

PATENT SPECIFICATION

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(54) REINFORCEMENT ELEMENT FOR USE IN STABILISED EARTH STRUCTURES

(71) I, HENRI VIDAL, a French citizen of 8 bis, Boulevard Maillot, 92 Neuilly-sur-seine, France, do hereby declare the invention for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

10 The present invention relates to reinforcement elements for stabilised earth structures.

It is known to provide such elements with improved frictional properties by imparting to the elements a simple roughness obtained by grooves which only slightly increase the coefficient of friction.

An object of the present invention is to provide improved reinforcement elements having an increased frictional contact with the earth.

According to the invention, there is provided a reinforcement element for a stabilised earth structure comprising a substantially flat strip having on one or both of its faces a multiplicity of spaced transverse ribs whose height is of the same order of magnitude as the thickness of the strip the spacing between the ribs being substantially greater than the height thereof.

The spacing between the ribs will preferably exceed 25mm. A mean value of this spacing is for example, about 80 mm.

35 The advantage of reinforcement elements in accordance with the invention is that the adherence between earth and the element is considerably increased by the transverse ribs. It is therefore possible, for a given tensile strength of the reinforcement elements to reduce the width of the latter and correspondingly increase its thickness and thereby increase safety as concerns corrosion. To further resist corrosion, when the material employed is steel,

a surface protection is normally provided, for example by hot galvanization, whenever the reinforcement element is to be incorporated in a definitive structure.

The ribs are preferably rectilinear and perpendicular to the edges of the strip. They may also be oblique or arranged in a chevron or herring-bone pattern. Their pitch may be constant or variable and the ribs may be provided on both faces of the strip with the same pattern of spacing, in which case the ribs of one of the faces may be offset with respect to those of the other face so as to facilitate, if need be, the hot rolling operation.

The end of the reinforcement element which is in use adjacent to the free or outer surface of the stabilised earth structure may be attached to a skin element in the form of a plate, employed for cladding the free surface. This connection may be achieved by making use of the presence of a face free of projections or indentations between two successive ribs by making the end of the reinforcement element coincide with a section of the strip devoid of ribs, in which case the connection can be achieved by means of at least one connecting means, preferably a bolt, which extends through an aperture formed in the end section and through a corresponding aperture in a metal tab which is anchored in the concrete skin element and projects from the rear face of the skin element.

In order to ensure that the aperture(s) do not reduce the tensile strength of the reinforcement element, the end section may be reinforced, for example by means of an attached plate. It is also possible to constitute the end portion of the reinforcement element by a plate which has a thickness which is greater than that of the strip and is welded at the end of the strip or fastened thereto by adhesive. In order

to assemble the end of the reinforcement element with a skin element, it is also possible to take advantage of the presence of ribs on one or both faces of the strip

5 by providing on the tab of the skin element at least one transverse rib against which rib a rib of the reinforcement element is made to abut in the direction of application of the tensile force. In this case, the connecting means, e.g. bolts, are not subjected to shear stress but simply serve to retain the fixing tab and the end portion of the strip in a direction perpendicular to the faces of the latter, so that, if bolts are subjected only to tensile stress owing to the wedge effect of the inclined faces of the ribs. It is advantageous to provide two ribs on the fixing tab of the skin element and associate them with two ribs on the end portion of the strip.

The foregoing concerning the attachment of an end of a reinforcement element to a fixing tab anchored in a skin element, of course also applies to the attachment of adjacent ends of two reinforcement elements.

The invention will be described in detail in the following description with reference to the accompanying drawings showing embodiments of reinforcement elements for stabilised earth structures. In the drawings:

Figure 1 is a longitudinal sectional view of a ribbed reinforcement element having ribs on both faces;

Figure 2 is a cross-sectional view in the region of a section of the reinforcement element devoid of ribs;

Figure 3 is a diagrammatic sectional view showing the interaction between a face of a ribbed reinforcement element and the earth in which the rib is embedded;

Figure 4 is a longitudinal sectional view of a skin element of concrete fixed to the ends of two reinforcement elements;

Figure 5 is a sectional view taken on line 5-5 of Figure 4;

Figure 6 is a sectional view showing diagrammatically the effect of corrosion on the junction between one reinforcement element and two fixing tabs anchored in a skin element;

Figure 7 is a sectional view of the junction between adjacent overlapping end portions of two reinforcement elements with one face of one element being applied against the face of the other;

Figure 8 is a sectional view of the junction between two reinforcement elements disposed in end-to-end relation by means of fish-plates;

Figures 9 and 10 are views of modifications of the profile of the ribs;

Figures 11 to 15 are views of reinforcement elements of rectangular cross section having arrangements of ribs which are different from those shown in Figure 1;

Figure 16 is a view of a reinforcement element having a somewhat elliptical cross section;

Figure 17 is a view of a reinforcement element assembled with a skin element in which ribbed zones alternate with smooth zones;

Figures 18 to 21 are views of reinforced reinforcement element end portions having a punched aperture for the passage of a fixing bolt;

Figure 22 is a plan view of a reinforcement element whose end portion has an aperture located in a widened part of the element so as to avoid decreasing the section of the latter;

Figure 23 is a view of a reinforcement element end portion provided with two apertures for the passage of bolts, and

Figure 24 is a view of a modification of the arrangement shown in Figure 4 in which the skin element has a ribbed fixing tab.

The reinforcement element A_1 shown in Figure 1 comprises a relatively flexible strip 1 which may be for example of hot rolled steel of a rectangular cross section which has on both faces ribs 2 of trapezoidal cross section. On each face of the band, the ribs 2 are spaced apart and define therebetween gaps 3 in which the face of the strip is substantially free of projections or indentations. The pattern of spacing of the ribs on each face of the strip of the same, but the ribs of one of the faces are offset with respect to those of the other face.

In the illustrated embodiment, the pitch of the ribs 2 varies, the successive ribs on one face of the strip being alternately spaced apart a distance d which normally exceeds 25mm (for example 50mm) and a distance $2d$, whereas on the other face every other rib coincides with the middle of each gap d of the first-mentioned face. Transversely of the strip, the section of the ribs 2 may have a slightly curved convex shape as shown in Figure 2.

Figure 3 shows one of the faces of the reinforcement strip 1 embedded in a mass of particulate material 4. The line 6 passes through the tops of the ribs 2 and defines with the ribs volumes of earth 7 which are retained between the ribs. The height h of the ribs 2 is of the same order of magnitude as the thickness of the strip 1. Thus, in respect of a strip whose thickness is 5mm, the ribs may have a height of 3mm.

In Figure 4, two reinforcement strips A_1 are attached to a concrete skin element 8

in a manner disclosed in French Patent No. 2,055,983. In the concrete of the skin element there are embedded two U-shaped members 9 whose branches extend out of the rear face of the skin element and form two parallel tabs 11 which are spaced apart a distance corresponding to the thickness of the strip 1, whose end portion 12, formed by a section of the strip devoid of a rib, is clamped between the two tabs 11 and fixed to the latter by a bolt 13 which is provided with a nut 14 and extends through registering apertures 15, 16 respectively formed in the end portion 12 and the tab 11.

Although the strips are weakened in the region of the aperture 16, the resulting assembly has been found to be satisfactory in use. Tests have shown that in such an assembly, only the uncovered faces are subjected to a corrosive attack as shown at 18 in Figure 6 and the interface between the strip and the tabs 11 undergoes practically no deterioration.

Figure 7 shows the attachment of overlapping face-to-face end portions 12 of two reinforcement elements A_1 also by bolts 13.

Figure 8 shows the attachment of two end portions 12 of two reinforcement elements A_1 disposed in end-to-end relation, by means of two fish-plates 19 between which plates the elements are clamped by two bolts 13.

In Figure 9 and 10, the section of the rib 2 does not have the shape of a symmetrical trapezium as shown in Figure 1, but an asymmetrical trapezium and a symmetrical wave-form respectively.

In Figure 11, the ribs on each face of the reinforcement element A_2 have a constant pitch and an oblique rectilinear disposition, with the ribs of one face being parallel to those of the other face.

In Figure 12, the ribs of the reinforcement element A_2 are in a chevron or herring-bone pattern arrangement.

Figures 13 to 15 show reinforcement elements A_1 , A_2 , A_3 in which the ribs are oblique with opposite orientations on the respective faces.

In the reinforcement element A_1 of Figure 16 the substantially flat strip has in the form of a flattened ellipse, with the ribs 2 of a corresponding curved convex shape.

In the reinforcement element A_2 of Figure 17, regions 21 having a high density of ribs alternate with regions 22 devoid of ribs. The end portion 12 has a smooth face and is fixed to a skin element 8, as in Figure 4, by a bolt 13.

In Figure 18, the end portion of a reinforcement element A_1 is constituted by a plate 23 which has a thickness exceeding

the thickness of the strip 1 and is provided with a punched aperture 16 and is fixed to the end face 1^a of the strip 1 by two weld beads 24. The plate may also be attached to the strip.

In Figure 19, the end portion 12 of the reinforcement element A_1 which is punched at 16, is reinforced by a plate 26 which is welded to the edges of the end portion 12 by two weld beads 27.

In Figures 20 and 21, the end portion 12 of the reinforcement element A_1 is reinforced by two washers 28 which are disposed on each side of the strip and have an annular boss 29 by which boss the two washers are fixed to the end portion 12 by resistance welding, or by adhesion.

In Figure 22, the end portion 12 of the reinforcement element is hot-forged so as to form an aperture 16 which is obtained without reducing the section of the strip. The hot-forging furthermore permits, if desired, the formation of a rib which may be provided on one of the faces of the strip.

Figure 23 corresponds to a modification of the embodiment of Figure 18, in which the end plate 23 has two apertures 16.

Figure 24 is a modification of the embodiment of Figure 4, in which the end portion of the reinforcement element has on its upper face two ribs 2 in contact with two ribs 31 formed on the bottom face of the tab 11 which is anchored in the skin element 9 in such an arrangement that the tensile force exerted on the strip presses the ribs 2 against the ribs 31 so that the bolt 13 which extends through the strip and the tab 11 in the gap between the ribs of each pair, is subjected not to shear stress but only to tensile stress.

It will be understood that the assembly of a reinforcement element with another such element or with a fixing tab anchored in a skin element can be achieved by other methods than by bolting, for example by a pin, stapling-clipping, forming-over etc.

The reinforcement element according to the invention when it is of steel may be employed in the as-rolled condition, if it is to be incorporated in a temporary structure in which corrosion is not to be feared. If it concerns a permanent structure, the element is advantageously protected against corrosion, for example by a hot galvanization by dipping. However, the general shape of the element and the simplicity of the relief formed by the ribs permit effecting such protection in a fully automatic manner. All processes of protection by spraying material may be envisaged, such as metallisation with a gun, by the spraying of molten metal (zinc or other metal) onto the product previously prepared by sanding, painting, coating with tar, enamel-

ling, glazing or vitrification, or coating with resin or plastics material.

It will be understood that the reinforcement elements described may be fixed to a skin element which is not of concrete but is, for example, constituted by a metal section, as disclosed in French Patent No. 1,393,988. Likewise the reinforcement elements may be of any metal or of any other material, such as plastics material, wood, etc.

WHAT I CLAIM IS:—

1. A reinforcement element for a stabilised earth structure comprising a substantially flat strip having on one or both of its faces a multiplicity of spaced transverse ribs whose height is of the same order of magnitude as the thickness of the strip, the spacing between the ribs being substantially greater than the height thereof.

2. A reinforcement element as claimed in claim 1 wherein the spacing of the ribs is at least 25 mm.

3. A reinforcement element as claimed in claim 1 or 2, wherein the ribs are rectangular and perpendicular to the edges of the strip.

4. A reinforcement element as claimed in claim 1 or 2, wherein the ribs are rectangular and oriented obliquely.

5. A reinforcement element as claimed in claim 1 or 2 wherein the ribs are arranged in a herring-bone pattern.

6. A reinforcement element as claimed in any of the preceding claims wherein the ribs have a constant pitch.

7. A reinforcement element as claimed in any of claims 1 to 5 wherein the ribs have a variable pitch.

8. A reinforcement element as claimed in any of the preceding claims wherein the ribs are provided on each face of the strip and the pattern of spacing of the ribs is the same on both faces, with the ribs of one of the faces being offset with respect to the ribs of the other face.

9. A reinforcement element as claimed in any of the preceding claims wherein at least one of the end portions of the element has at least one aperture for fixing the end portion either to another reinforcement element or to a skin element for cladding the structure of stabilised earth.

10. A reinforcement element as claimed in claim 9, wherein the fixing aperture(s) is (are) formed in a section of the reinforcement whose two faces are substantially free of projections or indentations.

11. A reinforcement element as claimed in claim 10, wherein the section in which the fixing aperture(s) is (are) formed in

reinforced by a plate which is welded flat against one of the faces of the section.

13. A reinforcement element as claimed in claim 10, wherein the section in which the fixing aperture(s) is (are) formed is reinforced by two washers welded or stuck to the respective faces of the section.

13. A reinforcement element as claimed in claim 9, wherein the fixing aperture(s) is (are) formed in a widened part of the strip whereby a reduction of the section of the strip is avoided.

14. A reinforcement element as claimed in claim 9, wherein the fixing aperture(s) is (are) formed in a plate which is welded or stuck to an adjacent part of the strip in end-to-end relation thereto.

15. A reinforcement element as claimed in any of the preceding claims, wherein the strip is of substantially rectangular cross-section.

16. A reinforcement element as claimed in any of the preceding claims wherein it is hot-rolled.

17. A reinforcement element for a stabilised structure, substantially as hereinbefore described with reference to and as shown in Fig. 1, or Fig. 2, or Fig. 9 or Fig. 10, or Fig. 11, or Fig. 12 or Fig. 13, or Fig. 14, or Fig. 15, or Fig. 16, or Fig. 17, or Fig. 18, or Fig. 19, or Fig. 20, or Fig. 21, or Fig. 22, or Fig. 23 of the accompanying drawings.

18. An assembly of a reinforcement element according to any of claims 1 to 8, with a generally flat shaped member which is disposed in overlapping relation, or which has an end portion disposed in overlapping relation, with one of the end portions of the reinforcement element for the transmission to the member of the tensile force exerted by the reinforcement element, the member and the reinforcement element being relatively retained positively in a direction perpendicular to the faces of the reinforcement element for example by bolting, wherein the member comprises on at least one of its faces at least one transverse rib against which a rib of the reinforcement element abuts in the direction of the application of tensile force.

19. An assembly as claimed in claim 18, wherein the member constitutes a part of a skin element for the cladding of the stabilised earth structure.

20. An assembly as claimed in claim 18, wherein the member constitutes another reinforcement element similar to the first-mentioned reinforcement element.

21. An assembly of a reinforcement element with another member, substantially as hereinbefore described with re-



ling, glazing or vitrification, or coating with resin or plastics material.

It will be understood that the reinforcement elements described may be fixed to a skin element which is not of concrete but is, for example, constituted by a metal section, as disclosed in French Patent No. 1,393,988. Likewise the reinforcement elements may be of any metal or of any other material, such as plastics material, wood, etc.

WHAT I CLAIM IS:—

1. A reinforcement element for a stabilised earth structure comprising a substantially flat strip having on one or both of its faces a multiplicity of spaced transverse ribs whose height is of the same order of magnitude as the thickness of the strip, the spacing between the ribs being substantially greater than the height thereof.

2. A reinforcement element as claimed in claim 1 wherein the spacing of the ribs is at least 25 mm.

3. A reinforcement element as claimed in claim 1 or 2, wherein the ribs are rectilinear and perpendicular to the edges of the strip.

4. A reinforcement element as claimed in claim 1 or 2, wherein the ribs are rectilinear and oriented obliquely.

5. A reinforcement element as claimed in claim 1 or 2 wherein the ribs are arranged in a herring-bone pattern.

6. A reinforcement element as claimed in any of the preceding claims wherein the ribs have a constant pitch.

7. A reinforcement element as claimed in any of claims 1 to 5 wherein the ribs have a variable pitch.

8. A reinforcement element as claimed in any of the preceding claims wherein the ribs are provided on each face of the strip and the pattern of spacing of the ribs is the same on both faces, with the ribs of one of the faces being offset with respect to the ribs of the other face.

9. A reinforcement element as claimed in any of the preceding claims wherein at least one of the end portions of the element has at least one aperture for fixing the end portion either to another reinforcement element or to a skin element for cladding the structure of stabilised earth.

10. A reinforcement element as claimed in claim 9, wherein the fixing aperture(s) is (are) formed in a section of the reinforcement whose two faces are substantially free of projections or indentations.

11. A reinforcement element as claimed in claim 10, wherein the section in which the fixing aperture(s) is (are) formed in

reinforced by a plate which is welded flat against one of the faces of the section.

13. A reinforcement element as claimed in claim 10, wherein the section in which the fixing aperture(s) is (are) formed is reinforced by two washers welded or stuck to the respective faces of the section.

13. A reinforcement element as claimed in claim 9, wherein the fixing aperture(s) is (are) formed in a widened part of the strip whereby a reduction of the section of the strip is avoided.

14. A reinforcement element as claimed in claim 9, wherein the fixing aperture(s) is (are) formed in a plate which is welded or stuck to an adjacent part of the strip in end-to-end relation thereto.

15. A reinforcement element as claimed in any of the preceding claims, wherein the strip is of substantially rectangular cross-section.

16. A reinforcement element as claimed in any of the preceding claims wherein it is hot-rolled.

17. A reinforcement element for a stabilised structure, substantially as hereinbefore described with reference to and as shown in Fig. 1, or Fig. 2, or Fig. 9 or Fig. 10, or Fig. 11, or Fig. 12 or Fig. 13, or Fig. 14, or Fig. 15, or Fig. 16, or Fig. 17, or Fig. 18, or Fig. 19, or Fig. 20, or Fig. 21, or Fig. 22, or Fig. 23 of the accompanying drawings.

18. An assembly of a reinforcement element according to any of claims 1 to 8, with a generally flat shaped member which is disposed in overlapping relation, or which has an end portion disposed in overlapping relation, with one of the end portions of the reinforcement element for the transmission to the member of the tensile force exerted by the reinforcement element, the member and the reinforcement element being relatively retained positively in a direction perpendicular to the faces of the reinforcement element for example by bolting, wherein the member comprises on at least one of its faces at least one transverse rib against which rib a rib of the reinforcement element abuts in the direction of the application of tensile force.

19. An assembly as claimed in claim 18, wherein the member constitutes a part of a skin element for the cladding of the stabilised earth structure.

20. An assembly as claimed in claim 18, wherein the member constitutes another reinforcement element similar to the first-mentioned reinforcement element.

21. An assembly of a reinforcement element with another member, substantially as hereinbefore described with re-



ference to and as shown in Fig. 4, or Fig. 6, or Fig. 7, or Fig. 8, or Fig. 24 of the accompanying drawings.

22. A stabilised earth structure including an assembly of reinforcement elements according to any claims 1 to 17.

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