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Separation Analyses for Fine Grained Soils with Geogrids:

The purpose of this document is to provide guidance on using geotextile separation with geogrids:

1. **Why use geotextile separation fabrics?**
2. **When should Designers specify geogrids with geotextile separation fabrics?**

Background

In roadway engineering, many define separation as: "*preventing the intermixing (contamination) of two dissimilar* soil *materials*." This is a concern when placing an open-graded sub-base or base aggregate over a fine-grained subgrade soil. The combination of load application (passing vehicles) and subgrade moisture tends to allow the migration of fine soil particles up into the aggregate and aggregate particles down into the sub-grade. This migration leads to a reduced effective thickness for the subbase or base course and reduced drainage. Due to reduced drainage, the contamination process begins to accelerate, and the roadway eventually fails due to lack of sub-base or base aggregate support. Figure 1 illustrates this trend.

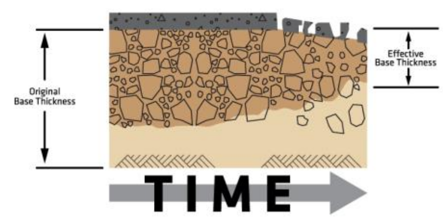

Figure 1

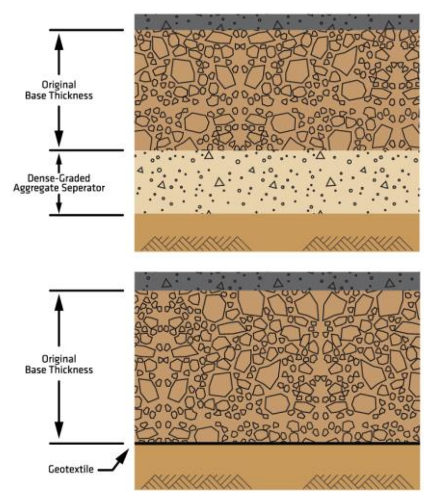

Figure 2

Until the 1970's, engineers and contractors used "dense-graded aggregate separation layers" to prevent the type of contamination, Figure 2. A dense-graded aggregate layer usually consists of 8 (or more) inches of a well-graded (having a broad particle size representation – including 5 to 10 percent fines) granular soil placed between the sub-grade and open-graded aggregate base. Through traditional geotechnical principles, this "separation layer" serves the dual purpose of preventing contamination of the open-graded base (separation) and supplying structural support (acting as the sub-base). However, in the 1970's geosynthetic materials, geotextiles, or filter fabrics, became increasingly popular as an alternative to dense-graded aggregate separation layers, Figure 2. These porous fabrics are durable, easy to install, and inexpensive. In addition, when carefully selected they supply separation characteristics.

Although a carefully selected geotextile provides excellent separation characteristics, it does not provide significant load carrying ability (USAE, 1991). Therefore, the engineer still must design a subbase layer thick enough to carry the required pavement loading. In this case, the geotextile simply becomes an added cost to the pavement section – acting as a good insurance policy against premature failure of the pavement due to contamination.

In the 1980's, this all changed due to the introduction of a new type of geosynthetic – Tensar's geogrids. When placed between a well-graded subbase or base and subgrade, the geogrid/soil system not only supplies separation, but also added load carrying capacity, Figure 3. In other words, the use of geogrids is truly an alternative to dense-graded aggregate separation, not just an insurance policy against contamination. Thus, the engineer can reduce the thickness of the designed pavement section (or increase the service life) without compromising performance.

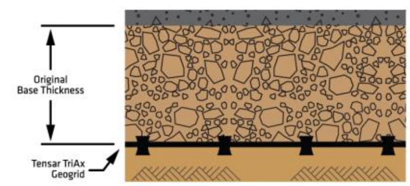

Figure 3

How do Geogrids Separate?

Intuitively, it is easy to understand how geogrids provide stabilization. The stiff, dimensionally stable apertures interlock with overlying sub-base or base aggregate to prevent lateral spreading (confinement) while the in-plane stiffness of the material efficiently distributes loading over a larger area of the subgrade (snow-shoe effect). On the other hand, one could argue that the large apertures that interlock so effectively with overlying aggregate would also allow easy passage of fines. This is a sensible argument on the surface. The following paragraphs explore this and other often asked questions about geogrids and separation.

Do geogrids really provide separation?

The answer to this question is simple. Geogrids alone do not provide separation. However, geogrids are part of the soil/geosynthetic system. The fact is when placed at the interface between a fine subgrade and a well-graded sub-base or base material, geogrid in combination with the overlying sub-base or base material provides very effective separation. Through lateral confinement of the overlying aggregate and distribution of loads to the subgrade, geogrids significantly reduce sub-base and base particle movement. Thereby, allowing the well-graded material to act as a natural soil filter – preventing the passage of fines up into the aggregate. In addition, the overlying aggregate cannot migrate down into the subgrade. The result is effective separation.

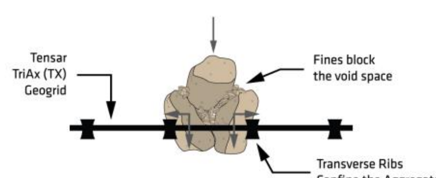

Figure 4

Is a geotextile ever required with a geogrid?

In limited instances, a geogrid will require geotextile separation. This typically occurs when designers require placing an open, poorly graded aggregate over a fine-grained subgrade. In this case, the open-graded aggregate does not have wide enough particle size representation to effectively produce a natural soil filter. Thus, subgrade fines could potentially migrate up into the aggregate void space through the geogrid apertures. Under these circumstances, Tensar suggests placing a medium-weight (4 to 8 ounces per square yard) nonwoven geotextile on top of the fine subgrade – directly beneath the geogrid. This creates a system that will prevent base aggregate contamination and allow for particle interlock with the geogrid.

How can Engineers design using geogrid separation?

In field situations, on-site personnel should use engineering judgement to estimate whether geotextile separation is needed (considering the above discussion). In general, field engineers should consider a separation fabric when:

- Observing free water ***and*** fine-grained materials on the subgrade surface. For example, a saturated clayey soil would require the use of a filter fabric, but a compact clayey material that is not saturated, would **NOT** using filter fabric. Another example would be if the field engineer sees water and coarse grained cohesionless materials on the subgrade surface, this section would not require a geotextile separation fabric because the subgrade is coarse grained.

- Encountering Non-Plastic Silts. If the subgrade material consists of non-plastics silts, wet or dry, the pavement section will require a geotextile separation fabric.

For Engineers designing with geogrids and separation fabrics Tensar suggest following the US Army Corps of Engineers criteria. This criterion has 4 steps to determine if a soil separator will perform effectively

1) Determine the D85, D50, and D15 of materials (i.e. subgrade = DXXsg, and subbase/base = DXXb).

2) Apply the filter criteria equations following the US Army Corps:

Filter Stability Criteria

Equation 1:

$$\frac{D15_b}{D85_{sg}} < 5$$

Equation 2 :

$$\frac{D50_b}{D50_{sg}} < 25,$$

*only critical if the subgrade is silty (i.e. PI<8)

Figure 5

** The U.S. Department of the Army Corp of Engineers (1986), says that if the 15% size of a filter is at least 5 times the 15% size of the protected soil, the filter will be approximately 25 times more permeable than the protected soil. In relation to filter protection, they say filter criteria (in EQ 1 and 2) are applicable to all soils with gradation curves approximately parallel to those for the chosen filter material except for medium to highly plastic (CL to CH) clay soils. Where the gradation curves are not approximately parallel, the filter design is based on filtration tests. For CL and CH soils without sand or silt partings, the 15% size of the filter (EQ 1) may be disregarded. (Cedergren, 1989)*

3) Determine the Plasticity Index (PI) of the subgrade material. If the PI is greater than 8, the pavement section will not require a geotextile separation fabric.

4) Designers do not need to specify geotextile separation if Equation 1 and Equation 2 are satisfied. If the material is clayey then only Equation 1 needs to be satisfied.

Designers rely on this criterion often. Tensar's SpectraPave[TM] Software has a design module to assist in performing filter criteria calculations.

However, any geotechnical text should provide more detailed guidance regarding natural soil filter design. If it is determined that a geotextile filter is required, it is also suggested that the filter be designed based on sound engineering principles such as those outlined by Koerner (1994).

References

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Koerner, R. M., (1994) "Designing with Geosynthetics," Prentice-Hall, Englewood Cliffs, NJ.

Perkins, S.W. (1999) "Geosynthetic Reinforcement of Flexible Pavements: Laboratory Based Pavement Test Sections," Final Report, FHWA/MT-99-001/8138.

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