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Geocomposite drains: what the eye can't see beyond lamination

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Geocomposite drains play a critical role in highway and waste containment structures. In many of theses applications, the geonet core of the product is sandwiched between two geotextiles. For the field inspector this poses a dilemma: How can the uniformity and integrity of the geonet core be confirmed since it is not visible? This article focuses on two actual biplanar geonet core problems that the authors have observed in the past two years. The article is not intended to impugn the quality of the vast majority of geocomposite drainage products. Conversely, it is the high quality of these products that has made the problems discussed in this article rare. However, this rarity also means that these problems have not been discussed in the literature before. Both problems discussed are the result of manufacturing conditions during fabric lamination that lead to a failure of normal quality control and assurance programs.

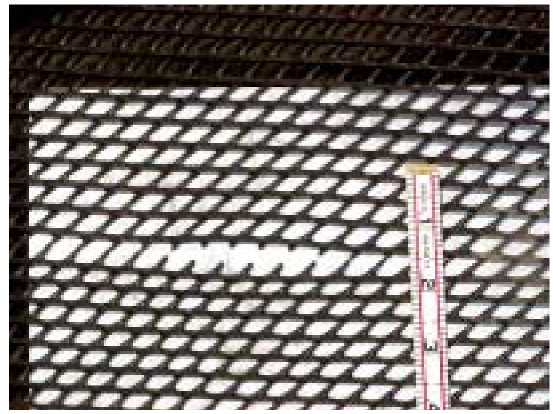

***Photo 1**. Though the problem is rare, close inspection of geocomposite drainage material at one job site revealed a damaged geonet core.*

Problem one: geonet separation failure

During the placement of a geocomposite drainage layer in a RCRA final cover at a Superfund site, the installation crew pointed out to the inspector that some rolls of the drainage composite appeared to have a 'broken' geonet. Closer examination of the geocomposite drainage material showed that the geonet core was indeed damaged. One layer of ribs was broken at the point of connection to the second rib. This is shown in **Photo 1**. It appeared that excessive tension in the geonet during lamination of the geotextiles had actually broken the geonet. The closer examination also showed that the breaks were visible in the composite as lines of depression in the geotextile as shown in **Photo 2**.

***Photo 2**. Lines of depression on the geotextile revealed further problems.*

Once this defect characteristic was observed, the defects in 4.4 acres (1.8 ha) of exposed geocomposite drainage material were mapped by visually examining all exposed geocomposite. This mapping showed that 45% of the panels had no defects. The remaining panels had defects that ranged from full width (6.5% of the panels) to smaller but more numerous defects. The defective panels were removed and replaced with defect free composite. Unfortunately 20.1 acres (8.1 ha) of this composite drainage material had been installed and covered with the vegetative soil support layer so that defects could not be detected and removed. These hidden defects present a potential mechanism by which detrimental pore water pressures could build up beneath the cover soil layer.

Transmissivity tests performed on the defective geocomposite showed that flow was significantly reduced across the defect due to intrusion of the overlying soil. Intact drainage composite samples had a transmissivity of approximately 1.4 x 10^{-4} m^2/sec. This was less than the required transmissivity of 3 x 10^{-4} m^2/sec. Additionally, tests on defective geocomposite samples indicated that the flow capacity was further reduced by a factor of 66 by the presence of the defect. Such a dramatic reduction in flow capacity could obviously lead to a backup of water in the drainage layer and potential slope failure of the overlying vegetative support layer (Richardson 1997, and Richardson, Giroud, and Zhao 2002).

Faced with the need to remove 20.4 acres (8.3 ha) of soil and geocomposite drainage layer, the contractor brought in drainage experts to evaluate remedial alternatives. Additional transmissivity testing of field conditions did find one bright point: The original specifications required removal of 6-inches of the lower geotextile along both edges of the composite before it was joined to the adjacent geocomposite panel. Transmissivity testing of the 12-in. zone that lacked the lower fabric showed that it had a flow capacity of approximately 1.7 x 10^{-3} m^2/sec. This zone of increased flow would play an important role in the final solution.

The overall failure of the geocomposite transmissivity meant that drainage lengths constructed were excessive and needed to be reduced. This was accomplished by retrofitting additional collector pipes to reduce the length of drainage in the composite by three to only 41 ft. (12.5 m). **Figure 1** shows the detail of the supplemental drainage intercepts. Note that a geomembrane flap is required to force the water draining in the geocomposite into the pipe. These supplemental drainage intercepts were installed by trenching the vegetative support soils, cutting the drainage composite, and then installing the supplemental drain components.

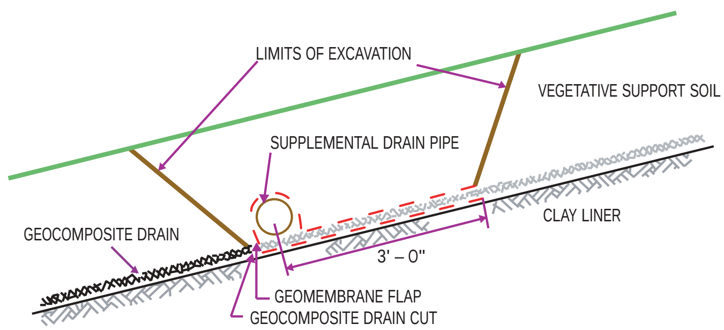

Figure 1. *Supplemental drainage intercepts. A geomembrane flap is required to force the water draining in the geocomposite into the pipe.*

Next, the question of the impact of defects in the composite on the stability of the cover on the 4H:1V slopes had to be addressed. It must be noted that this question was never addressed to the satisfaction of all parties involved. The following approach is that used by the first author. **Figure 2** shows the worst potential drainage condition observed in the field mapping of geocomposite defects. Here the defect runs the full width of the panel. Conservatively modeling the defect as a total flow blockage, the maximum quantity of water, Q_{in}, that would impinge on this defect can be estimated by assuming a unit gradient inflow, $q_h = k_{soil}$. For this site, the vegetative cover soil had a permeability of 4.0 x 10^{-7} ft/sec (1.2 x 10^{-7} m/sec). The contributing area up-gradient of the defect is approximately 13(18.6 + 31.4/2) = 438 $ft.^2$ (40.7 m^2). The total lateral drainage impinging on the defect is given by the product of q_h and the contributing area or 1.75 x10^{-4} $ft.^3$/sec (4.9 x 10^{-6} m^3/sec).

The total lateral drainage impinging on the defect must flow down parallel to the defect. Flow testing along the defect indicated a transmissivity of 0.9×10^{-4} m^2/sec. The flow gradient for flow parallel to the defect can be calculated to be 0.23. Given that the maximum flow capacity of a geonet is equal to the transmissivity time the gradient, the maximum width, w, of flow due to the total lateral drainage impinging on the defect can be calculated as follows:

$w = 4.9 \times 10^{-6}/(0.23 \times 0.9 \times 10^{-4}) = 0.24$ m (0.8 ft)

This small width of confined flow will not create a slope stability problem and the repair is complete. Note also that the higher flow capacity strip between each geocomposite drain panel has a capacity of $0.25 \times 1.7 \times 10^{-3}$ m^2/sec = 0.43×10^{-3} m^3/sec. This is larger than the maximum total lateral drainage impinging on the defect. Thus, the flow moving down parallel to the defect has unrestricted drainage when it reaches the panel edge.

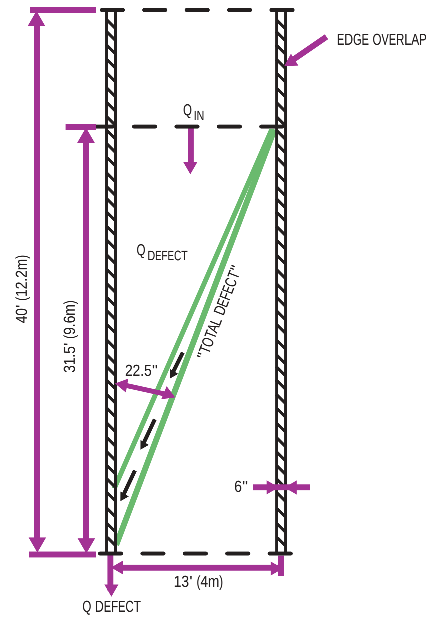

Figure 2. *The worst potential drainage condition observed in the field mapping of geocomposite defects. Here the defect runs the full width of the panel.*

Problem two: geonet specification problem

About a year ago, an engineer specified a standard 250-mil geocomposite with a 6-oz. geotextile on the bottom and an 8-oz. geotextile on the top facing the GCL. Some of the specified properties were:

Peel strength: 20 lb./in. (ppi) (min)
Geonet thickness: 250 mils (min)
Transmissivity: 8×10^{-4} m^2/sec; between two steel plates; seating time: 24 hrs; normal load: 12,500 psf; gradient: 0.1

Needless to say, a product could not be found meeting the high peel strength criteria regardless of the resin density. Subsequent testing by several laboratories verified this. During a conference call with the engineer, he stated that he performed the necessary calculations, was quite satisfied that a 250-mil geocomposite would meet his criteria and that it was the contractor's responsibility to find the product. Numerous tests were performed but no product was found to meet these criteria. Ultimately, another product was used (gravel).

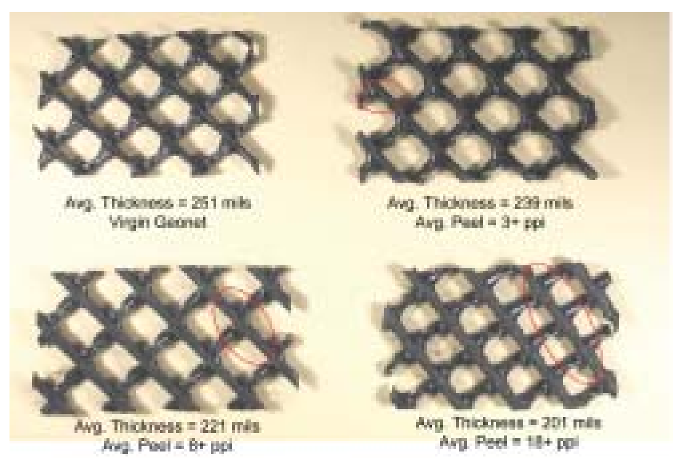

Photo 3*. Peel strength vs. thickness for increasingly aggressive bonding heat and pressure. Transmissivity from 3 to 18 ppi products differed by nearly one order of magnitude.*

Recently, several tests were performed on a similar 250-mil geocomposite with high peel strengths. The bonding process needed to be quite aggressive to obtain these high strengths (e.g., high heat of bonding) but resulted in a decrease in transmissivity.

A closer look at this particular bonding process revealed that the higher heat coupled with increased bonding pressure resulted in damage to the ribs and loss of rib thickness. **Photo 3** shows the physical results of peel strength versus thickness for increasingly aggressive bonding heat and pressure. The difference in transmissivity between the 3 ppi peel strength product and that of the 18 ppi product was almost one order of magnitude. This reduction was attributed to the following:

• The pressure and heat reduced the thickness of the geonet by about 20%.
• The softened geonet resin squeezed laterally to reduce the capacity of the flow channels.
• The opposing 8 oz./yd.^{2} fabrics squeezed together to close the flow channels.

Testing by other labs over the past decade has clearly indicated that peel strengths of 0.5 to 1 ppi are sufficient to prevent shearing of the fabric under load. This minimal peel strength also minimizes damage to the ribs and facilitates overlapping of adjacent geocomposites.

Summary

Both geocomposite drainage problems presented are the result of the geonet drainage core being hidden by the geotextile separation and friction layers. In both cases, damage to the geonet occurred during the lamination process due to excessive heat or tension in the geonet. Unfortunately, it is a rare project that still sends construction quality assurance (CQA) technicians to the factory to observe the manufacturing of this material. To avoid service problems due to damaged geonet cores, the following practices should be followed:

• Before specifying a geocomposite: Carefully read and understand GRI-GC8, *Determination of the Allowable Flow Rate of a Drainage Geocomposite*, only specify what you really need and perform your design verification tests to simulate the anticipated field conditions. It is the designer's responsibility to develop a workable design based on sound engineering principles and confirmation testing. You should not just specify some theoretical criteria and expect the contractor to provide this theoretical product, for it may be a figment of your imagination. Peel strength in excess of 1 ppi is not possible using polypropylene geotextiles without significantly reducing transmissivity.

• Field inspection of drainage composite: Look for unusual depressions in the upper geotextile. These depressions may signify a damaged geonet core. Obviously, the field CQA technician should walk the geocomposite and perform a visual inspection. Also, proper installation following the recommendations of the engineer is important, as shown in the first case with the removal of 6 inches of the lower geotextile.

Both authors feel that the problems identified in this article are very rare. Geocomposite lateral drainage products are amazingly effective and uniform in properties. It is our hope that a better educated designer will make these problems extinct. GFR

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