Geosynthetic-Reinforced Soil Walls and Slopes: Brazilian Perspectives

Benedito de S. Bueno[1]

[1] Department of Geotechnical Engineering, School of Engineering at Sao Carlos, University of Sao Paulo, Brazil, Av. Trabalhador SaoCarlense, 400, 13.566-590 - Sao Carlos, SP, Brazil, PH: (55) 16-3373-9505; fax: (55) 16-3373-9509; e-mail: bsbueno@sc.usp.br

Abstract

This paper presents a summary of recent research results relative to soil reinforcement in Brazil. Initially the historical aspects of geosynthetic application in Brazil are presented and related to the current construction practice. Following, design parameters such as tensile strength, pullout and creep behavior are discussed in the light of the last researches. Finally developments in design methods which consider modern approaches of the interaction soil-inclusion and construction sequence and examples of history cases are presented.

Introduction

In Brazil, in the last two decades, the use of geosynthetics in geotechnical and geoenvironmental problems experienced a marked increase due to its relatively small cost and easy of construction.

Soil reinforcement applications as a whole have also increased despite the fact that a large percentage of Brazilian territory is covered by fine graded soils (% passing sieve 200 > 50%), generally of tropical origin, that could be classified as poor drainage soils. These soils do not attend technical recommendation for backfill of reinforced walls and slopes as required by AASHTO and BS 8006, for example, and constitute a research challenge to Brazilian geotechnical engineers.

A typical soil profile in tropical areas, according to Vargas (1985), consists of a superficial horizon, the mature residual layer, generally of lateritic nature (clay; sandy clay), or sometimes constituted by micaceous silt, and sand or bycolluvial soils that overlay the mature residual soil; an intermediary mantle of hard clays occasionally showing relic structure or sometimes being expansive; and a saprolitic layer consisting of gravelly sand, clayey or sandy soils showing relic structure from parent rocks.

The clay mineral of lateritic soils is manly kaolinite. It may be covered and agglutinated by iron and aluminum hydroxides resulting in particles sizes varying from very small micrometer grains to large aggregates with dimensions of centimeters. In some cases kaolinite may be a secondary mineral with predominance of iron and aluminum hydroxide materials.

Although generally fine and poorly graded materials, if classified according to traditional grain size analysis, lateritic soils are excellent construction materials behaving as if were coarser and well graded soils.

The geotechnical behavior of saprolitic soils depends on physical and mineralogical characteristic of parent rocks and on the degree of weathering. However, if it is properly compacted and surrounded by an efficient drainage system, most saprolitic soils provide a satisfactory mechanical behavior.

Because of the many advantages of reinforced soil over traditional geotechnical solutions and also due to large experience accumulated in working with compacted tropical soils (see, for example, Cruz, 1996), it is natural to expect the extension of this knowledge to the construction of earth reinforced structures in Brazil.

The current design and construction practices of soil reinforcement in Brazil were, therefore, influenced by the excellent mechanical behavior of compacted tropical soils and also by the historical development of geosynthetic industry in the country, where, for example, geotextiles, both woven and non-woven, and geogrids share the Brazilian market as far as soil reinforcement is concerned. However, questions related to the mechanical behavior of the geosynthetic reinforced system such pore pressure developments and soil suction are still not totally resolved.

This paper presents a historical resume of soil reinforcement in Brazil, discusses the most important research contribution of input parameters used in soil reinforced design methods, introduces the Brazilian contribution to the development of design methods and list some of the most important published case histories.

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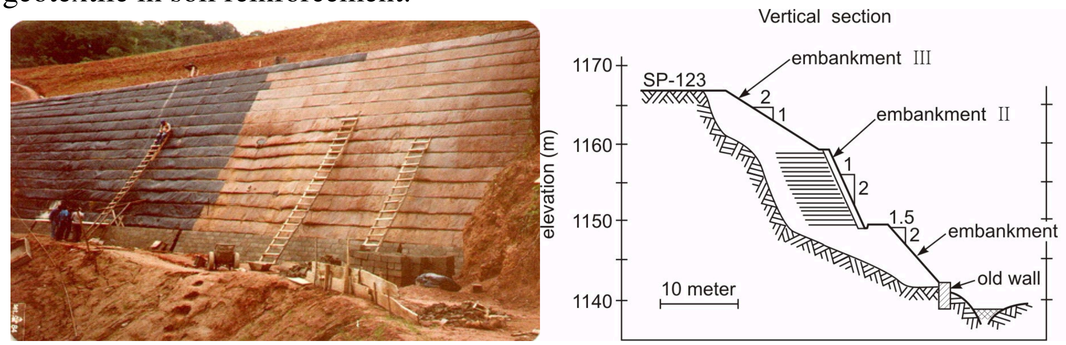
Brief History of Soil Reinforcement in Brazil

Geosynthetics were introduced in Brazil in 1971 with the inauguration of an industrial plant that fabricates non woven needle punched polyester geotextile. In 1980 slit film woven geotextiles also began to be manufactured in the country and this lead to an increase in soil reinforcement works. Although small earth reinforced structures have been built during the first decade (1970-1980), the landmark of geosynthetics soil reinforcement in Brazil is the rebuild of a middle section of a slope of highway SP-123 in Sao Paulo State (Carvalho et al., 1986). This reinforced section was 10m high and presented an average length of 50m. For comparison purpose one half of the reinforced slope was built with non-woven needle punched continuous filament polyester (PET) geotextile and the other half with woven slit film polypropylene (PP) geotextile. Both geotextiles presented ultimate tensile stress of 22kN/m and elongations were 39 and 10% for PET and PP, respectively. The work was fully instrumented with earth pressure cells, piezometers, settlement plates and horizontal displacement transducers. Figure 1a (Maroni, 1999) is a picture of the slope during construction and Figure 1b (Ehrlich et al., 1996) presents a cross section of the central part of the slope showing the reinforced zone (embankment II). The backfill soil was a granite saprolite soil (clayed silty sand with 26% finer than 20μm).

Vertical spacing between geotextile layers, built using wrap around process, was 0.60m and inclusion length reached 7m. Face protection was built after embankment construction with a concrete block wall.

Data from the instrumentation were later reviewed (Ehrlich et al., 1996). The horizontal displacements of the reinforced slope in the non-woven area were smaller than in the woven area, especially near the wall face as shown in Figure 2. This behavior was attributed to the soil confinement and boosted the use of non-woven geotextile in soil reinforcement.



(a) (b)

Figure 1: Reinforced slope of SP-123: (a) front view (Maroni,1999); (b) Cross section details (Ehrlich et al., 1996).

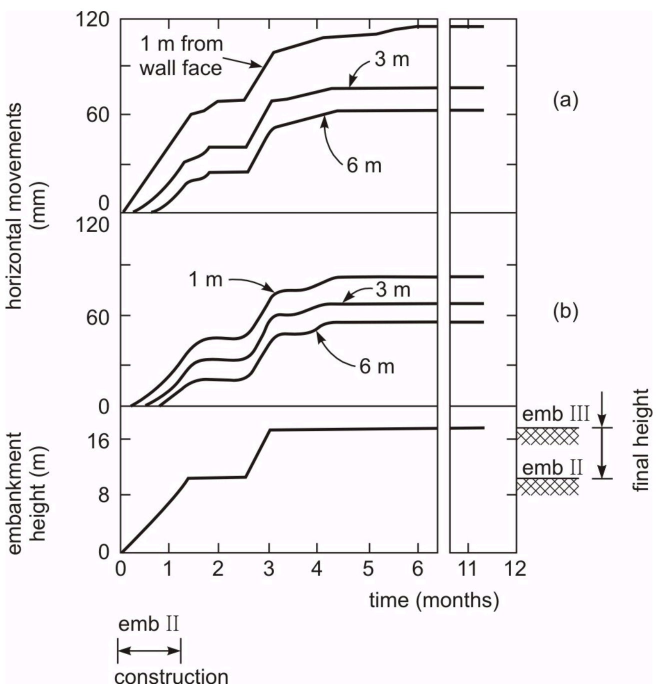


Figure 2: Measured horizontal movements of embankment II (Ehrlich et al., 1996): (a) woven area; (b) non-woven area