



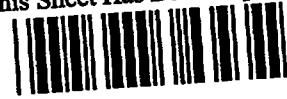
Method for producing underground watertight screens,
and screens thus produced.

Watertight screens of approximately horizontal extension may be
5 produced within the mass of permeable ground by means of two main types of
techniques, injection techniques and rotary jet techniques.

The objective in both cases is the same. It is to fill as closely as
possible the voids existing between the grains making up the ground in question
so as to reduce its porosity and, consequently, to make it watertight. This is
10 obtained by introducing into the ground an exogenous material giving rise to a
setting phenomenon.

For the case of the injection technique, the watertightening material
is introduced under pressure into the ground in question, in a liquid form called
grout (suspension or true liquid) from boreholes, so as to penetrate the existing
15 porosity of the ground until the latter is impregnated in as complete a manner
as possible. With this technique, the existing structure of the ground is
practically preserved.

For the case of the jet technique, the exogenous material or grout is
introduced into the ground in question also from boreholes but in the form of
20 a horizontally oriented jet at high speed which, along its trajectory, destroys the
structure of the ground on the site, and, depending on the nature of the said
ground, either mixes with the elements making up the latter and results, after
setting, in the formation of a soil concrete or mortar (which is the case, for
example, for gravelly or sandy ground), or purely and simply replaces the
25 ground and results, after setting, in the formation of a hardened grout (which is
the case, for example, for clayey ground). The jet, as a function of the flow rate,
of the driving pressure and of the characteristics of the ground, has a certain
radius of action. If the tool for forming the jet is moved in slow
rotation-translation inside the borehole, a more or less cylindrical volume of
30 treated ground is obtained, having as radius the radius of action of the jet under
the conditions in question, and a height corresponding to the amplitude of the
movement of translation.



It is easily understood that it is thus possible to produce, by means of this jet technique, watertight screens of approximately horizontal extension by the juxtaposition of a plurality of cylindrical elements (or columns), of ground thus treated over a certain height, which are produced from a meshwork of substantially vertical parallel boreholes having a density such that the elements or columns intersect each other so as to form a continuous body.

This continuity, which is imperative since the objective is to produce a watertight structure, requires a perfect mastery of all the parameters of construction and, in particular, of the radius of action of the jet, of the accuracy in the layout of the boreholes and of their spatial accuracy in formation (height of the treatment, impacts of the boreholes at the treatment level).

This mastery is difficult to ensure, on the one hand, because of the variability in the radius of action of the jet depending on the ground encountered, but especially, on the other hand, because of the inaccuracy inherent in the formation of treatment boreholes, which inaccuracy becomes greater as the depth of the screen is increased.

All this results in the provision of a density of treatment points and a height of treatment (at least of the order of one metre) which are much greater than would theoretically be necessary.

The invention aims to provide in particular a method for producing, by the rotary jet technique, underground watertight screens of generally approximately horizontal extension, which makes it possible to overcome the difficulties described above and their repercussions on the design, safety and cost of the operation.

More precisely, the invention relates to a method for producing an underground watertight screen extending in a generally horizontal direction, by forming, by means of the rotary jet technique, a plurality of solid unit elements intersecting each other without discontinuity between them, made of a soil concrete or mortar or of a hardened grout of inorganic nature, the said method employing, for the formation of the said elements, at least one jet forming with the horizontal an angle α of between 5 and 60° inclusive.



The invention also relates to an underground watertight screen, extending in a generally horizontal direction, comprising at least one stratum consisting of a plurality of solid unit elements intersecting each other without discontinuity between them and formed by a soil concrete or mortar or of a hardened grout of inorganic nature, the said unit elements having the shape of a cone with a substantially vertical axis and of which the angle at the apex θ is between 60 and 170° inclusive, preferably between 100 and 160°.

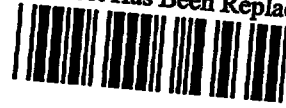
For the implementation of the method of the invention, it is possible to use a jet device comprising a pipe string supplied with grout under a high pressure, intended to be introduced into a borehole and comprising, at its lower part, at least one spray nozzle, the said nozzle forming with the pipe string an angle β of between 30 and 85° inclusive, preferably between 50 and 80° inclusive.

The use of at least one jet inclined with respect to the horizontal results in the formation of a unit element of conical shape, resembling a Chinese hat. Depending on the operating conditions and ground encountered, each elementary cone can have, at its base, a diameter of 0.5 m to several metres.

As a result of the conicity of the unit elements, a unit element will intersect, without discontinuity, with the adjacent unit elements even if a certain offset in level is produced during the formation of these elements. In other words, the method of the invention allows a greater tolerance in the accuracy of the boreholes to be formed.

In addition, since it provides a greater guarantee of continuity, the method of the invention makes it possible to reduce considerably the thickness of the watertight screen. Whereas the prior art required unit elements having a thickness of 1 metre or more to be produced in order to guarantee the continuity and therefore the watertightness of the screen, the present method makes it possible to make do with a thickness of the order of 5 to 100 cm, preferably of 5 to 40 cm, for the elementary cones, which results in savings in time, material and cost which can be considerable.

The jets used for the implementation of the method of the invention can be of all known types, that is to say they can consist of a simple jet of grout



of inorganic nature, or of a jet of grout surrounded by an annular air jet in order to increase its radius of action, or of a combination of a water jet surrounded by an annular air jet for destroying the structure of the ground and of a separate jet of grout, usually provided at a level below that of the water jet.

5 By way of indication, it is possible to use a jet device comprising a plant for producing a cement grout supplying one or more pumps with grout, which pumps are connected, via a rotating joint, to a pipe string introduced into the vertical borehole where the jet treatment is to take place. The pipe string can be driven in translation and rotation by virtue of a hydraulic rotary head
10 clamping the upper end of the pipe string, which is itself mounted on a drilling jar. The pump or pumps deliver the structure-destroying fluid (grout or water) at pressures of the order of 200 to 700 bars or more.

 The pipe string is formed from connectable unit tubular lengths provided with suitable seals and each length can be formed by a single pipe
15 (single jet) or by several coaxial pipes (double or triple jet). The liquids (grout, water) are ejected by one or more nozzles having a diameter of approximately 2 to 4 mm. The lengths of pipe string can have a diameter of approximately 50 to 200 mm.

 It is possible to resort to a device producing a single jet, or two or
20 more jets. In the case of a single jet, it is possible to produce a conical unit element simply by rotating the pipe string introduced into the previously formed borehole while keeping it at a given height. It is also possible to produce a first conical unit element as described above, and then to produce one or more other such elements, superimposed on the preceding one, simply by raising the
25 pipe string in the borehole and restarting the operation for forming the unit cone at the new height reached. The chosen heights can be such that the successive cones produced are separate from one another or are merged in order to form a thicker cone. For the case of the use of a spray device having two jets, these can operate at the same level (2 jets at 180° for example) or at separate levels.
30 These jets can all be oriented upwards or downwards, or one (generally the lower jet) can be oriented downwards and the other (generally the upper jet) can be oriented upwards. It is also possible to use a device simultaneously



generating several jets, for example 3 or 4, as will be obvious to a person skilled in the art. Instead of keeping the jet or jets at a fixed height during the operation, it is also possible to move the tool in a vertical motion over a certain height interval, so as to "thicken" the conical unit element.

5 Depending on the device used and, consequently, the jet configuration produced, it is thus possible to obtain a simple watertight screen, consisting of a single stratum formed by a plurality of cones intersecting each other or a multiple watertight screen formed by two or more superimposed strata each formed by a plurality of cones intersecting each other. The strata can
10 be formed by cones oriented in the same direction, that is to say upwards or downwards, or by cones oriented in opposite directions (a lower stratum being formed for example by cones oriented upwards and another upper stratum being formed by cones oriented downwards). The strata can be spaced apart, be tangent at the location of the apexes of the cones, or mutually intersect each
15 other, as desired.

 The angle β formed by each jet with the vertical, whether this jet is oriented downwards or upwards, must be at most 85° because, beyond this value, elementary cones are obtained which are too flattened and it would not be possible to guarantee their intersection with the adjacent cones. It is not
20 desirable either that the angle β be less than approximately 30° because, below this value, elementary cones are obtained which are too pointed, and which have a small diameter at the base, which would require a considerable increase in the density of the boreholes to be formed for the implementation of the jet technique and would therefore be uneconomical. An angle β of between
25 approximately 50 and 80° is preferred, which corresponds to a conical unit element whose angle at the apex θ goes from 100 to 160° inclusive.

 It is to be noted finally that, if desired, the watertight screen of the invention can be formed by conical unit elements whose angles at the apex θ do not have to be the same everywhere. The angles at the apex can vary from
30 one zone to another in a given stratum and/or vary from one stratum to another.

 The invention will be better understood from the description which will follow, given with reference to the drawings.



Figure 1 is a diagrammatic view in vertical cross-section of an underground watertight screen according to the invention;

Figure 2 is a diagrammatic view along cross-section line II-II of the screen in Figure 1;

5 Figure 3 is a partial diagrammatic cross-section on a larger scale of the screen in Figure 1; and

Figures 4 to 6 illustrate three embodiment variants of the screen according to the invention.

10 Figures 1 and 2 show an underground watertight screen according to the invention which is a raft 1 produced in the ground at the location of excavation to be dug subsequently, but delimited by a wall 2 cast beforehand in the ground. The raft 1 consists of a multiplicity of unit elements 3, of conical shape, which intersect each other, as shown by Figure 2.

15 As illustrated by Figure 3, each unit element is produced by supplying hardenable inorganic grout, under a high pressure, to a pipe string 4 provided at its lower part with a lateral nozzle 5 oriented downwards and introduced into an oversized borehole such as 6, and then by slowly rotating the pipe string 4 about itself while keeping it at a stationary level. The sprayed grout jet 7 destroys the structure of the ground encountered, and either mixes with the elements making up the latter in order to form, after hardening, a soil concrete or mortar 8, or replaces the ground in order to form, after hardening, a
20 hardened grout, depending on the nature of the ground.

Figures 4 to 6 illustrate a few variants in accordance with the invention.

25 In Figure 4, a screen is depicted, formed by two superimposed strata 11 and 12, each formed by a plurality of conical unit elements 3 similar to those in Figures 1-3. Such a screen can be produced simply by forming, from each borehole, a first unit element, and then by slightly raising the conduit 4 in the borehole, a second unit element located above the first one. As a variant, it
30 could be possible to use a pipe string with pipes provided with two nozzles which are spaced apart and kept at a stationary level.



In Figure 5, a watertight screen is depicted, which is formed by two strata 21 and 22 each formed by a plurality of conical unit elements 3, the cones formed from the same borehole being in opposite directions with their apexes contiguous. Such a configuration is easily obtained by using a pipe string
5 which is provided with two nozzles located substantially at the same level but one being directed downwards and the other upwards.

In Figure 6, a watertight screen is depicted, which is similar to that in Figure 5, except for the fact that the apexes of the cones formed from the same borehole are spaced apart instead of being contiguous. Such a configuration is
10 obtained by using a pipe string provided with two nozzles which are spaced apart and superimposed, one being directed downwards and the other upwards.

It goes without saying that the embodiments described are only examples and that it will be possible to modify them, particularly by substitution of technical equivalents, without departing from the scope of the invention.



CLAIMS

- 5 1. An underground watertight screen (1), extending in a generally horizontal direction, characterized in that it comprises at least one stratum consisting of a plurality of solid unit elements (3) intersecting each other without discontinuity between them and formed of a soil concrete or mortar (8) or of a hardened grout of inorganic nature, the said unit elements having the shape of
- 10 a cone with a substantially vertical axis and of which the angle at the apex θ is between 60 and 170° inclusive.
2. Screen according to Claim 1, in which the angle at the apex of the cone is between 100 and 160° inclusive.
3. Screen according to Claim 1, in which the unit cones have their apex
- 15 directed towards the ground surface.
4. Screen according to Claim 1, which comprises a single stratum of unit elements.
5. Screen according to Claim 1, which comprises two strata of unit elements.
- 20 6. Screen according to Claim 1, in which the conical unit elements have a thickness of the order of 5 to 40 cm.
7. A method for producing an underground watertight screen (1) extending in a generally horizontal direction, characterized in that it comprises forming, by means of the rotary jet technique, a plurality of solid unit elements
- 25 (3) intersecting each other without discontinuity between them, made of a soil concrete or mortar (8) or of a hardened grout of inorganic nature, the said method employing, for the formation of the said elements, at least one jet (7) forming with the horizontal an angle α of between 5 and 60° inclusive.
8. Method according to Claim 7, in which the angle α is between 10 and
- 30 40° inclusive.