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(54) Stone column sealing plug

(57) In order to reduce the likelihood of water percolation along a ground improvement stone column, a sealing plug (10) is established immediately below or within the column. The sealing material may be a sealing solution, suspension, cementitious grout, chemical grout or other such material. Conveniently, the apparatus (3') used in establishing the compacted stone column incorporates a passageway (11) having an outlet near the lower end thereof from which a sealing material can be discharged to establish the sealing plug (10) at a desired location and usually within the stone aggregate (8) forming the column.

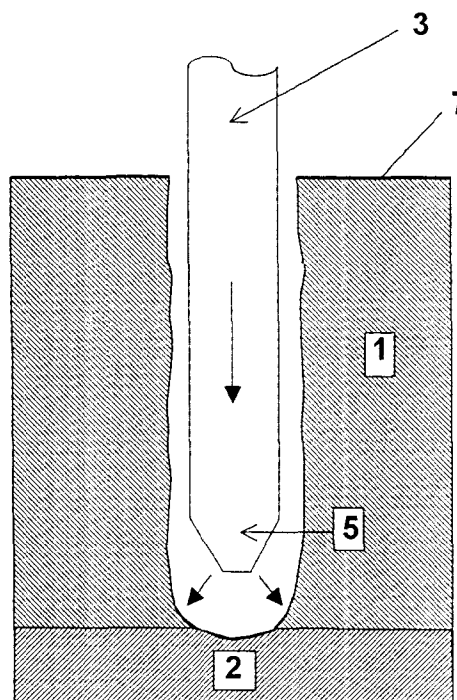


Fig. 1a

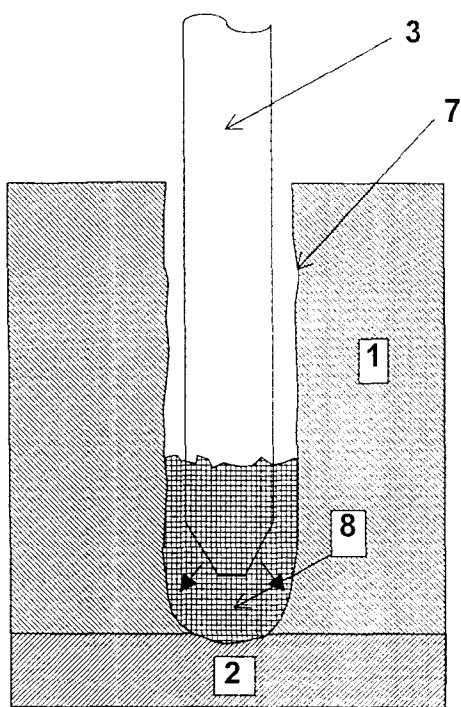


Fig. 1b

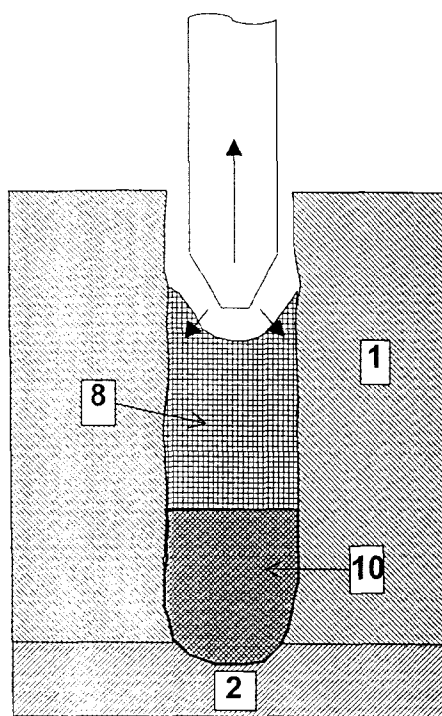


Fig. 1c

Description

The present invention relates to ground improvement techniques utilising stone columns.

The strengthening of a wide range of weak natural soils and fills is well established and several vibratory techniques are known for establishing stone columns. The stone columns are formed utilising materials such as coarse gravel, crushed stone or slag, but more usually will utilise relatively uniformly sized particles of stone - say of the order of 50mm grade. The stone column technique is conventionally employed with cohesive impermeable soils such as silts or clays or other cohesive fills having relatively low permeability.

Because the stone column is formed in material which is relatively impermeable and may extend through it into a underlying aquifer, concern has been expressed that the stone column (which may be more permeable than the material in which is formed) would provide a route by which water can percolate through the stone column into the underlying aquifer and that, as a consequence, there is a possibility of introducing contaminated water into the underlying aquifer, with a consequential increase in contamination, not withstanding that the water may already flow from the relatively impermeable material into the aquifer.

The present invention aims to solve this possible problem.

Accordingly, a first aspect of the invention provides, in association with a ground improving stone column, a sealing plug disposed immediately below or within the column.

The positioning of the sealing plug will be determined by the ground conditions and whilst in the majority of cases it will be established at the bottom of the stone column over a predetermined distance, there may be occasions where it is preferable to establish it intermediate the length of the stone column and more usually in those circumstances at a predetermined depth. Most usually the sealing plug will be established in a bottom portion of the stone column.

Various types of seal material can be employed, for example, sealing solutions or suspensions such as Bentonite (registered trade mark), cementitious grouts, chemical grouts or other such sealing material. The sealing material is conveniently introduced as a slurry, solution or suspension at the desired location. Preferably, the sealing plug is a flexible plug.

Another aspect of the invention provides a method of establishing a ground improving stone column comprising the step of establishing a sealing plug at a desired position within or relative to the stone column.

A further aspect of the invention provides a method of introducing a sealing plug below or within a stone column the method comprising establishing a passageway whose outlet is disposed at the desired location at which the sealing plug is to be established, connecting the passageway to a source of sealing material and causing a

desired quantity of material to be discharged from the outlet to establish the sealing plug.

The sealing material to be discharged is preferably selected from one the above mentioned types of sealing material accordingly to preferences for a flexible, rigid, solution or suspension type sealing material. A particularly convenient way of establishing the passageway to the desired discharge location is to incorporate the passageway into the apparatus which is used to form the hole in which the stone column is established. By this means, on withdrawal of the said apparatus the sealing material can be discharged at the appropriate location.

Accordingly, another aspect of the invention provides apparatus for use in establishing a ground improving stone column, said apparatus comprising a ground penetrating device and incorporating a passageway having an outlet adjacent a lower end of the device from which sealing material can be discharged to establish the sealing plug at a desired location relative to the stone column.

There follows a description of two methods of establishing a stone column using vibratory techniques, although it will be understood that this is not intended to exclude other techniques for establishing a sealing plug in association with a stone column.

The present invention will now be described further, by way of example only, with reference to the accompanying drawings; in which :-

Figures 1a-1c show diagrammatically three steps in the establishment of a stone column, using a vibrator/vibroflot with sealing plug according to one embodiment of the invention,

Figure 2a-2c illustrate diagrammatically three steps in the establishment of a stone column, using a steel casing, with sealing plug according to another embodiment of the invention, and

Figure 3 is a perspective view of part of the apparatus utilised in the embodiment of figures 2a-2c.

Referring firstly to figures 1a-1c, a layer of soil in which one or more stone columns is to be established for ground improvement purposes is illustrated at 1 and an underlying aquifer is shown at 2. A hole forming tool 3 having a vibration generating end formation 5 of known design (such as a vibrator/vibroflot) and not described further hereafter, is suspended by a crane or other support above the selected point where the stone column is to be established. The effect of the weight of the vibrator/vibroflot together with the vibration causes the hole forming device to penetrate into the ground. In the embodiment shown in figure 1, the vibration is generally normal to the axis of the tool thereby generating a hole 7 which is larger than the size of the vibrator/vibroflot. One or more pipes maybe attached to the vibrator/vibroflot or passageways incorporated therein which have their outlet adjacent the end of the tool and by which a source of air or water can be communicated to

the end of the vibrator/vibroflot. The air and/or water is used in certain applications to generate a jetting action and thereby assist penetration of the vibrator/vibroflot.

Once the hole has been established to the desired depth, a quantity of the material 8 which will form the stone column is delivered to the bottom tip of the vibrator/vibroflot by lifting the machine and either tipping aggregate into the hole from the surface or by pipes leading down to the nose either within or attached to the side of the equipment. The bit is then re-inserted and the weight of the device and vibration serves to compact the infill material see Fig. 1b. The radial force produced by the vibrating end formation forces added material horizontally out against the in-situ soil. In establishing a stone column in accordance with current practice when the required degree of compaction has been achieved the vibrator/vibroflot is again removed and a further quantity of filling material introduced and the compacting cycle repeated. See Fig 1c. This is continued until the desired dense column of granular material interlocking with the surrounding ground is formed up to and adjacent the ground surface.

In accordance with the present invention the sealing plug is established in the stone column, and usually this will be established after an initial quantity of infill material has been compacted at the bottom of the column, as illustrated in figure 1b. The desired sealing material is conveniently introduced into the column in a slurry, solution or suspension form by way of one or other of the above described air or water passages or preferably by a passage which is specifically provided for this purpose. The diamond hatching 10 represents the location of the sealing plug. The axial extent of the plug is not shown to scale, being exaggerated for the convenience of illustration.

An alternative method of installing the stone column and the sealing plug is described with reference to figures 2a-2c. In this embodiment the tool 3' comprises a cylindrical or other shaped sleeve which is vibrated, forced or hammered longitudinally into the ground. The material which will form the stone column is introduced into the sleeve which initially protect it from contamination by the external surrounding ground. Once the sleeve has penetrated to the desired depth withdrawal is commenced and this is accompanied by vibration, hammering or ramming to procure compaction of the stone column below the sleeve. Where it is not required to establish a sealing plug then this is continued until the sleeve is removed from the ground. Where a sealing plug is required then a convenient means of introducing the sealing material 8 into the stone column is by way of a passageway 11 formed along the inside of the sleeve. Conveniently small diameter pipes can be fixed on the inside or outside of the sleeve and having their outlets near the bottom of the sleeve to serve as the passageway for the sealing material. Thus when the outlet is at the desired depth then seal material can be introduced into the passageway to emerge from the outlet

and thereby establish the sealing material within the stone column as indicated by diamond hatching in the illustrations of figure 2c. As with the previous mentioned embodiment air and/or water jetting may be employed via for example pipes 12, 13. The pipes provided for this purpose may be utilised for introducing the sealing material or a separate pipe may be employed.

10 Claims

1. In association with the establishment of a ground improving stone column, the improvement comprising the provision of a sealing plug immediately below or within the column.
2. A stone column as claimed in claim 1 in which the material of the sealing plug is one of a sealing solution, suspension, cementitious grout, chemical grout or other material.
3. A method of establishing a ground improving stone column comprising the step of establishing a sealing plug at a desired position within or relative to the stone column.
4. A method of establishing a ground improving stone column as claimed in claim 3, the method comprising creating a ground penetrating hole accommodating infill material and compacting same.
5. A method as claimed in claim 3 or 4 in which the sealing material is introduced as a slurry by way of a passageway forming part of a ground penetrating vibrator, vibroflot or sleeve.
6. Apparatus for use in establishing a ground improving stone column, said apparatus comprising a ground penetrating tool (3) and incorporating a passageway (11) having an outlet adjacent a lower end of the tool from which sealing material can be discharged to establish the sealing plug at a desired location relative to the stone column.
7. Apparatus as claimed in claim 6 in which the ground penetrating tool comprises a hollow sleeve (3') and the passageway comprises a pipe (11) disposed within or outside the sleeve.
8. Apparatus as claimed in claim 6 in which the ground penetrating tool comprises a radial vibration generating member disposed at the end of a longitudinal carrier and further comprising a passageway disposed externally of the carrier.
9. A method of introducing a sealing plug below or within a stone column, the method comprising establishing a passageway whose outlet is disposed

at the desired location at which the sealing plug is to be established, connecting the passageway to a source of sealing material and causing a desired quantity of material to discharge from the outlet to establish a sealing plug.

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10. A method as claimed in claim 9, the method comprising creating a ground penetrating hole of a desired depth and introducing and compacting infill material.

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11. A sealing plug for use in anyone of the preceding claims in which the material of the plug remains flexible.

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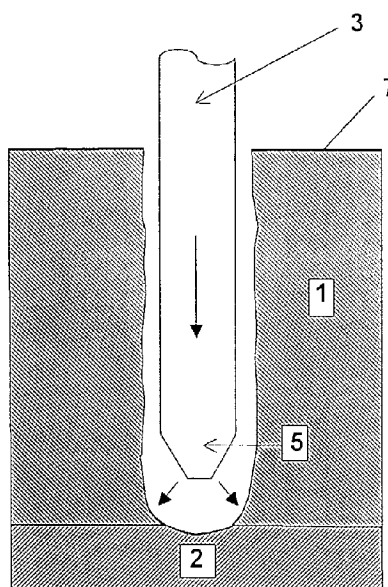


Fig. 1a

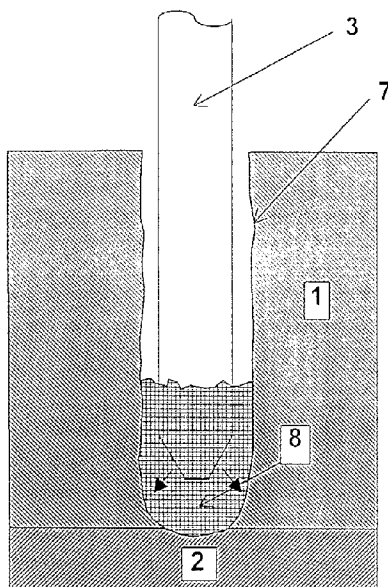


Fig. 1b

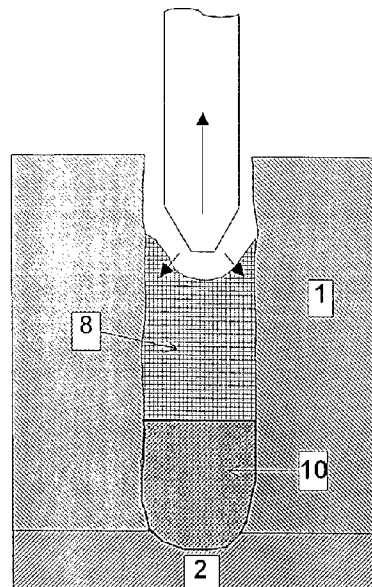


Fig. 1c

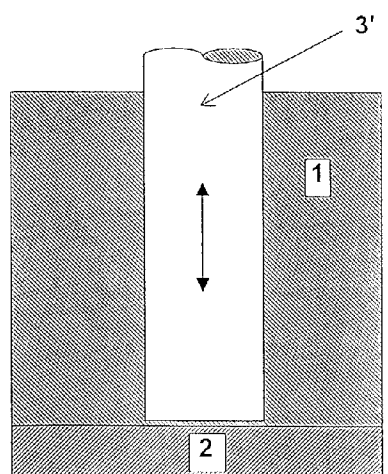


Fig. 2a

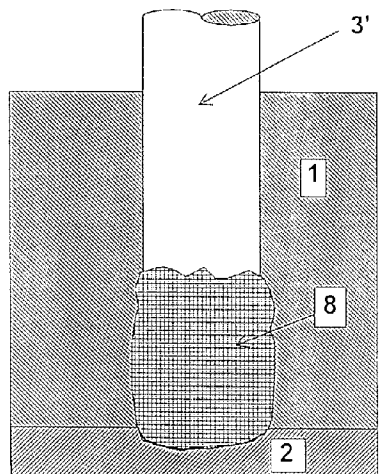


Fig. 2b

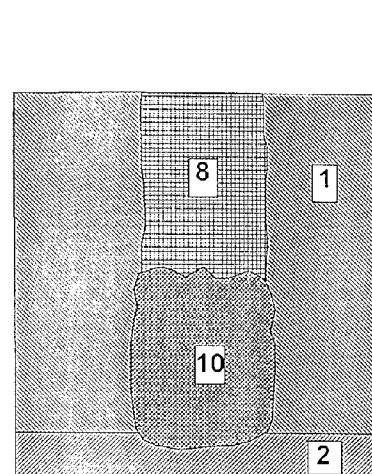


Fig. 2c

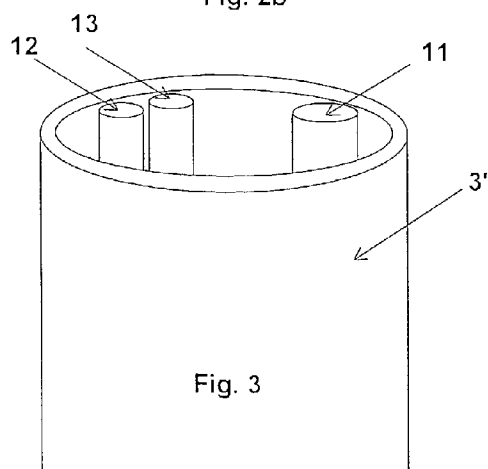


Fig. 3



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EUROPEAN SEARCH REPORT

Application Number
EP 98 30 1730

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	EP 0 608 928 A (VERSTRAETEN FUNDERINGSTECH BV) 3 August 1994 * column 2, line 41 - column 5, line 40; figures 1-3 *	1-3, 5, 9, 11	E02D3/08
A	US 4 126 007 A (MARS BERNARD S) 21 November 1978 * column 4, line 25 - column 6, line 48; figures 1-7 *	1, 3, 6	
A	US 3 793 844 A (CHELMINSKI S) 26 February 1974 * column 3, line 54 - column 11, line 60; figures 1-7 *	1-10	
A	US 3 638 433 A (SHERARD JAMES L) 1 February 1972 * column 37, line 51 - column 39, line 47; figures 15, 20-25 *	1-3	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			E02D E02B
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 2 June 1998	Examiner Tellefsen, J
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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