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(54) **A reinforced soil vegetative wall and method for realizing the same.**

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Description

The present invention relates to a reinforced soil vegetative wall and to a method for realizing the same.

More particularly, the invention relates to a wall of the said type, suitable for creating more or less steep walls or embankments where it is necessary to reinforce the structure of the soil within the full respect of the characteristics of the landscape.

As is known, this type of reinforcements are necessary, in particular, in proximity to realizations of motorways, roads generally, railways and the like.

It is likewise known that one tries more and more to safeguard the impact that this type of realizations has on the landscape.

Many of the solutions suggested in the past provided reinforcements mainly realized in reinforced concrete or the like.

These solutions, if on a hand were able to constitute a good solution to the specified problem of the reinforcement of the soil, on the other hand went to make the situation considerably worse from the viewpoint of the landscape, a situation already ruined enough by the road and/or railway realized structure.

In successive times, just to obviate this drawback, solutions have been suggested that provide the utilization of the soil bottom as a carrier material and the employment of geotextile materials to realize the structure and allow the turning green of the wall.

Among the various suggested solutions there is that disclosed in EP-A-197 000, of the Fritz Landolt AG.

In said patent an arrangement is claimed of the realization of a turned green steep escarp of the type that provides, according to already known techniques, several support grids, having two substantially parallel horizontal walls and a front wall covered by an insert in a geotextile material.

The innovatory characteristics described in said patent consist in the fact that the front walls of the support grids have an inclination corresponding to that of the steep escarp, in the fact that among the superposed support grids reinforcement members in a geotextile material are arranged, fixed by fasteners, and in the fact that said reinforcement members cover the inserts in correspondence with the horizontal walls of the grids.

Moreover, a turning green of the front wall of the grids is provided.

Moreover, a process is disclosed for realizing the said arrangement that provides the realization of a support floor; the arrangement of a first reinforcement thereon; the incorporation of a support grid with the geotextile insert already coupled; the introduction of soil into the grid, compacting it; the realization of another support floor to execute the preceding stages again, and the turning green of the escarp.

It is to be pointed out first of all that geotextiles are made up of very flexible threads and that the junctions of the threads in the knots are not perfectly connected.

The structure described in said patent turns out to be very complex in that it provides, besides the geotextile material, a reinforcement indispensable to be able to obtain the necessary strength characteristics.

Moreover, besides requiring the employment of filler soil with particular characteristics, it provides the turning green, and therefore the sowing in situ.

In Polymer Grid Reinforcement, Thomas TELFORD LTD, London/ 1985, a vegetative wall is described having the features included in the preamble of claim 1.

The Applicant with the solution suggested according to the present invention, intends obviating all the mentioned drawbacks realizing a vegetative wall having a very simple structure, that allows the realization of efficacious anchorages with a reduced length, without having to employ external reinforcements.

Indeed, the vegetative wall according to the present invention ensures a staticity equal to that deriving from the structures in concrete.

These and other results are obtained by a vegetative wall having the features recited in claim 1.

This type of solution combines the strength typical of two different materials: the soil and the extruded geogrid.

A comparatively great amount of the cheaper and more resistant to compression - soil - is improved in its strength characteristics by the combination with a comparatively small amount of a more costly and much more traction stress resistant material, such as the extruded geogrid.

A synergy is so realized between the strength to compression and to traction of the two materials, which improves the global characteristics of the composite material, as occurs with concrete and steel.

The extruded geogrid, in a plastic material, will have, preferably, openings with a maximum size between 7 and 16 cm and an empty area greater than the 50% of the total.

Said presown biomat, in a long decay nonwoven fabric, preferably will have the following features:

- weight: 750±5% g/m ^{2};
- composition:

vegetable fibres and cellulose	85% by wt.

fertilizer	3% by wt.
water holder	5% by wt.
blend of seeds	7% by wt.

It is a further object of the invention a process for the realization of a vegetative wall according to claim 4, which provides the stages of:

- breaking digging of the embankment which it is intervened upon, thath ensures the minimum project depth;
- distributing and rolling an inert material to a thickness of 15 to 20 cm at the base of the breaking;
- erecting a temporery front caisson work, with a containment function, inclined according to the project data;
- tentering the extruded geogrid onto all the precedently tamped inert material, for such a length as to ensure the successive recovering of the same:
- close contact depositing a presown biomat onto the internal portion of the geogrid that will be folded:
- stratifying the filler material, and carefully roll tamping the same, on the geogrid, with a simultaneous deposition of vegetable soil into the portion of the layer closest to the face itself;
- folding of the geogrid on the filler material, respecting the inclination of the outer face, according to the project calculations and slightly soil filling of the same in the most internal portion in order to close the first horizontal layer;
- depositing a row of scions and/or rhyzomes over the previously folded geogrid, in the most external portion;
- realizing the second layer with the deposition of the geogrid and then execution of the preceding stages up to the project height.

Now the present invention will be disclosed according to its preferred embodiments, with particular reference to the figures of the annexed drawings, in which:

Figure 1 is a vertical section view of a vegetative wall according to the invention;

Figure 2 shows a detail of the wall of Figure 1;

Figure 3 shows, in axonometry, the detail relevant to the extruded geogrid, with the presown biomat applied.

With reference now to the annexed drawings, it can be seen that the vegetative wall 1 in reinforced soil according to the invention comprises a series of superposed horizontal layers 2, each one made up of an extruded geogrid 3, upon which a presown biomat 4 is arranged.

After having carried out the breaking digging of the embankment which it is to be so intervened, as to ensure the minimum project depth, an inert material layer 5 of about 15 to 20 cm is distributed onto the base.

A temporarary front caisson work, not shown, is then erected and the geogrid 3 is tentered on the inert material 5, so as to recover it for all the length and the presown biomat 4 is internally deposited onto the same geogrid 3.

Then one stratifies the filter material 6, carefully tamped, onto the geogrid 3 and, simultaneously, a certain amount of vegetable soil 7, in the front portion of the layer 2.

At this point the geogrid 3 is bent onto itself, respecting the slope of the external face, so closing the first horizontal layer 2.

Over the geogrid 3 a row of rhizomes or scions is arranged and then the sucessive layers are analogously realized.

The thickness of each layer 2, and therefore the filler material amount to be utilized will be everytime calculated as a function of the characteristics of the slope and of the soil.

The extruded geogrid 3, in a plastic material, is a particular plane structure made up of a regular arrangement of members resistant to traction, which structure is endowed with openings of a size sufficient to allow the jointing of the surrounding soil, so as to accomplish the functions of reinforcement and/or separation.

An extruded geogrid 3 is dimensionally stable, with rigid threads and fixed joints, and this ensures the integrity of the structure and of the geometry of the grid 3 during the laying and the tamping of the soil.

As regards the geometry, the geogrids 3 most used by far have openings with a maximum size comprised between 7 and 16 cm, and an empty area greater than the 50% of the total.

As regards the dimensional stability, it is to be recalled that the resistance capacity of the geogrid 3 is "utilized" at the moment in which the soil particles push jointing themselves between the longitudinal loop members; the latter transfer the stress, through the junctions, to the adjacent transverse members, which resist to the traction stress.

The transfer of the load through the junctions is the mechanism by which the geogrid 3 causes the reinforcement action in the surrounding soil.

Not at the end, the extruded geogrid 3, compared with the traditional geotextiles, has shown that: it reacts

well to "creep" - a strain under load in time - a phenomenon to which traditional geotextiles, for which, as already mentioned, it is necessary to provide strengthening reinforcements (electrowelded nets; iron rods; tie rods), are on the contrary subject; and it possesses a high resistance to both chemical and physiical agents, such that practically it can be considered very durable in time.

The choice of the type and of the amount of geogrid 3 to be utilized is a function of the characteristics of the soil and of the characteristics of the slope.

Among the first characteristics the inner friction angle and the specific weight of the filler soil 6 assumes a peculiar importance; among the characteristics of the slope the height of the slope, the angle of inclination of the outer face, the breaking depth, the overload, etc., are pointed out.

The filler material 6 of the layers formed by the geogrid 3 can be of the most different types and even possess poor geomechanical characteristics (Fig. 1 and Fig. 2).

This means a great advantage, as is apparent, because it allows the utilization, as the building material, a great portion of that actually present in situ.

Only in particular cases it is timely to correct the composition of the soil with sand and/or an inert material.

The biomat 4 is made up of a long decay nonwoven fabric mat, comprised of biodegradable fibres made cohesive mechanically by stretching, without employing bonding agents or sizes or sewings, and/or of filaments and a plastics net (Fig. 2).

Moreover, the aforesaid material possesses the following characteristics:

- weight: 750± g/m^2
- composition:

vegetable fibres and cellulose	85% by wt.
fertilizer	3% by wt.
water holder	5% by wt.
blend of seeds	7% by wt.

The choice of the seeds to be inserted into the mat 4 is based in particular upon the biotechnical aptitudes of the vegetable.

Euriecal,perennial species, with deep and wide hypogeal apparatuses will be chosen, in order to aggregate the filler material and the geogrids 3 in a compact mass.

The characteristics of the placement station, such as the climate and the autochtonous vegetation, turn out to be not less important for the choice of the vegetable.

In this way, the essences most consonant from both the biotechnical and the phytosociological point of view will be chosen as a function of the location of the vegetative wall.

In a short time, the vegetation will reach an optimum- development and the external face will turn out to be entirely turned green and the various constructive handworks will turn out to be obstructed to the view.

The vegetation, once reached the omeostasis, will be able to live, progress and autonomously reproduce, without any external intervention.

As already mentioned, the outerest portion of the layers 2 will be occupied by vegetable soil 7 (Fig. 2) so as to create the optimum habitability and nutrition conditions for the development of the vegetation.

The easy radication scions or rhyzoms 8, interposed between the layers 2, will ensure, with their developed and deep root apparatus, an aggregation and a further consolidation of the earthy particles, of the filler material 6 and of the geogrid 3 in a stable and compact mass.

In this case also, the essences most consistent from the phytosociological and biotechnical point of view will be chosen, as a function of the placement site.

It turns out apparent, from the above, that the vegetative wall according to the present invention allows a support and consolidation embankment to be realized having even considerable slopes, and therefore reduced depth encumbrances, with a completely turned green outer face.

Moreover, it is possible to employ autochtonous material to fill the layers 2, even if a poor carrying capacity material iis dealt with.

The resulting structure, besides not requiring a further ordinary maintenance, resists seismic stresses, is perfectly draining and is comprised of unalterable materials.

Finally, it involves considerable decreases of labour and furniture costs.

The present invention has been disclosed with specific reference to some its preferred embodiments, but it is to be understood that variations and/or modifications can be made by those skilled in the art, without so departing from the scope of protection of the present invention as defined in the appended claims.

Claims

1. A vegetative wall (1) having a front face included to the horizontal level, said wall being made up of superimposed layers (2), each layer having a front face inclined for an angle corresponding to the slope of the front face, wherein each one of said horizontal layers comprises an extruded geogrid (3) arranged in front of the layers and having upper and lower bent inwards portions; a presown biomat (4) arranged inside said geogrid, at least in correspondance with its front face; vegetable soil (7), arranged in the front zone of the layer, in proximity of the geogrid (3) and of the biomat; and filler material arranged at the rear of said vegetable soil, characterized in that said vegetative wall comprises a plurality of rows of rhyzomes and/or scions, each row being arranged between the outermost portion of the upper bent inwards geogrid portion of each layer and the outermost portion of the lower bent inwards portion of the subsequent superposed layer.

2. A vegetative wall according to Claim 1, characterized in that said extruded geogrid presents openings with a maximum size comprised between 7 and 16 cm and an empty area greater than the 50% of the total.

3. A vegetative wall according to anyone of the preceding claims, characterized in that said presown biomat, in a long decay nonwoven fabric, presents the following characteristics:
   - weight 750±5% g/m^2;
   - composition:

vegetable fibres and cellulose	85% by wt.
fertilizer	3% by wt.
liquid holder	5% by wt.
blend of seeds	7% by wt.

4. A method for the realization of a reinforced soil vegetative wall according to one of the preceding claims, comprising the stages of:
   - breaking digging of the embankment which it is intervened upon, that ensures the minimum project depth;
   - distributing and rolling an inert material to a thickness of 15 to 20 cm at the base of the breaking;
   - erecting a temporary front caisson work, with a containment function, inclined according to the project data;
   - tentering the extruded geogrid onto all the precedently tamped inert material, for such a length as to ensure the successive recovering of the same;
   - close contact depositing a presown biomat onto the internal portion of the geogrid that will be folded;
   - stratifying the filler material, and carefully roll tamping the same, on the geogrid, with a simultaneous deposition of vegetale soil into the portion of the layer closest to the face itself;
   - folding of the geogrid on the filler material, respecting the inclination of the outer face, according to the project calculations and slightly soil filling of the same in the most internal portion in order to close the first horizontal layer;
   - depositing a row of scions and/or rhyzomes over the previously folded geogrid, in the most external portion;
   - realization of the second layer with deposition of the geogrid and then execution of the preceding stages up to the project height.

Patentansprüche

1. Begruenbare verstaerkte Erdwand (1) mit einer gegenueber der Waagerechten geneigten Stirnflaeche, wobei diese Wand aus uebereinander angeordneten Schichten (2) besteht, von ded jede eine, mit einem der Neigung der Stirnflaeche entsprechenden Winkel geneigte Stirnflaeche hat und wobei jede waagerechte Schicht ein fliessgepresstes gegenueber den Schichten angeordnetes und nach innen ausgebonene Ober-und Unterteile anweisendes Geogitter (3) aufweist; mit einer vorgesaeeten und innerhalb des vorgenannten Geogitters mindestens an dessen Stirnflaeche angeordneten Biomatte (4); eine in der Stirnzone der Schicht nahe des Geogitters (3) und der Biomatte (4) angeordnete vegetative Erde (7) und mit einem der vorgenannten vegetative Erde nachgeordneten Fuellstoff, dadurch gekennzeichnet, dass die vegetative Wand mehrere Reihen von Rhizomen und Setzlingen enthaelt, wobei jede Reihe zwischen dem obersten Teil des oberen, nach innen ausgebogenen Geogittersteiles jeder Schicht und dem

aussersten Teil des unteren, nach innen ausgebogenen Teiles der naechsten uebergelagerten Schicht angeordnet ist.

2. Begruenbare Wand nach Anspruch 1, dadurch gekennzeichnet, dass das vorgenannte Geogrill Oeffnungen mit hoechster Grosse von 7 bis 16 cm und leere Flaechenteile, deren Groesse groesser als 50% der gesamten Flaeche ist, aufweist.

3. Begruenbare Wand nach je einem der vorhergehenden Ansprueche, dadurch gekennzeichnet, dass die vorgesaeete Biomatte ein nicht gewebter, lang faulender Stoff ist und folgende Eigenschaften hat:
   - Gewicht 750 ± 5% g/m²;
   - Zusammensetzung:

vegetative Faser und Zellulose	85 Gwt.%
Duengemittel	3 Gwt. %
Fluessigkeitsgehalt	5 Gwt. %
Samengemisch	7 Gwt. %

4. Verfahren zur Herstellung einer begruenbaren verstaerkten Erdwand nach einem der vorhergehenden Anspruechen, welches folgende Verfahrenschritte umfasst:
   - Ausgraben des zu bearbeitenden Auftrags, das kleinste Projekttiefe versichert;
   - Aufbreiten und Einebnen eines inerten Materials bis zu einer Dicke von 15 bis 20cm auf der Eindaemmung basis;
   - Errichtung eines vorlaeufigen Abstuetz-Geruestes, das gemaess dem Projektwerten geneigt ist;
   - Aufstellung des Geogitters auf dem ganzen, vorher eingeebneten inerten Material auf einer zur Auskleidung desselben notwendig Laenge;
   - Anordnung der vorgesaeetigten Biomatte dicht auf dem inneren Teil des einzubiegenden Geogitters;
   - Schichtlagerung des Fuellmaterials und sorgfaeltiges Zusammenpressen desselben mit Walze auf dem Geogitter, mit gleichzeitiger Anordnung der vegetativen Erde auf dem zum Aussenumfang am naehesten liegenden Schichteil;
   - Einbiegung des Geogitters ueber dem Fuellmaterial gemaess der Neigung der Aussenflaeche und den Projektberechnungen und leichtes Einlegen esselben in den innersten Teil, zum Schliessen der ersten waagerechten Schicht;
   - Herstellung der zweiten Schicht durch Auflage des Geogitters und Durchfuehrung des vorher angegebenen Verfahrensschritte bis zur projektmaessig bestimmten Hoehe.

Revendications

1. Mur à planter en terre renforcée, ayant une face frontale inclinée au regard de l'horizontale, realisé par de couches superposées (2), chaque couche ayant une face frontale, inclinée d'un angle correspondant à l'inclinaison de la face frontale du mur, dans lequel chacune desdites couche comprend une geo-grille extrudée (3), placée vis à vis des couches et ayant de parties pliées supérieure et inférieure; une bionatte pre-semée (4) placée dans ladite geo-grille, au moins en correspondance de sa face frontale; terre végétative (7) arrangée dans la zone frontale de la couche, en proximité de la geo-grille (3) et de la bionatte (4); et un matériel de remplissage placé derrière ladite terre végétative, caractérisé en ce que ledit mur végétatif comprend une pluralité de files de rhizomes et/ou de boutures, chacune couche étant placée entre la partie la plus extérieure de la partie supérieure, pliée vers l'intérieur, de la geo-grille de chacune couche et la partie la plus extérieure de la partie inférieure, pliée vers l'intérieur, de la couche superposée suivante.

2. Mur végétatif selon la revendication 1, caractérisé en ce que ladite geo-grille extrudée a de ouvertures de dimension maximum entre 7 et 16 cm et un'air vide plus grand du 50% du total.

3. Mur végétatif selon une quelconque des revendications précédentes, caractérisé en ce que ladite bio-natte presemée, d'étoffe non tissue à longue décadence, present le caractéristiques suivantes:
   - poids 750 ÷ 5% g/m²
   - composition:

fibres vegetales et cellulose	85% en poids
engrais	3% en poids

rétenteur liquid	5% en poids
mélange de graines	7% en poids

4. Procédé pour la réalization d'un mur végétatif en terre renforcée selon une des revendications précédentes, comprenant les phases de:
   - creusage de deblai du remblai à ouvrager, qui assure une profondeur minime du projet;
   - distribution et roulage d'un matériel inerte jusque à un épaisseur de 15 à 20 cm a la base du creusage;
   - éréction d'un platelage frontal provisoire, ayant la function de confinement, incliné selon les donnés du projet;
   - étalement de la geo-grille extrudé sur l'entiere matériel inerte précédemment comprimé, sur un longueur susceptible d'assurer la suivante couverture du même;
   - mise à contact intime de la bio-natte sur la partie entiere de la geo-grille à plier;
   - stratification du matériel de remplissage et compactage à rouleau du même sur la geo-grille, avec la mise contemporaine de terre végétative dans la partie de la couche, la plus voisine à la face même;
   - pliage de la geo-grille sur le matériel de remplissage selon l'inclinaison de la face extérieure et conformément aux calculs du projet et couchage légere du même dans la partie la plus intérieure, afin de fermer la première couche horizontale;
   - mise d'un file de boutures et/ou de rhizones sur la geo-grille précédemment pliée, dans la partie la plus extérieure;
   - réalisation de la deuxième couche avec la mise de la geo-grille et l'exécution suivante des phases précédentes jusqu'a l'hauteur du projet.

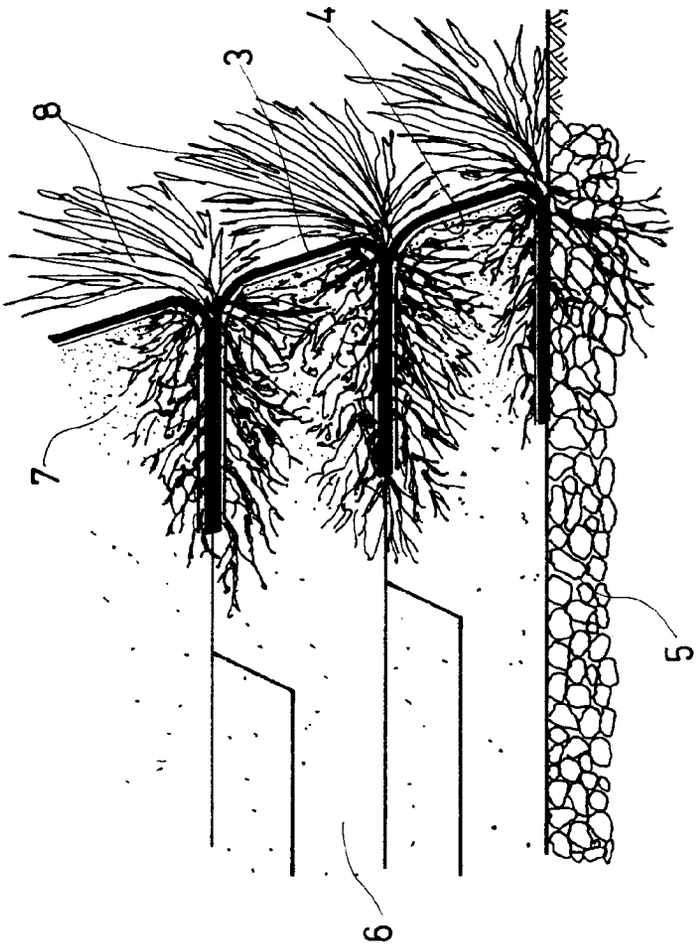

FIG. 2

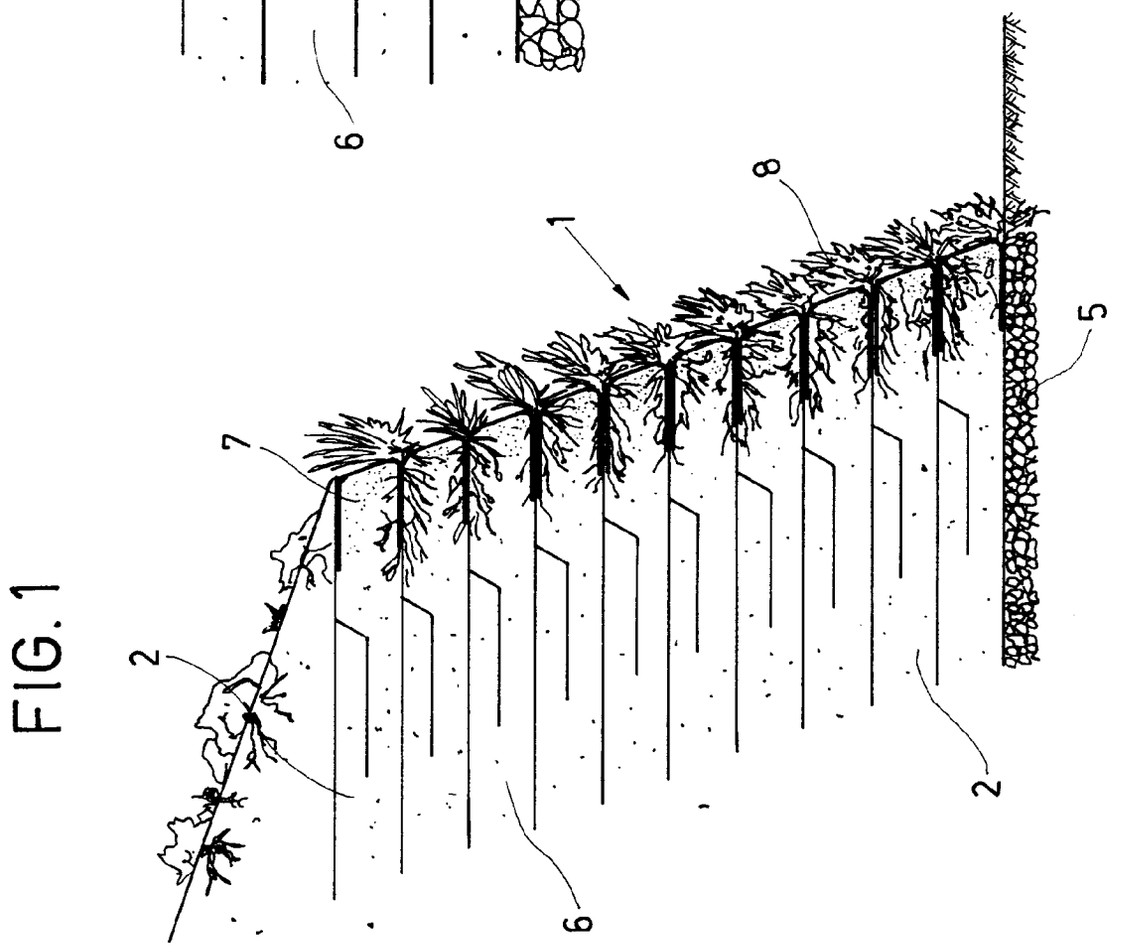

FIG. 1

FIG. 3