SHALLOW FOUNDATIONS ON GEOGRID-REINFORCED SOIL

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The major function of geogrids is reinforcement. Geogrids are used extensively in the backfill of retaining walls, as well as in the construction of slopes and embankments. In the last 10 years, several laboratory studies and a limited number of field studies—including some large-scale field tests at the Federal Highway Administration's Turner-Fairbank Highway Research Center—have shown that layers of geogrids can also be used for soil reinforcement. The result is an improvement in the ultimate and allowable load-bearing capacities of shallow foundations in granular and cohesive soils. Almost all of the exploratory tests conducted to date have been done on footings placed on the surface of the soil (see Figure 1).

Geogrids were first produced in the United Kingdom. In 1982 they were introduced in the United States. Since then, the use of geogrids in various civil engineering construction projects in the United States has grown rapidly.

Geogrids are made of high-modulus polymer materials, such as polypropylene, polyethylene, and polyester. The geogrids discussed here are composed of relatively stiff, net-like materials with apertures that are large enough to allow interlocking with the surrounding soil and rock to provide reinforcement and/or segregation. Commercially available geogrids are generally either uniaxial or biaxial (see Figure 2). The grids used for soil reinforcement usually have apertures that are rectangular or elliptical in shape. All geogrids are manufactured so that the open areas of the grids are greater than 50 percent of the total area.

The increase in soil-bearing capacity provided by geogrids is due primarily to the anchorage developed at the geogrid–soil interface during load application and the decrease in soil compressibility with inclusion of the geogrid reinforcement layers. The anchorage strength (or pullout resistance) results from the contribution of shear strength along the top and bottom longitudinal and transverse ribs, as well as passive resistance against the front of the transverse ribs.

Results of recent studies indicate that several major factors affect the improvement in the bearing capacity of foundations obtained by using geogrid-reinforced soils. These factors include the vertical distance of the first layer of geogrid with respect to the bottom of the foundation, the spacing between consecutive geogrid layers, the width of the geogrid layers, the depth of reinforcement, and the relative compaction of the soil.

In general, for a continuous foundation, a reinforcement depth exceeding about 1.8 to 2.0 times the width of the foundation does not contribute to an increase in bearing capacity. For square foundations, the depth of maximum reinforcement for enhancement of bearing capacity should be approximately equal to the width of the foundation. And

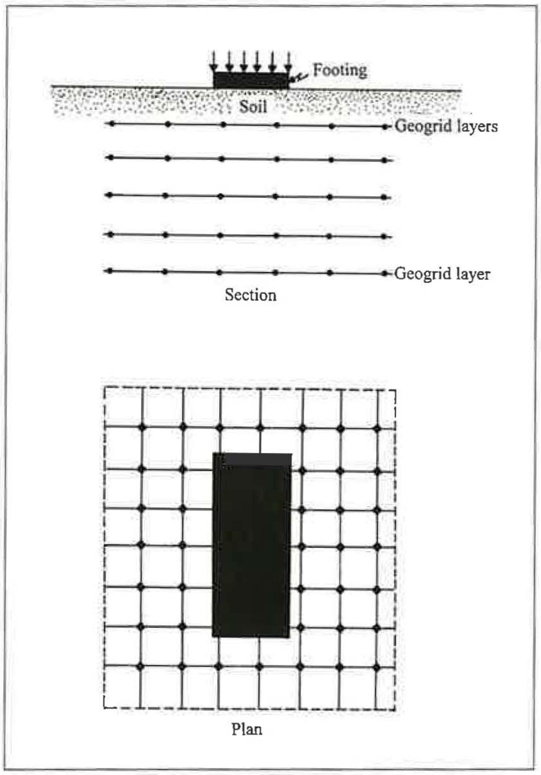
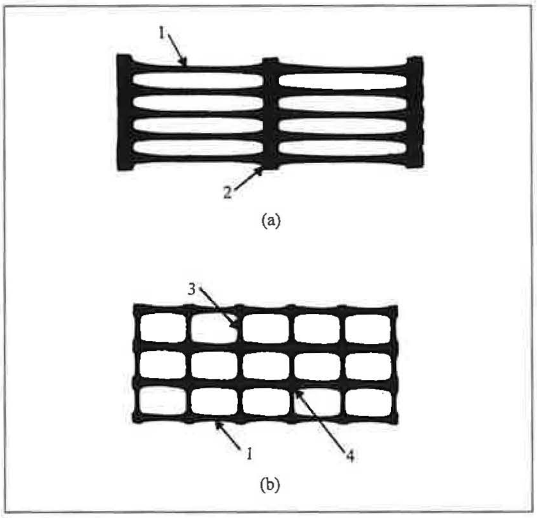


FIGURE 1 Foundation on geogrid-reinforced soil.

FIGURE 2 Geogrids: (*a*) uniaxial; (*b*) biaxial.

NOTE: 1 = longitudinal rib, 2 = transverse bar, 3 = transverse rib, 4 = junction.



most recent studies have revealed that 80 percent of the improvement in bearing capacity may be realized when the width of the geogrid layers is about 2.0 times the foundation width.

In sand with full-depth and full-width geogrid reinforcement, the ultimate bearing capacity of foundations may be 250–350 percent of that obtained without the reinforcement. Often the design of a shallow foundation is based on limited levels of settlement. In these cases, the allowable bearing capacity in reinforced sand may be about 150–250 percent of that obtained with sand with no reinforcement. In reinforced saturated clays, the ultimate and allowable bearing capacity at permissible levels of settlement may be about 150 percent of that derived when the soil is not reinforced.

In addition to the enhancement of static ultimate bearing capacity and allowable bearing capacity at limited levels of settlement, geogrid reinforcement can play a major role in reducing the permanent settlement of shallow foundations subjected to live loads that impart cyclic or impact loading. For example, shallow foundations supporting rotating machines are subjected to cyclic loading, railroad ties transmit cyclic load to the supporting soil when trains pass over them, and foundations supporting hammers are subjected to impact loads of short duration. Such loading can lead to the permanent settlement of shallow foundations. Results of a limited number of recent laboratory tests have shown that settlement of a shallow foundation due to cyclic and impact loading may be reduced by 50–75 percent with full-depth geogrid reinforcement in sand and saturated clay soils.

Further small-scale laboratory and large-scale field tests are necessary to quantify several unknown factors, such as the economical width of geogrid layers, the depth of reinforcement below the bottom of the foundation, and the effect of the depth of embedment of foundations on load-carrying capacity. Results of such tests can be used to support the development of guidelines for the design of shallow foundations on geogrid-reinforced soil.