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(54) **METHOD AND APPARATUS FOR IMPROVING HEAT STABILITY IN TEMPERATURE-SENSITIVE GEOTECHNICAL APPLICATIONS**

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(57) **ABSTRACT**

A geotechnical application including a geotechnical site having a process area sensitive to temperature. A geosynthetic sheet covers the site process area, wherein the geosynthetic sheet includes an ultraviolet (UV) light stabilizer, is substantially impervious to water, and is at least translucent to light. The geosynthetic sheet prevents heat loss to the air which helps to elevate and/or maintain the temperature of the process area.

# METHOD AND APPARATUS FOR IMPROVING HEAT STABILITY IN TEMPERATURE-SENSITIVE GEOTECHNICAL APPLICATIONS

## CROSS-REFERENCE TO RELATED APPLICATIONS

**[0001]** This is a non-provisional patent application claiming priority to U.S. Provisional Application Ser. No. 61/831,466, filed Jun. 5, 2013, entitled "Method and Apparatus for Improving Heat Stability in Temperature-Sensitive Geotechnical Applications", which is hereby incorporated by reference in its entirety.

## FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

**[0002]** Not Applicable.

## MICROFICHE/COPYRIGHT REFERENCE

**[0003]** Not Applicable.

## FIELD OF THE INVENTION

**[0004]** The present invention relates to temperature-sensitive geotechnical applications, and more particularly to a method and apparatus for improving the thermal stability in such applications.

## BACKGROUND OF THE INVENTION

**[0005]** Efficient geotechnical applications are, of course, important not only to a particular business purpose of an application, but also to the environment. Whatever efficiencies can be provided in such applications are thus important on many levels, and can have worldwide implications. Many such geotechnical applications are temperature-sensitive.

**[0006]** In some instances, temperatures in geotechnical applications are the result of an external process, such as with ponds used to store warm processing water. In such geotechnical systems, the solution will readily cool when exposed to the atmosphere due to heat transfer to the air. Further, evaporation during hot and/or dry months may also cause cooling. Still further, such evaporation may also cause undesirable fluctuations in the concentration of any added materials in the processing water, as may rain during wet periods. Of course, during cool months, the external process may require more energy to provide sufficiently heated processing water, and may even require that the process be halted if sufficiently warm processing water cannot be provided due to the ambient air temperature.

**[0007]** In other geotechnical applications, desired temperatures result from an internal process, such as a chemical or biological reaction. For example, in precious metal mining involving heap leaching, ore containing precious metal is piled on top of geosynthetic materials and then reactive chemicals are trickled through the ore in order to extract the metals. The solution then travels to the bottom of the ore pile where it is harvested. As the reaction proceeds in such applications (which can take months through recirculation of the solution), heat is produced which advantageously raises the temperature of the heap (since the rate of the reaction will typically increase with temperature, the produced heat thereby increases the overall yield of the heap). However, because the heap is exposed to the atmosphere, some of the generated heat is undesirably dissipated due to heat transfer to the air. Also, especially during hot and/or dry months, evaporation of the leaching solution into the atmosphere will occur, thereby causing undesirable fluctuations in concentration of the leaching solution. Further, during wet periods, the leaching solution may be diluted by rain water (thereby decreasing the effectiveness of any concentration-driven reactions) and during cool months, the leaching process may even be required to be halted at times because an effective heap temperature cannot be maintained due to the ambient air temperature.

**[0008]** The present invention is directed to overcoming one or more of the problems set forth above.

## SUMMARY OF THE INVENTION

**[0009]** In one aspect of the present invention, a geotechnical application is provided including a geotechnical site having a process area sensitive to temperature, and a geosynthetic sheet covering the site process area. The geosynthetic sheet includes an ultraviolet (UV) light stabilizer, is substantially impervious to water, and is at least translucent to light.

**[0010]** In one form of this aspect of the present invention, the sheet is linear low density polyethylene (LLDPE). In other forms, as well as LLDPE, the sheet may be one or more of high density polyethylene (HDPE), polypropylene (PP), ethylene propylene diene monomer (EPDM), thermoplastic olefins (TPO), ethylene vinyl acetate (EVA) and/or other thermoplastic materials and their coextruded variations.

**[0011]** In another form of the present invention, the sheet is sufficiently translucent to allow visual inspection of underlying materials in the process site through the sheet, and in a further form the sheet is substantially transparent.

**[0012]** In still another form of the present invention, the UV light stabilizer includes a hindered amine light stabilizer (HALS) formulated to resist extraction/destruction by chemicals used in the geotechnical site process area. Thermal stabilizers are also included to stabilize the geomernbrane under elevated temperatures in addition to providing extended longevity due to the syngergistic effect between the UV stabilizer and the thermal stabilizer. The thermal stabilizers also resist extraction/destruction by chemicals and do not add color/opacity to the geomembrane.

**[0013]** In another aspect of the present invention, a geosynthetic sheet is provided for covering a geotechnical site having a process area sensitive to temperature. The geosynthetic sheet includes an ultraviolet (UV) light stabilizer, is substantially impervious to water, and is at least translucent to light.

**[0014]** In one form of this aspect of the present invention, the sheet is linear low density polyethylene (LLDPE). In other forms, as well as LLDPE, the sheet may be one or more of high density polyethylene (HDPE), polypropylene (PP), ethylene propylene diene monomer (EPDM), thermoplastic olefins (TPG), ethylene vinyl acetate (EVA) and/or other thermoplastic materials and their coextruded variations.

**[0015]** In another form of the present invention, the sheet is sufficiently translucent to allow visual inspection of underlying materials in the process site through the sheet, and in a further form the sheet is substantially transparent.

**[0016]** In still another form of the present invention, the UV light stabilizer includes a hindered amine light stabilizer (HALS) formulated to resist extraction/destruction by chemicals used in the geotechnical site process area.

**[0017]** Other objects, features, and advantages of the invention will become apparent from a review of the entire specification, including the appended claims and drawings.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

**[0018]** In accordance with the present invention, a geosynthetic sheet may be used as a cover for temperature sensitive geotechnical applications, and more specifically as a cover for areas in which a process sensitive to temperatures is desired (such as leaching of precious metal ores).

**[0019]** In one advantageous configuration, the geosynthetic sheet or geomembrane according to the present invention may be generally formed, with certain differences as disclosed herein, of linear low density polyethylene (LLDPE) materials such as heretofore used for geosynthetic products, such as UltraFlex@ textured and smooth geomembranes from GSE Environmental, LLC of Houston, Tex.

**[0020]** The heretofore used GSE UltraFlex® textured geomembrane is a co-extruded textured linear low density polyethylene (LLDPE) geomembrane according to the specifications of Table 1, which meet GRI GM17.

TABLE 1

| | | | Minimum Average Value | | | |
|---|---|---|---|---|---|---|
| Tested Property | Test Method | Frequency | 1.00 mm | 1.50 mm | 2.00 mm | 2.50 mm |
| Thickness, mm | ASTM D 5994 | every roll | 1.00 | 1.50 | 2.00 | 2.50 |
| Lowest individual reading | | | 0.90 | 1.35 | 1.8 | 2.25 |
| Density, g/cm$^3$, (max.) | ASTM D 1505 | 90,000 kg | 0.939 | 0.939 | 0.939 | 0.939 |
| Tensile Properties (each direction) | ASTM D 6693, Type IV | 9,000 kg | 11 | 16 | 21 | 26 |
| Strength at Break, N/mm | Dumbbell, 50 mm/min | | 250 | 250 | 250 | 250 |
| Elongation at Break, % | G.L. 50 mm | | | | | |
| Tear Resistance, N | ASTM D 1004 | 20,000 kg | 100 | 150 | 200 | 250 |
| Puncture Resistance, N | ASTM D 4833 | 20,000 kg | 200 | 300 | 400 | 500 |
| Carbon Black Content, % (Range) | ASTM D 1603/4218 | 9,000 kg | 2.0-3.0 | 2.0-3.0 | 2.0-3.0 | 2.0-3.0 |
| Carbon Black Dispersion | ASTM D 5596 | 20,000 kg | Note(1) | Note(1) | Note(1) | Note(1) |
| Asperity Height, mm | ASTM D 7466 | second roll | .045 | .45 | 0.45 | 0.45 |
| Oxidative Induction Time, min | A5TM D 3895, 200° C.; $O_2$, 1 atm | 90,000 kg | >100 | >100 | >100 | >100 |
| | TYPICAL ROLL DIMENSIONS | | | | | |
| Roll Length, m | Double-Sided Textured | | 213 | 158 | 122 | 100 |
| | Single-Sided Textured | | 236 | 164 | 124 | 100 |
| Roll Width, m | | | 6.86 | 6.86 | 6.86 | 6.86 |
| Roll Area, m$^2$ | Double-Sided Textured | | 1,463 | 1,087 | 836 | 690 |
| | Single-Sided Textured | | 1,619 | 1,125 | 851 | 690 |

Note(1) - Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.

**[0021]** The above described GSE UltraFlex® textured geomembrane has been available with texture on one or both sides, and has been used in applications that require increased frictional resistance, flexibility and elongation properties where differential or localized subgrade settlements may occur such as in landfill closures and mining applications.

**[0022]** The heretofore used GSE UltraFlex® smooth geomembrane is a smooth linear low density polyethylene (LLDPE) geomembrane according to the specifications of Table 2 (which also meet GRI GM17).

TABLE 2

| | | | Minimum Average Value | | | |
|---|---|---|---|---|---|---|
| Tested Property | Test Method | Frequency | 1.00 mm | 1.50 mm | 2.00 mm | 2.50 mm |
| Thickness, mm | ASTM D 5199 | every roll | 1.00 | 1.50 | 2.00 | 2.50 |
| Lowest individual reading | | | 0.90 | 1.35 | 1.8 | 2.25 |
| Density, g/cm$^3$, (max.) | ASTM D 1505 | 90,000 kg | 0.939 | 0.939 | 0.939 | 0.939 |
| Tensile Properties (each direction) | ASTM D 6693, Type IV | 9,000 kg | 27 | 40 | 53 | 66 |
| Strength at Break, N/mm | Dumbbell, 50 mm/min | | 800 | 800 | 800 | 800 |
| Elongation at Break, % | G.L. 50 mm | | | | | |
| Tear Resistance, N | ASTM D 1004 | 20,000 kg | 100 | 150 | 200 | 250 |
| Puncture Resistance, N | ASTM D 4833 | 20,000 kg | 250 | 370 | 500 | 620 |
| Carbon Black Content, % (Range) | ASTM D 1603/4218 | 9,000 kg | 2.0-3.0 | 2.0-3.0 | 2.0-3.0 | 2.0-3.0 |
| Carbon Black Dispersion | ASTM D 5596 | 20,000 kg | Note(1) | Note(1) | Note(1) | Note(1) |
| Oxidative Induction Time, min | A5TM D 3895, 200° C.; $O_2$, 1 atm | 90,000 kg | >100 | >100 | >100 | >100 |

TABLE 2-continued

| Tested Property | Test Method | Frequency | Minimum Average Value 1.00 mm | 1.50 mm | 2.00 mm | 2.50 mm |
|---|---|---|---|---|---|---|
| TYPICAL ROLL DIMENSIONS | | | | | | |
| Roll Length, m | Double-Sided Textured<br>Single-Sided Textured | | 265 | 171 | 131 | 103 |
| Roll Width, m | | | 6.86 | 6.86 | 6.86 | 6.86 |
| Roll Area, $m^2$ | Double-Sided Textured<br>Single-Sided Textured | | 1,819 | 1,171 | 899 | 710 |

Note(1) - Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.

**[0023]** The above described GSE UltraFlex® smooth geomembrane has been used in applications that require increased flexibility and elongation properties where differential or localized subgrade settlements may occur, such as in a landfill closures and mining applications.

**[0024]** As well as LLDPE such as described above, the sheet may alternatively be one or more of high density polyethylene (HDPE), polypropylene (PP), ethylene propylene diene monomer (EPDM), thermoplastic olefins (TPO), ethylene vinyl acetate (EVA) as well as LLDPE and/or other thermoplastic materials and their coextruded variations.

**[0025]** As one difference from sheets such as the above described GSE UltraFlex® textured or smooth geomembranes used in geotechnical applications, the geosynthetic sheet according to the present invention is translucent or transparent (and thus does not include carbon black).

**[0026]** Additionally, an ultraviolet light (UV) additive is included in the geomembrane whereby UV protection may be provided by (and substantially only by) a UV stabilizer. The UV additive may advantageously include a hindered amine light stabilizer (HALS) formulated to resist extraction/destruction by strong chemicals such as expected to be encountered in the temperature-driven process area to be covered by the sheet (e.g., such as concentrated sulfuric acid commonly utilized in copper mines to extract precious metals). HALS further introduces very little color or opacity to the geomembrane so as to not detrimentally impact the desired opacity of the sheet. Thermal stabilizers may also be advantageously included to stabilize the geomembrane under elevated temperatures in addition to providing extended longevity due to a syngergistic effect between the UV stabilizer and the thermal stabilizer. The thermal stabilizers also resist extraction/destruction by chemicals and do not add color/opacity to the geomembrane.

**[0027]** Advantageously, the sheet may have a thickness of about 1.0 mm, although it should be understood that still other thicknesses might be used, with the process area covered by a single layer of sheet. That is, as is known in the geotechnical industry, sheets may be installed to cover large areas by laying out several rolls of material in the field side by side with about 6 inches of overlapping, with the overlap suitably bonded (as by heat welding) to form a closed seam.

**[0028]** Besides LLDPE, still other types of plastic materials might alternatively or in combination be advantageously used to form the geosynthetic sheet to improve the clarity of the geosynthetic sheet, such as high density polyethylene (HDPE), polypropylene (PP), ethylene propylene diene monomer (EPDM), thermoplastic olefins (TPO), ethylene vinyl acetate (EVA) and/or other thermoplastic materials and their coextruded variations. Further, it should be appreciated that various layer configurations within the sheet may be utilized, as well as clarifying agents and other additives, to provide a desired sheet clarity (translucence/transparency) and other properties such as UV stabilization, thermal stabilization, chemical resistance, mechanical properties, and others.

**[0029]** It should be appreciated that by utilizing such geosynthetic sheets to cover temperature sensitive geotechnical applications, heat loss from the underlying materials to the atmosphere can be reduced. Thus, more heat may be retained in the underlying material or liquid, which retained heat will increase the effectiveness of the process occurring therein.

**[0030]** Further, the geosynthetic sheet will reduce the amount of evaporative loss to the atmosphere. In applications that utilize a liquid, preventing the material loss of the liquid is important for maintaining the composition of the liquid (e.g., in heap leach mining applications, retaining the liquid facilitates maintaining a proper chemical concentration in the leaching solution). Still further, in areas having wet seasons and/or heavy rain events, the geosynthetic sheet will prevent water from being undesirably added to the process area, which added water could also cause undesirable dilution.

**[0031]** Still further, use of a geosynthetic sheet as disclosed herein allows the above advantages to be obtained without blocking inspection of the materials, equipment and/or liquids below while the temperature sensitive process takes place, and without exposure to the sun reducing the desired useful life of the sheet.

**1**. A geotechnical application, comprising:

a site having a process area, wherein said process area is temperature sensitive;

a geosynthetic sheet covering said site process area, said geosynthetic sheet including a ultraviolet (UV) light stabilizer and thermal stabilizer and being substantially impervious to water, and

at least translucent to light.

**2**. The geotechnical application of claim **1**, wherein said sheet is linear low density polyethylene (LLDPE).

**3**. The geotechnical application of claim **1**, wherein said sheet one or more of linear low density polyethylene (LLDPE), high density polyethylene (HDPE), polypropylene (PP), ethylene propylene diene monomer (EPDM), thermoplastic olefins (TPO), ethylene vinyl acetate (EVA) and coextrusions thereof.

**4**. The geotechnical application of claim **1**, wherein said sheet reduces heat loss to air at the site.

**5**. The geotechnical application of claim **1**, wherein said sheet is sufficiently translucent to allow visual inspection of underlying materials in said process site through said sheet.

**6**. The geotechnical application of claim **5**, wherein said sheet is substantially transparent.

**7**. The geotechnical application of claim **1**, wherein said UV light stabilizer includes a hindered amine light stabilizer (HALS) formulated to resist extraction/destruction by chemicals used in the geotechnical site process area.

**8**. A geosynthetic sheet for covering a geotechnical site having a temperature sensitive process area, said sheet including a ultraviolet (UV) light stabilizer and being

substantially impervious to water, and

at least translucent to light.

**9**. The geosynthetic sheet of claim **8**, wherein said sheet is linear low density polyethylene (LLDPE).

**10**. The geosynthetic sheet of claim **8**, wherein said sheet one or more of linear low density polyethylene (LLDPE), high density polyethylene (HDPE), polypropylene (PP), ethylene propylene diene monomer (EPDM), thermoplastic olefins (TPC), ethylene vinyl acetate (EVA) and coextrusions thereof.

**11**. The geosynthetic sheet of claim **8**, wherein said sheet reduces heat loss to air at the site.

**12**. The geosynthetic sheet of claim **8**, wherein said sheet is sufficiently translucent to allow visual inspection through said sheet of underlying materials.

**13**. The geosynthetic sheet of claim **12**, wherein said sheet is substantially transparent.

**14**. The geosynthetic sheet of claim **8**, wherein said UV light stabilizer includes a hindered amine light stabilizer (HALS) formulated to resist extraction/destruction by chemicals used in a covered geotechnical site process area.

**15**. The geosynthetic sheet of claim **8**, wherein said sheet further includes a thermal stabilizer.

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