installer/Contractor documentation).

The Engineer is to provide the following within 30 days of completion of installation to the Employer.

- The Installer/Contractor Data Pack
- An outline of the project
- A description of the lining system
- GCL Material Specification
- Batch and roll numbers of panels used
- A summary of on site CQA activities, quantities, samples etc
- A photographic record of construction
- Discussion of problems and solutions
- As built drawings

**PS GCL 9: MEASUREMENT AND PAYMENT**

**PS GCL 9.1: Measurement**

Quantities for payment will be measured to finished shapes, sections, and profiles as shown on the Drawings will be included in the measurements unless performed on the written instruction of the Engineer.

Final quantities for the payment will be determined by the Engineer from the pre-construction, intermediate, and post-construction surveys and the approved as-built drawings. The Contractor shall provide all personnel, equipment and materials required to make such surveys, measurements, and other computations as are necessary to determine all estimates of monthly and final payments for Work performed, or as requested from time to time by the Engineer. A copy of the survey data and calculations shall be provided to the Engineer. Failure on the part of the Contractor to submit its survey data to the Engineer before commencing work will be held to indicate that it is prepared to accept the areas provided by the Engineer for the purposes of measurement and payment.

The Engineer may conduct such checks on the Contractor's survey, measurements and calculations, as he considers necessary, to confirm their adequacy and accuracy. Any discrepancies in the survey data identified by the Engineer shall be resolved with the Contractor before the Contractor may proceed with Work in that area. In the event of such failure, no subsequent claim in this regard will be considered. The Contractor shall allow in its construction schedule for the Engineer to check the surveys, measurements and computations.

Note: Subgrade preparation items to be covered in the earthworks specification

**PS GCL 9.1.1: Length**

The measurement of length will be made along the centreline, adjusted for slope.

**PS GCL 9.1.2: Area**

Unless GCL is deployed in simple geometric forms, area will be computed using a planimeter, survey methods, or other means as determined by the Engineer. The plan area measured will be adjusted for slope.

Measurement will not be made of geosynthetic waste, overlaps, patches, or scrap unless otherwise approved by the Engineer. Geosynthetics placed in trenches will be measured according to the embedded length shown on the Drawings multiplied by the length of the trench.

**PS GCL 9.1.3: Anchor Trench**

The excavation and backfilling of the anchor trenches is measured separately in the schedule of quantities.

**PS GCL 9.2: Payment**

Items listed in the Schedule of Rates and Prices are deemed to cover all work indicated in the Drawings or detailed in the Contract. No additional items may be

claimed by the Contractor and the Contractor must allow in the unit rates and prices for completing the GCL installation in its entirety.

Notwithstanding the above, the Contractor declares that every unit rate and price submitted in the Schedule of Rates and Prices has been derived in a reasonable fashion and properly reflects the cost of doing the portion of work to which that unit rate or price pertains.

**PS GCL 9.3: Listed Items**

**PS GCL 9.3.1: Supply Geosynthetic Clay Liner (m<sup>2</sup>)**

Separate items will be listed for each structure or work area and for each GCL type. The Tendered Rate for the supply of the GCL shall include full compensation for all materials, plant, labour, training and other incidentals required to manufacture, purchase, transport, deliver, store the material on and/or off site, test or comply with all Manufacturing and Construction Quality Assurance and Control requirements, in full accordance with the relevant specifications, irrespective of the source or point of manufacture. Waste allowance, overlap etc. shall be deemed to be included in the tendered rate. The quantity measured for payment shall thus be the net area installed including GCL placed in anchor trenches.

The costs of Freight, Duty, Landing charges and Rates of exchange shall be included in the Tendered Rate as well as an allowance for waste and overlap. Variations in these costs are dealt with under special materials. The rate of exchange should be as stipulated by the Engineer before tender closure.

Payment shall be made, in accordance with the contract document, on receipt of materials on site or receipt of cession of ownership for materials stored off site.

**PS GCL 9.3.2: Install Geosynthetic Clay Liner (m<sup>2</sup>)**

Separate items will be listed for each structure or work area and for each GCL type. The quantity measured for payment shall thus be the net area installed including GCL placed in anchor trenches.

The Tendered Rate for the installation of the GCL shall include full compensation for all materials, plant, labour, training and other incidentals required to install the GCL, and all jointing (both longitudinal and transverse) in accordance with the relevant specifications. No additional payment will be made for any transport, handling, cutting, waste, placing, joining, overlapping, temporary anchoring/securing, testing or compliance with all Quality Assurance and Control requirements and Construction Quality Assurance Plans.

**PS GCL 9.3.3: Penetration (No.)**

Items will be provided for penetration configuration as detailed on the drawings. The Tendered Rate shall include full compensation for all materials, plant, labour, training and other incidentals required to construct the penetration.

**PS GCL 9.3.4: 3<sup>rd</sup> Party Testing (No.)**

Items will be provided for each GCL type. The costs shall include the material cost of the samples, marking, cutting, packaging, transporting, testing the samples at the laboratory and reporting thereon.

## Appendix A: Applicable Standards

### American Society for Testing and Materials (ASTM)

D 792	Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
D 882	Test Method for Tensile Properties of Thin Plastic Sheeting
D 1141	Practice for Preparation of Substitute Ocean Water
D 1505	Test Method for Density of Plastics by the Density-Gradient Method
D 4354	Practice for Sampling of Geosynthetics for Testing
D 4439	Terminology for Geosynthetics
D 4632	Test Method for Grab Breaking Load and Elongation of Geotextiles
D 4759	Practice for Determining the Specification Conformance of Geosynthetics
D 5199	Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes
D 5261	Test Method for Measuring Mass per Unit Area of Geotextiles
D 5721	Practice for Air-Oven Aging of Polyolefin Geomembranes
D 5887	Test Method for Measurement of Index Flux Through Saturated Geosynthetic Clay Liner Specimens Using Flexible Wall Permeameter
D 5888	Standard Guide for Storage and Handling of Geosynthetic Clay Liners
D 5889	Practice for Quality Control of Geosynthetic Clay Liners
D 5890	Test Method for Swell Index of Clay Mineral Component of Geosynthetic Clay Liners
D 5891	Test Method for Fluid Loss of Clay Component of Geosynthetic Clay Liners
D 5993	Test Method for Measuring the Mass per Unit Area of Geosynthetic Clay Liners
D 5994	Test Method for Measuring the Core Thickness of Textured Geomembrane
D 6072	Standard Practice for Obtaining Samples of Geosynthetic Clay Liners
D 6102	Standard Guide for Installation of Geosynthetic Clay Liners
D 6141	Guide for Screening the Clay Portion of a GCL for Chemical Compatibility to Liquids
D 6243	Method for Determining the Internal and Interface Shear Resistance of Geosynthetic Clay Liner by the Direct Shear Method
D 6495	Guide for Acceptance Testing Requirements for Geosynthetic Clay Liners
D 6496	Test Method for Determining Average Bonding Peel Strength Between the Top and Bottom Layers of Needle-Punched Geosynthetic Clay Liners
D 6693	Test Method for Determining Tensile Properties of Non-reinforced Polyethylene and Non-reinforced Flexible Polypropylene Geomembranes
D 6766	Test Method for Evaluation of Hydraulic Properties of Geosynthetic Clay Liners Permeated with Potentially Incompatible Liquids
D 6768	Test Method for Tensile Strength of Geosynthetic Clay Liners