

Knitted Geotextiles for Road Reinforcement

Abstract

In this article geotextiles knitted in the form of 3D products composed of knitted bands joined at points to form a cellular net-like configuration are proposed for the reinforcement of roads. As yet, no one has ever succeeded in producing cellular geotextiles with the use of textile machines. However, the technical solution described in this article makes it possible. The technology of manufacturing knitted cellular geotextiles in a single process significantly lowers the costs of production. Moreover, due to higher deformability, knitted cellular geotextiles would be less subject to degradation caused by the aggregate filling the cells of the net.

Key words: knitted geotextiles, cellular geonets, road reinforcement.

The bearing capacity of each layer of the ground forming earthen structures greatly influences road life. One of the many solutions for increasing the bearing capacity of the ground are geosynthetics, used for many years in the form of products made of synthetic plastics that increase the strength of each layer of the road. Among geosynthetics we can find geotextiles produced by techniques used in the textile industry.

The technology of geotextiles is a new field which was created thanks to cooperation between the textile and road sectors. The first use of textile material in roads in Poland was in 1973, which was the stratification of a nonwoven fabric, produced by Austrian company Lins PT Vlies, on a part of the road between Siedlce and Sokółów Podlaski. The first geosynthetics in Poland were produced in the 1980's. In the following years, the demand for these products increased even three-fold. In 1994 the demand for geosynthetics in USA reached over 450 million square meters.

The basic functions of geosynthetics in roadway constructions are the following:

- Separation of each layer of the road structure
- Drainage of water from each layer of the road structure
- Stabilisation of material in individual layers of the road structure.

Beside roadway constructions, geosynthetics are also used in development applications including railroads, airfields, car parks, squares, tunnels, pavements, landfill sites, sports grounds and other structures which require reinforcement. The use of geosynthetics results in an increase in the persistence of a structure, a decrease in the time of building, the saving of traditional building materials, the lowering of the costs of building due to a decrease in the use of traditional building materials, and the lowering of the costs of transport.

Geosynthetics can be divided into the following two groups: a 2D surface and the quite new spatial 3D, which include cellular geonets.

Cellular geonets

As opposed to the two-dimensional nets commonly used, a three-dimensional cellular net (*Figure 1*) has an additional di-

mension G, which is a few centimeters high. Such a net is perfect for the drainage of water from the ground, providing an aggregate placed in the cells of this net, which is unable to move around due to the action of water, and in this way increasing the strength of the asphalt bed-rock of the road.

Geonets also have other applications such as the reinforcement of retaining structures as well as structures made of plastic and concrete.

Cellular geonets currently used are produced by a multi-process technique which includes the preparation of polyethylene bands, the perforation of bands and joining at points to form a net-like system of cells.

Knitted cellular geonets can also be produced using a one-process technique by producing knitted bands on a machine and joining them at points to obtain a net-like system of cells. The machine used to produce knitted geonets can be combined with a device for padding the geonet with resin and stiffening the structure, thereby increasing its strength.

Knitted cellular geonets are more resistant to damage (of their walls) caused by sharp edges of the filling aggregate as knitted fabric is easier to deform than polyethylene films, and thus local pressure of the elements of the aggregate filling the cells of the net would deform the weave structure of the knitted fabrics without breaking the bands of the cellular geonet.

Conception of producing cellular geotextiles

The idea of novel cellular knitted geonets and a device for their production was born at the Department of Knitting Technology of the Technical University of

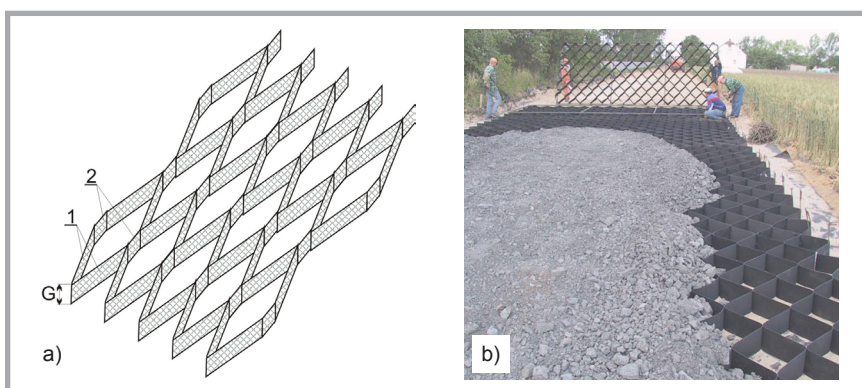


Figure 1. Structure of a cellular geonet (a) and arrangement and filling the net (b).

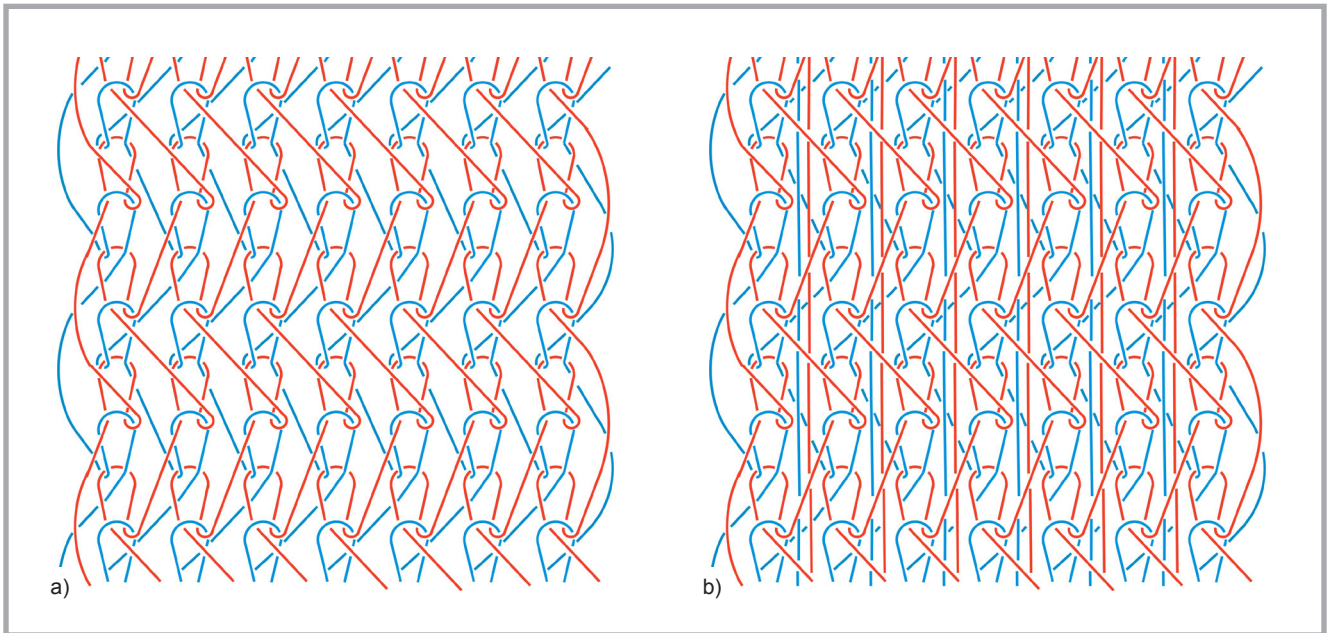


Figure 2. Stitch forming the bands (a) and the knots (b).

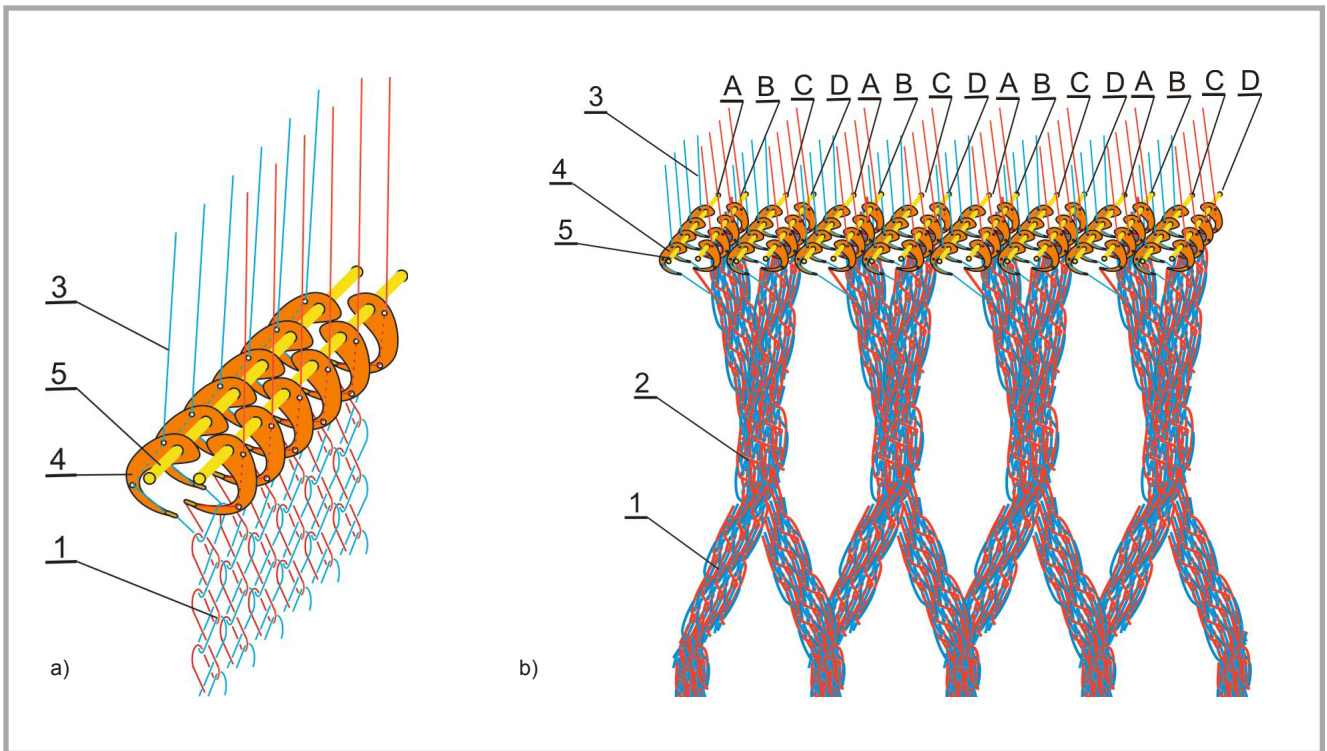


Figure 3. Set of sinkers forming the stitch of the knitted fabric (a) and set of elements forming loops in a device for producing cellular knitted geonets (b).

Łódź, and the patent application has been already submitted [5].

Knitted cellular geonets (**Figure 1.a**) are composed of knitted bands (1) of width G linked to the knitting stitch to create knots (2).

Such a net is produced with the use of a device whose structure is original and not similar to any other device that has been

used so far to produce knitted or woven fabrics.

The knitting stitch (**Figure 2**) used for the bands of the knitted fabric is composed of two sets of threads which form loops alternately at every second row. At the same time the links of the loops are placed on the external layers of the knitted fabric and the loops are joined together at every second course thereof.

Such a stitch has not been known so far as it appeared impossible to form it with any of the knitting machines used previously. The structure of this stitch is the result of an innovative technique for producing three dimensional objects in the form of a cellular net. This technique can be realised only with the use of the device designed by us, which is described in [5]. In order to fulfill its purpose of roadway reinforcement, the cellular knitted net

should be produced from resistant threads, such as polypropylene threads of a thickness reaching a few hundreds of Tex.

Knots (2) of a cellular knitted net are characterised by a stitch similar to that in the bands (1), with the only difference being that between the links of left and right loops, the warp threads are straight (Figure 2.b). The set of sinkers forming the stitch of the knitted fabric (Figure 3) is composed of two rows of sinkers (4) forming loops fixed at equal intervals on the roller (5), placed parallel to each other.

The rollers and sinkers move with a swinging motion along their axis. As a result, the loops form a knitted fabric (1) from threads (3). The sinkers are in the form of bent arms of oval shape and are equipped with guides leading the thread along the sinkers.

The device for producing cellular knitted geonets, presented in Figure 3.b, is composed of sets of sinkers parallel to each other (4), placed on rollers (5), whose axes are perpendicular to the width of the device. The width of the cellular knitted geonet produced depends on the number of roller sets (5) and sinkers (4) placed along the width of the device.

The rollers and sinkers move with a swinging motion around their axis and in a push-pull motion in the direction of their axis. The swinging motion is necessary to form loops of the stitch (Figure 4). The length of the displacement of the rollers in the direction of its axis is a multiplicity of the pitch of the sinkers displaced on the rollers. The value of these displacements decides the length of links joining the loops in a stitch (Figure 2.a).

Bands of knitted fabric, which are elements of the cellular net, are formed using the sets of sinkers AB, CD etc. (Figure 3.b). When bands of a suitable length are formed (1), the sets of sinkers B and C are disengaged by lifting them, and sinkers A and D approach each other and form a knot of the net (2). In the next step bands of the knitted fabric are formed again on the sinkers of sets AB and CD. Another knot is formed on the sets of sinkers C and D, which approach each other, while sets D and A are disengaged. The working cycle described is continued throughout the whole process of forming the cellular net.

Figure 4 presents the action of sinkers during the loop forming process of the knitted fabric.

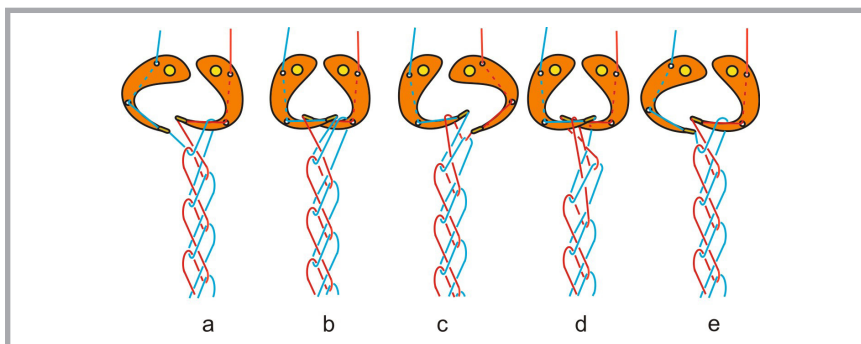


Figure 4. Forming loops of the stitch.

In Figure 4.a, a loop of the weave is hanged on the right sinker. As a result of the swinging motion of the left sinker, the blue thread is introduced by this sinker into the space between the loop on the right sinker and the red thread (Figure 4.b). In the next step, due to the swinging motion, the right sinker drops the loop formed by the blue thread, while on the left sinker a new loop is formed by the red thread (Figure 4.c). Next, due to the swinging motion, the right sinker introduces red thread into the space between the red loop on the left sinker and the blue thread (Figure 4.d). Then, due to the swinging motion of the sinkers, the loop formed by the red thread is dropped, while on the right sinker a new loop is formed by the blue thread (Figure 4.d). The working cycle described is repeated in the next steps of the process of forming a stitch of the knitted fabric. In order to introduce threads into the space between the loop on a sinker and the thread, the sinkers have to be bent so that the top of the sinker is displaced of half size of the pitch of the sinker arrangement (4) on the rollers (5) in comparison with its middle part. Such an effect can also be obtained due to additional displacement of the set of collaborating sinkers of half size pitch of their arrangement along the axis of rollers, when the top of a sinker is introduced into the space between the loop on the opposite sinker and the thread coming out from the top.

The knitted cellular net formed then goes through the finishing process, that is, padding with hardening resins. The process can be performed on a special separate device or on a device combined with the machine forming the net, which is similar to that currently used for two dimensional geonets.

Practical aspects of the conception of producing knitted cellular nets proposed will be further analysed in a scientific research entitled "Cellular geotextiles

for the reinforcement of composites and ground in roadway constructions and a machine for their production" NN 508617240, funded by the Ministry of Science and Higher Education.

Conclusions

1. Knitted cellular geonets can be great competition for similar products made from polyethylene bands.
2. A machine of innovative construction is required to produce knitted cellular geonets.
3. The device proposed in this article enables to produce knitted cellular geonets by single-process technology.
4. Due to the structure and properties of the knitted fabric, it can be predicted that knitted cellular geonets will be great competition for similar products made from polyethylene bands.

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