Geosynthetic drainage composite materials connections and attachments

Robert Koerner & George Koerner
Geosynthetic Institute, USA

ABSTRACT: Geonet and geospacer cores covered with geotextile filter/separators, called drainage composites or geocomposite drains, have been a revolution in civil and geotechnical applications. These lightweight, thin materials have replaced natural sand and gravel drainage soils in many transportation, geotechnical and hydraulic engineering applications. Due to their excellent performance, low cost and ease of construction they are regularly used as drainage media in all types of civil construction projects. That said, panels or rolls of geocomposite drains are finite in their dimensions and generally not able to cover the entire footprint of a project site. Therefore, connections and attachments at ends and edges are required on all projects. This paper addresses proper procedures with the required details. Furthermore, a new test method to evaluate the strength of the usual plastic cable ties will illustrate how conventional connections perform in the laboratory, as well as the field. The paper also gives recommendations on field installation of such materials (such as no butt joining of cores, no intervening geotextiles within flow region and no exposed drainage core against the adjacent soil) are concerned.

Keywords: geonets, geospacers, drainage composites, connections, attachments

1 INTRODUCTION AND BACKGROUND

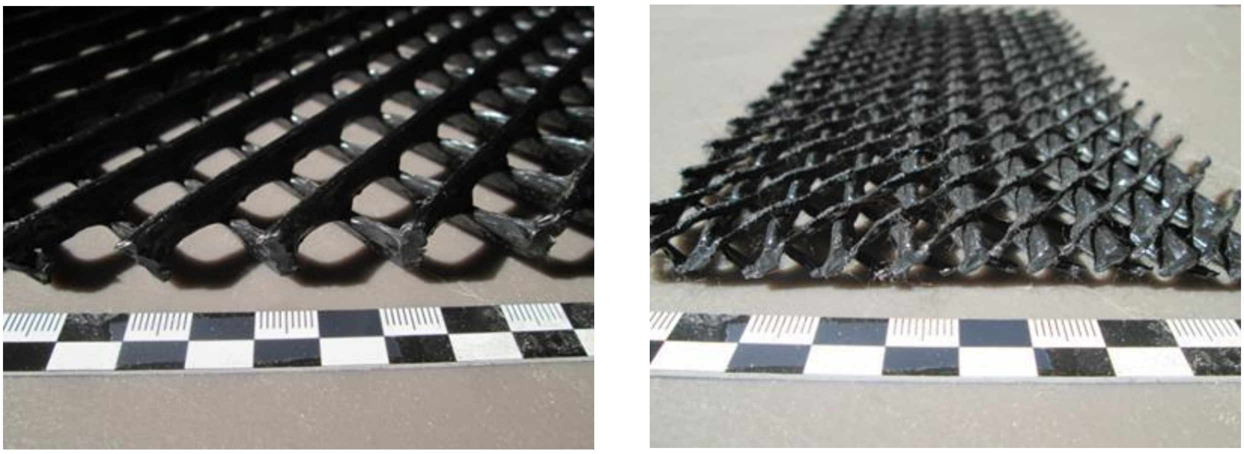
Biplanar geoents made from high density polyethylene were first developed and made by Netlon Ltd. in the U.K. (now Tensar Corp.) in the 1950’s (Austin 1994). While they are only 5-10 mm thick is was quickly realized that the in-plane flow rate was approximately equivalent to 300 mm of 0.01 cm/sec hydraulic conductivity sand. Thus drainage situations were the obvious target application. This equivalency was clearly proven in field trials with a full scale field demonstration in a 220 × 86 m landfill leak detection layer at a 2.9% grade. Water was injected at three normal load increments and the resulting transmissivities indicated the anticipated response; i.e., at no-load $\theta = 45.2 \times 10^{-4}$ m^2/sec, at mid-load $\theta = 43.5 \times 10^{-4}$ m^2/sec and at full load, $\theta = 40.5 \times 10^{-4}$ m^2/sec (Eith and Koerner, 1992). A variation, called a triplanar geonet was developed sometime later wherein the large central rib produced significantly greater flow in this direction (Zhao, et al., 2012). See Figure 1a for both types of geonets. When geotextiles are heat-laminated to one or both sides of geonets, for the dual purpose of filtration and separation, they are known as *geonet drainage composites*.

Beginning in about 1980, manufacturers began producing drainage cores with very different shapes, configurations and resin formulations. Starting with stiff three-dimensional mats of nylon and dimple-shaped protrusions of high-impact polystyrene a new category of drainage core (called geospacers herein) was being used for various drainage projects. The applications were drainage of retaining walls, tunnels, building plaza decks, green roofs, etc. See Figure 1b for the various type of geospacers. In most cases a geotextile was bonded to both sides or even surrounding the entire core. These core types with their accompanying geotextiles are known as *geospacer drainage composites.* Some distinguishing characteristics between geonet and geospacer drainage cores are given in Table 1.

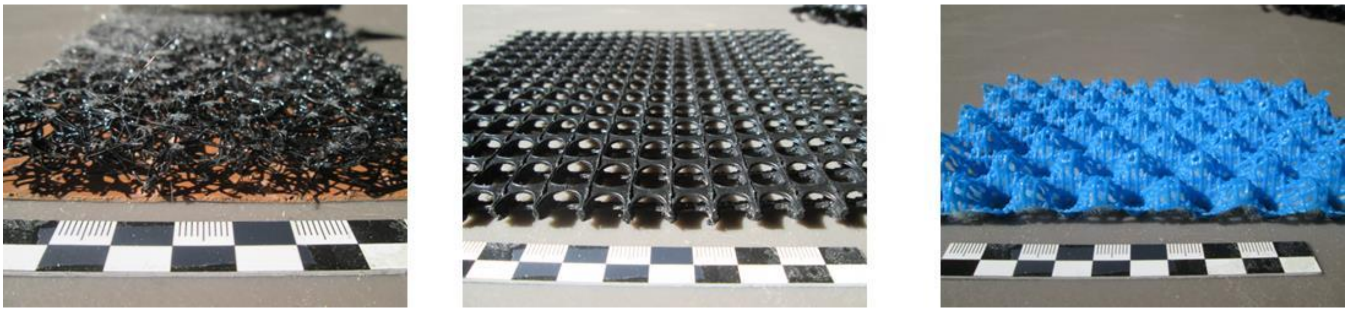
Table 1. Some distinguishing characteristics between geonet and geospacer cores.

Item	Geonets	Geospacers
Type of structure	biplanar/triplanar	3-D mats, channels, protrusions
Resin type	HDPE	PA, PE, PP, PS, etc.
Flow rate	mod/high	low-to-very high
Compressive strength	high/v. high	v. low-to-mod
Joining	cable ties	cable ties or interlocks
Geotextile covering	none, 1-side, 2-side	none, 1-side, 2-side
Geotextile bonding	thermal	thermal, adhesive or tape
Shipping configuration	rolls	rolls or panels

Both geonet and geospacers drainage composites will be addressed in this paper from the perspectives of their connections and attachments.



(a) Geonets - biplanar and triplanar types



(b) Various geospacers

Figure 1. Various types of geonet and geospacer drainage cores.

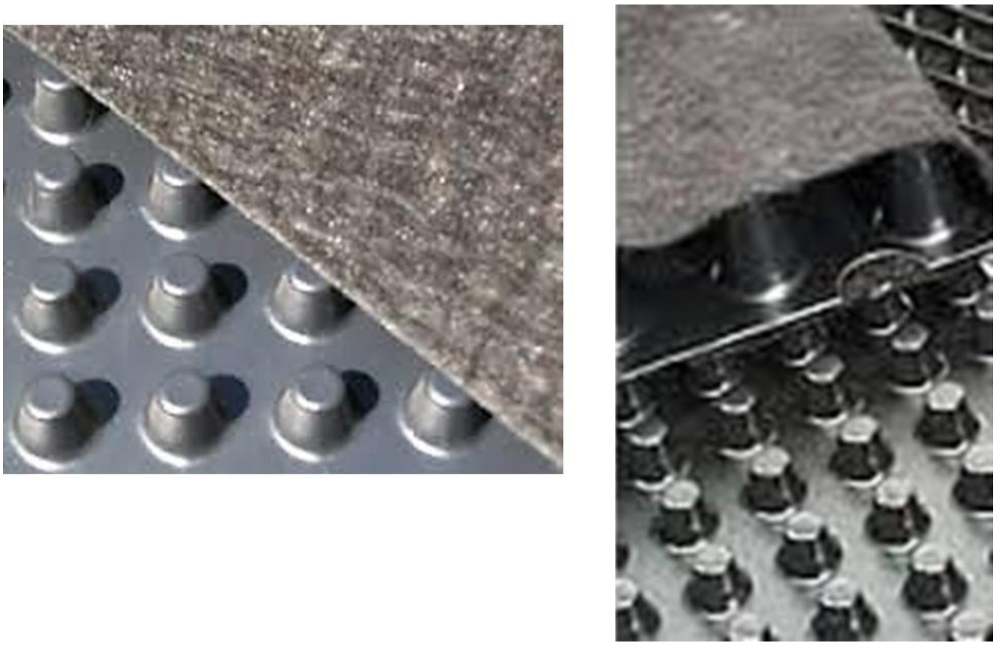
2 GEONET AND GEOSPACER CORE CONNECTIONS AND ATTACHMENTS

The ends and edges of panels or rolls of drainage composites must be such that flow coming from the up-gradient to the downgradient cores is uninterrupted insofar as the planar flow is concerned. Thus some general best-practices are as follows:

- Butt joining of cores is not acceptable.
- Adjacent cores must be overlapped in a downgradient shingling configuration.
- The amount of overlap varies with the particular design replacement but is generally greater in the direction of flow (the ends) than in the opposite direction (the edges).
- The covering geotextiles must be capable of being hand-stripped off of the core for the required overlap distances.
- There can be no geotextiles located within the overlapped core flow areas.

- There can be no geonet or geospacer core exposed to adjacent soil without a geotextile filter-separator being present.
- The usual method of joining geonet cores is by using plastic cable ties, while geospacer cores are joined by interlocking protrusions or plastic cable ties; see Figure 2a and 2b, respectively.

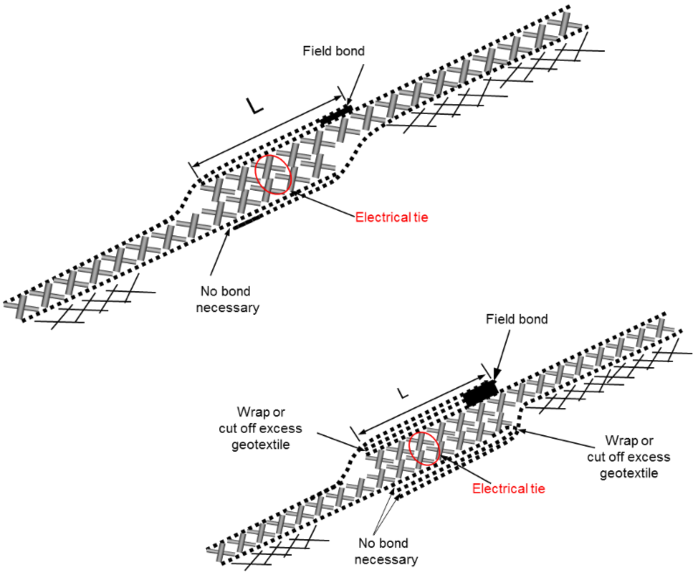
(a) Plastic cable ties joining or overlapping geonets

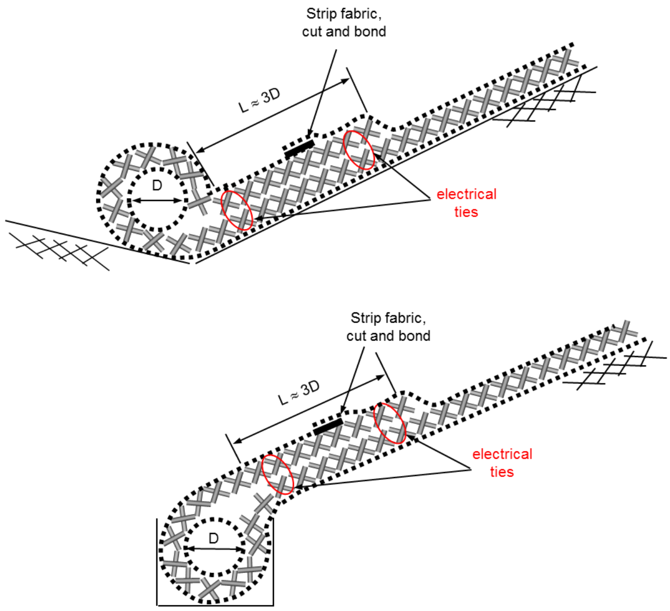


(b) Protruding columns and cuspations of geospacers can often interlock together

Figure 2. Connecting overlapping geonet and geospacer drainage cores.

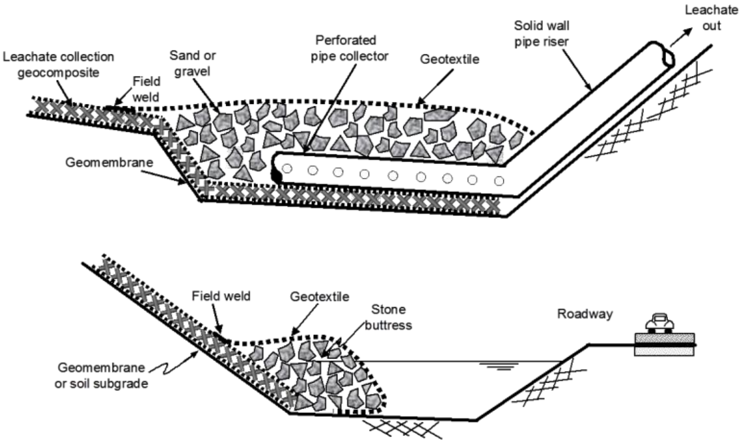
Figure 3 presents several different application situations where drainage cores of either type are properly positioned after removing and reassembling the geotextile in the overlapped regions. This is an important and yet difficult detail to accomplish particularly when the geotextiles are too firmly bonded to the drainage cores.

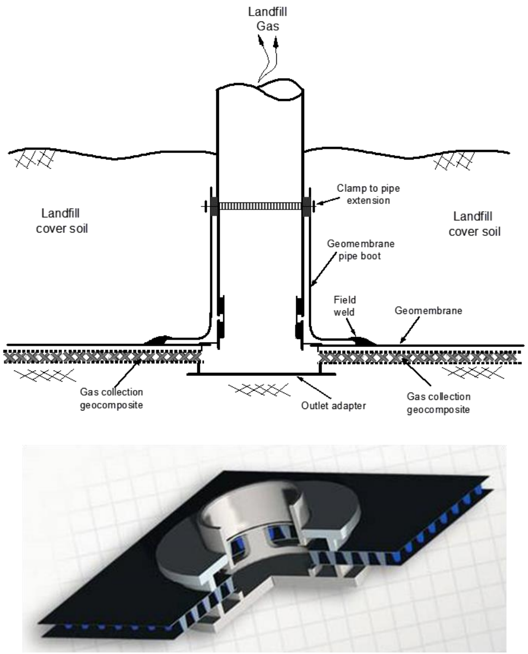




(a) Recommended overlapping of geocomposite drainage materials. (compl. COE)

(b) Recommended drainage core to drainage pipe connections. (compl. COE)





(c) Recommended drainage geocomposite terminating into a sump or an open collection area. (compl. GSI)

(d) Recommended drainage geocomposite to vertical pipe connections. (compl. Drain Great^{TM})

Figure 3. Drainage geocomposite core connections and attachments with emphasis on proper geotextile configurations.

While Figure 3 presents proper connection and attachments of geocomposite drainage cores, it is the outlet of the drainage cores which has caused most of the field problems. Four separate case histories have been investigated by the authors. The general scenario is that blockage of the core outlet at the base of a wall, slope, structure, etc., causes water to build-up within the core itself. It thus becomes a mini-reservoir. As such, it can result in a build-up of hydrostatic pressure and cause slope failures (one case), basement flooding (one case) or become a source for vegetative growth and hence long-term clogging of the drainage core (two cases). See Figure 4 for this latter situation.

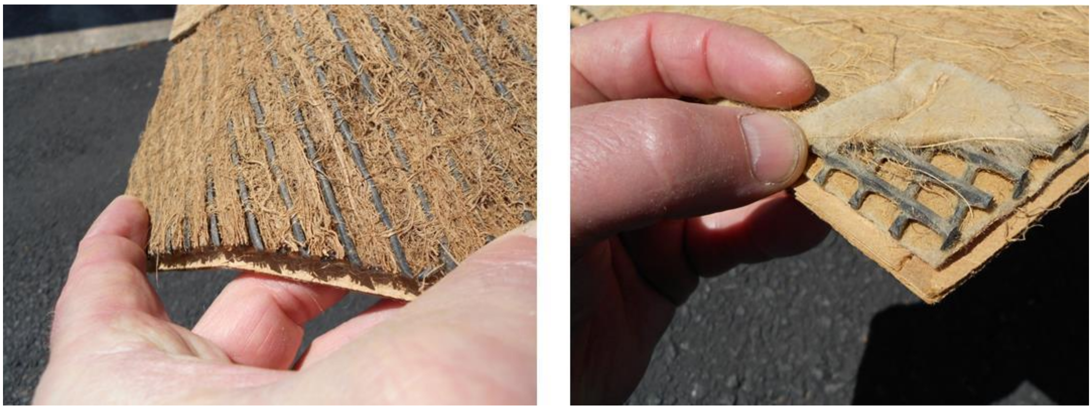


Figure 4. Field cases of vegetative clogging of drainage cores.

3 PLASTIC CABLE TIE BREAKAGE AND AN ASSOCIATED TEST METHOD

While constructing a new landfill cell liner system to be connected to an existing cell's liner system, excavation was required on the intermediate soil berm. In so doing the geonet leak detection layer between primary and secondary geomembranes had an overlapped region which was plastic cable tie joined. As shown in Figure 5 all five plastic cable ties were broken. This prompted a laboratory investigation which follows.

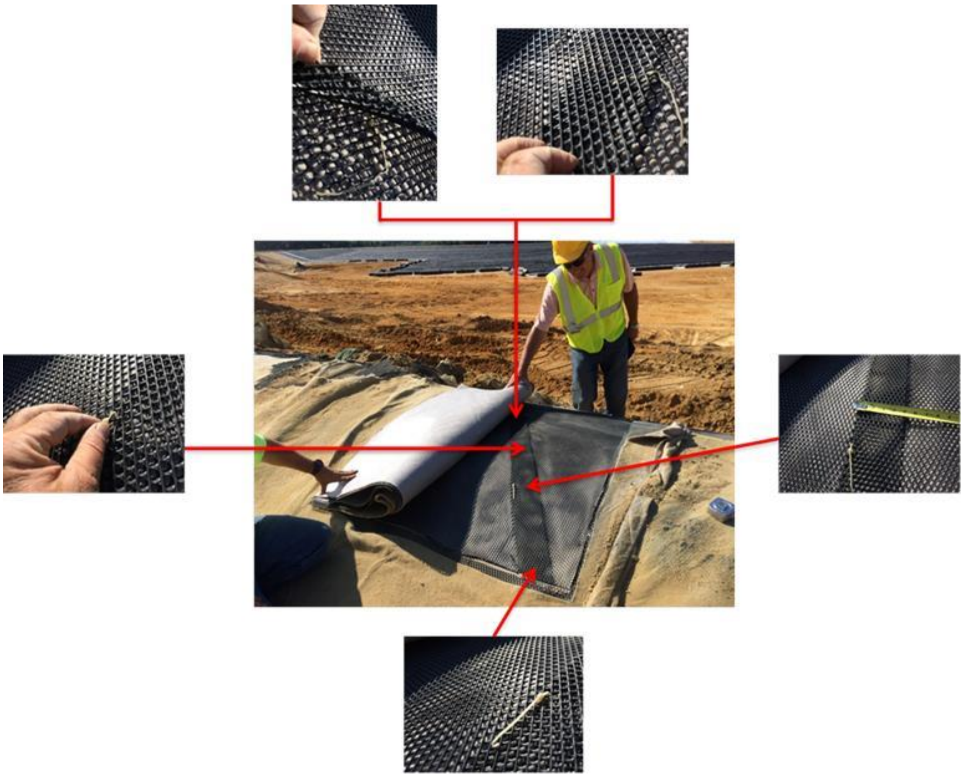


Figure 5. Exhuming a geonet overlap that has its plastic cable ties broken.

The plastic cable tie investigation to be described is in two-parts; the ties by themselves and the ties when joining test specimens of geonet cores. The ties themselves were tested in three different configurations; tie in tension, connection head in peel and entire tie in a loop. Configurations are shown in Figure 6 and testing details are given in Table 2. In general, the loop test is preferred since this best simulates the field situation.

Table 2. Testing details for cable tie strength.

Operation Details	Tie in Tension	Connection Head in Peel	Entire Tie in a Loop
Gage Length	62 mm	62 mm	62 mm
Strain Rate	50 mm/min	50 mm/min	50 mm/min
Specimen Size	150 mm	45 mm dia. loop cut in half opposite from the connecting head	45 mm dia. loop
Grip Face Details	25 × 27 mm serrated steel faces	25 × 37 mm serrated steel faces	16 mm dia. stainless steel eyelets

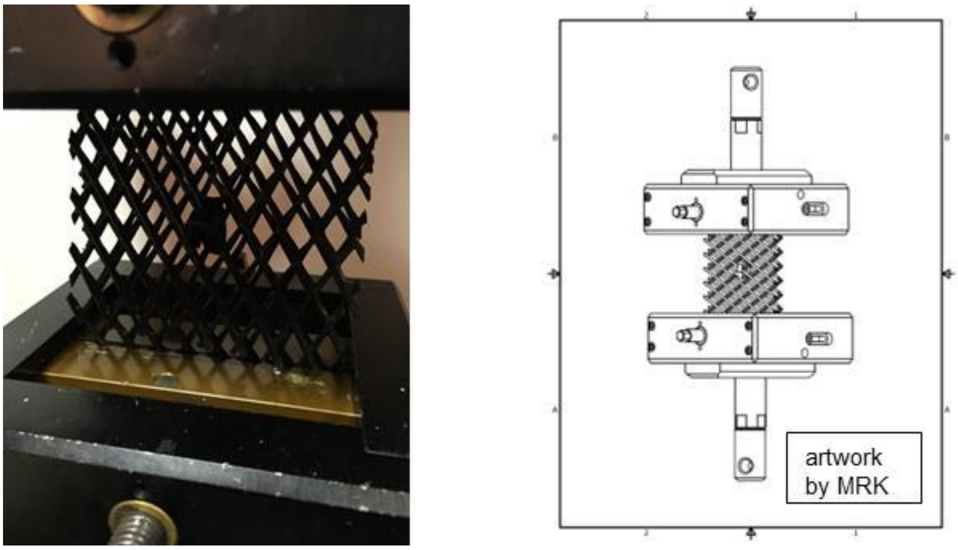
(a) Tail itself in tension (b) Connection head in peel (c) Looped tie in tension

Figure 6. Tension tests on the tie, head and loop.

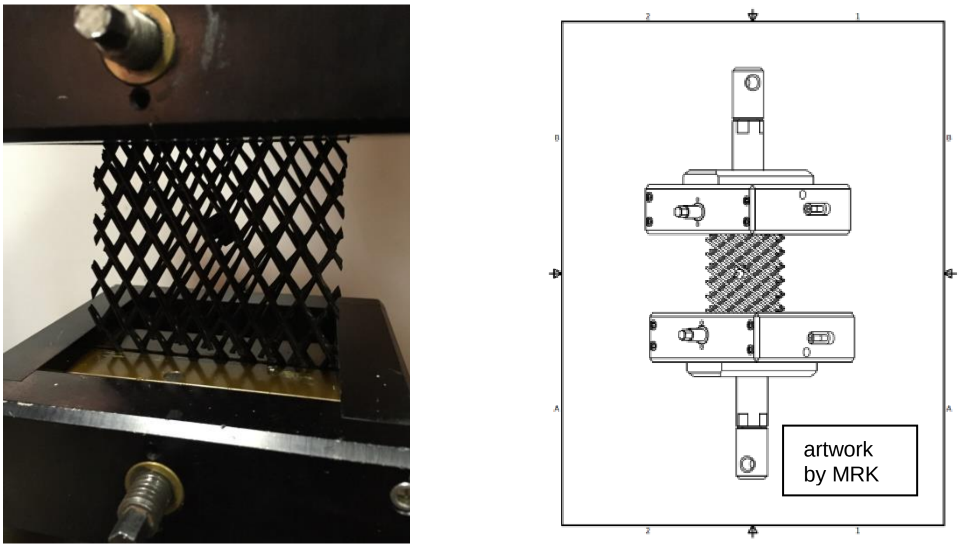
The second part of the laboratory investigation consisted of plastic cable tie joining of two geonet test specimens and then tension testing the complete assemblage. Configurations are shown in Figure 7 and testing details are given in Table 3. The failure mode was generally within the geonet ribs, depending on how many were gripped within the cable tie loop. Some recommendations will follow.

Table 3. Testing details for cable tied geonet specimen strength.

Operation Details	Node or Rib Connections
Gage Length	100 mm
Strain Rate	50 mm/min
Specimen Size	Two 100 × 125 mm rectangular specimens, 100 mm overlap, connected with cable tie at center of specimens
Grip Face Details	Serrated facing of 100 × 25 mm size



(a) Cable tie connecting to geonet node



(b) Cable tie connecting geonet ribs

Figure 7. Various tension tests of joined biplanar geonets.

4 CONCLUSIONS AND RECOMMENDATIONS

Drainage geocomposites, whether geonet or geospacer core related, have completely outmoded the conventional geotechnical practice of using a 300 mm thick sand layer to convey liquid (usually water) from the point of ingress to egress. Every metric conceivable points in this direction, e.g., product availability, ease-of-installation, rapidity of liquid transmission, constructability when in a sloped or vertical orientation and particularly low costs.

The issue of selecting a geonet or geospacer core, and variations within each category, is the duty of the design engineer in light of the site-specific situation. Table 1 presented a qualitative assessment of the two different core types. Obviously, product-specific testing is necessary for the final decision in this regard.

Regarding field performance, there have been several outlet blockages but the products or concept should not be faulted; in all cases it was due to the lack of long-term field maintenance. As with all man-made systems and materials, maintenance for the lifetime of the facility must be assured.

In recognition of the joining of most cores in the field, plastic cable ties are most common. It should be noted that there are a tremendous variety of them that are available. As a result, laboratory testing was conducted on the ties themselves and on geonet test specimens joined with such ties. Some recommendations stemming from these test results are as follows:

- Ties should be around at least two adjacent ribs.
- The tie connection (called the "panduit") should be oriented so that it results in the minimum protrusion above the cores surfaces.
- Tie spacings must follow the installation QA plan; they are usually closer when attaching the ends than when attaching the sides of the drainage cores.

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