SUMMARY

In an aspect, the present disclosure refers to a multilayer integral geogrid for interlocking with, stabilizing, and strengthening aggregate, said integral geogrid comprising:

a plurality of layers each of a polymeric material,

with at least a first outer layer and a second outer layer of said plurality of layers having a cellular structure to improve the initial interaction between and compatibility of a soil or aggregate and the integral geogrid to maximize soil or aggregate density and properties after compaction, and

each of the polymeric layers comprising a plurality of interconnected oriented strands and partially oriented junctions forming a repeating pattern of outer hexagons having an array of openings therein,

supporting ribs extending inwardly from each of said outer hexagons to support inside each of said outer hexagons a smaller inner hexagon having an unobstructed, open center and oriented strands and tri-nodes, each of said tri-nodes interconnecting only one of said supporting ribs and two of said oriented strands of the inner hexagon,

said outer hexagons, said supporting ribs and said inner hexagons defining three different geometric configurations which are repeating throughout an entirety of the integral geogrid, and

said oriented strands and said partially oriented junctions of said outer hexagons defining a plurality of linear strands that extend continuously throughout the entirety of the integral geogrid.

In an example, the present disclosure refers to a starting material for making a multilayer integral geogrid, said starting material comprising a multilayer polymer sheet having a plurality of layers each of a polymeric material, with at least a first outer layer and a second outer layer of said plurality of layers having an expansion structure capable of forming a cellular structure in a first outer layer and a second outer layer of the multilayer integral geogrid, the multilayer polymer sheet having holes or depressions therein that provide openings when the sheet is biaxially stretched.

In another aspect, the present disclosure refers to a soil construction comprising a mass of particulate material strengthened by embedding therein a multilayer integral geogrid of the above aspect.

In another aspect, the present disclosure refers to a method of strengthening a mass of particulate material, comprising embedding in the mass of particulate material the multilayer integral geogrid of the above aspect.

In another aspect, the present disclosure refers to a method of making a multilayer integral geogrid for interlocking with, stabilizing, and strengthening a soil or aggregate, said method comprising:

providing a multilayer polymer sheet having a plurality of layers each of a polymeric material, with at least a first outer layer and a second outer

layer of the plurality of layers having an expansion structure capable of forming a cellular structure in the first and second outer layers of the multilayer integral geogrid; providing a patterned plurality of holes or depressions in the multilayer polymer sheet; and biaxially orienting the multilayer polymer sheet having the patterned plurality of holes or depressions therein to provide a plurality of interconnected oriented strands and partially oriented junctions forming a repeating pattern of outer hexagons having an array of openings therein,

supporting ribs extending inwardly from each of the outer hexagons to support inside each of the outer hexagons a smaller inner hexagon having an open center and oriented strands and tri-nodes, each of said tri-nodes interconnecting only one of the supporting ribs and two of the oriented strands of the inner hexagon,

the outer hexagons, the supporting ribs and the inner hexagons defining three different geometric configurations which are repeating throughout an entirety of the integral geogrid, and

the oriented strands and the partially oriented junctions of the outer hexagons defining a plurality of linear strands that extend continuously throughout the entirety of the integral geogrid,

so as to provide the biaxially oriented integral geogrid with at least a first cellular outer layer and a second cellular outer layer configured to improve an initial interaction between, and compatibility of the soil or aggregate

with, the integral geogrid, so as to maximize soil or aggregate density and properties after compaction.

In another aspect, the present disclosure refers to a method of strengthening a mass of particulate material, said method comprising: providing a multilayer integral geogrid having

a plurality of layers each of a polymeric material,

with at least a first outer layer and a second outer layer of said plurality of layers having a cellular structure to improve the initial interaction between and compatibility of a soil or aggregate and the integral geogrid to maximize soil or aggregate density and properties after compaction, and

each of the polymeric layers comprising a plurality of interconnected oriented strands and partially oriented junctions forming a repeating pattern of outer hexagons having an array of openings therein,

supporting ribs extending inwardly from each of said outer hexagons to support inside each of said outer hexagons a smaller inner hexagon having an unobstructed, open center and oriented strands and tri-nodes, each of said tri-nodes interconnecting only one of said supporting ribs and two of said oriented strands of the inner hexagon,

said outer hexagons, said supporting ribs and said inner hexagons defining three different geometric configurations which are repeating throughout an entirety of the integral geogrid, and

said oriented strands and said partially oriented junctions of said outer hexagons defining a plurality of linear strands that extend continuously throughout the entirety of the integral geogrid; and embedding the multilayer integral geogrid in a mass of particulate material.

In another aspect, the present disclosure refers to a multilayer integral geogrid comprising: a plurality of interconnected oriented first strands and partially oriented junctions forming a repeating pattern of outer hexagons having an array of openings therein; supporting ribs extending inwardly from each of said outer hexagons to support inside each of said outer hexagons a smaller inner hexagon having an open center and oriented second strands and tri-nodes, each of said tri-nodes interconnecting only one of said supporting ribs and two of said oriented strands of the inner hexagon, said oriented first strands and said partially oriented junctions of said outer hexagon forming a plurality of linear strands that extend continuously throughout the entirety of the multilayer integral geogrid, said integral geogrid having a plurality of layers each of a polymeric material extending throughout said geogrid, and at least one layer of said plurality of layers having a cellular structure.

The object of the instant disclosure, therefore, is to deliver improved functional performance from multiaxial integral geogrids by enhancing certain physical, mechanical, and geometrical properties of the multiaxial integral geogrid structure that improves functional performance, such as by modifying and/or incorporating other new physical, mechanical, and geometrical properties.

By careful physical positioning and manipulating of the amount of different polymeric materials that have the desired mechanical and physical properties in specific locations of integral geogrid structures, and by optimizing all other physical parameters of the geogrid structure, significant performance improvements can be achieved.

Another object of the instant disclosure is to provide a multilayer integral geogrid in which layers thereof are modified to reduce the amount of polymer required by converting the polymer in those layers from a solid, i.e., continuous, structure to a cellular structure, i.e., a structure having dispersed therein a plurality of voids, cavities, pores, fissures, bubbles, holes, or other types of openings, i.e., cellular openings, produced according to the methods described herein.

More specifically, subsequent to the filing of the '960 application, it has been surprisingly discovered that improved initial compatibility between the aggregate and layers of the multilayer integral geogrid having the cellular structure can be achieved if certain parameters for the layers with the cellular

structure are included in the geogrid, as disclosed herein. These parameters include the following:

1. the minimum rib thickness or height of the multilayer integral geogrid having one or more cellular layers in accordance with the present disclosure is preferably from about 0.5 mm to about 6 mm, and more preferably from about 1.15 mm to about 4 mm.

2. the aspect ratio of the ribs of the multilayer integral geogrid having one or more cellular layers in accordance with the present disclosure is preferably from about 0.75 to about 3.0, and more preferably from about 1 to about 2.

3. the initial height or thickness of the one or more cellular layers at their thinnest height (likely the midpoint of the strands or ribs) after stretching is from about 0.1 mm to about 4 mm, and more preferably from about 0.5 to about 3 mm;

4. the cellular openings of the one or more cellular layers comprise at least 20% by volume of the one or more cellular layers, and preferably from about 30% to about 50%;

5. the one or more cellular layers have a minimum “crushability” or height reduction under load of at least 20% and preferably from about 30% to about 50%; and