

SPECIFICATION

A Method of Anchoring Elements in Boreholes and a Device for Use in Carrying Out the Method

5 The present invention relates to a method of anchoring different elements in boreholes. The method according to the invention and the device invented for carrying out the method enables such elements to be fastened with great reliability with an activated binding agent mixture.

10 The anchorage of elements such as reinforcement bolts in, for example, tunnel construction or mining is effected in principally two manners. One method, which can be called a mechanical anchoring, is characterized in that, during anchoring, a portion of the anchoring element is caused to expand in one way or another. The use of special expansion elements which are caused to expand either during the anchorage of the main element or separately as a preliminary step, the main element then being anchored in the expansion elements in any one of various manners, can be included in this category. In mechanical anchorage, the special expansion element or a portion of the main element presses against the material surrounding the element so as to be held there by the frictional forces between the material and the element. The other method of anchoring elements intended for said purposes can be called a chemical anchorage. In this type of anchorage, a more or less viscous or plastic substance is, in one way or another, caused to more or less completely surround the inserted portion of the element. By means of chemical reactions, the substance is then caused to harden and said element is held by the hard body which is formed between the surrounding material and the portion of the element inserted in the same. A more or less accentuated adhesion which actively contributes to holding the element is formed between the substance and said element and between said substance and the surrounding material. One can also distinguish two types of methods in this case as well, one of which is characterized in that the formed substance contains a binder of inorganic origin, the other being characterized in that the binder is of organic origin. The method of mechanically anchoring the element in boreholes can also be combined with chemical anchoring, especially injection of cement mortar.

50 When mechanically embedding elements in holes, it has been found that the method is very unreliable as regards the magnitude of the frictional force arising between the element and the surrounding material. This type of embedment carries the risk that the element will creep in the event of great and/or prolonged stress. In order to reduce said problems, the mechanical anchoring method can be combined with the chemical anchoring method. In such cases, the injection of cement mortar is normally resorted to. In such injection, the used mortar should have a consistency of relatively low viscosity. Despite

65 this, however, one cannot control how large a portion of the element portion inserted in the borehole has actually been embedded therein.

Attempts have been made to solve these problems by means of resorting completely to the chemical method. However, a method other than the injection method has been used in this connection. The binder substance has been introduced into the borehole in the form of different kinds of cartridges.

70 As regards inorganic binders, methods were developed according to which a mortar prepared on the construction site out of the inorganic binder and a filler and including activating liquids, normally water, was filled into cartridges which were then inserted into the borehole, whereupon the element which is to be anchored is inserted into said borehole, the mortar in the cartridge being thereby pressed out of the same and filling the space between the element and the material. This has not been found to be a totally unobjectionable method. This is primarily due to the rather complicated process of introducing finished mortar into the cartridges. According to a proposed method, this problem is solved by means of an ampule-like vessel consisting of a brittle material inside of which water has been enclosed being inserted into a cartridge filled with the binder and filler. During embodiment, a cartridge is inserted into the borehole, after which the element which is to be anchored is inserted. The vessel containing water is thereby crushed, as is the cartridge. The "released" binder mixture and the water shall be mixed together by means of the element being rotated. However, there is one great disadvantage with said process. The mortar which is intended to bond the element to the surrounding material cannot be controlled as regards the quality of the mixing effect. A poorer mixture can entail that a portion of the binder is not supplied with any water at all. This results in that a portion of the binder is not utilized, the rest of the binder receiving an excessive amount of water. The fact that a portion of the binder is not used at all results in less strength than was intended, at the same time as the reacted mortar is of poor strength due to excess water.

According to other proposed methods, substances of partially organic origin are used, i.e. having an artificial resin as binder. Cartridges in which the bonding substance is stored until the cartridge is crushed by the penetrating portion of the element intended for anchorage are used in these methods as well. Methods of this kind differ from each other essentially in the construction of the cartridge containing the binder substance. Generally, when synthetic resins are used as binder, a hardener must be added to the bonding component. According to the different proposals, the hardener can be placed in the center of the cartridge next to the main substance or be placed so that the hardener surrounds the bonding component. According to some methods, the hardener and bonding substance are separated by different kinds of membranes. According to other

methods, the hardener and binder are allowed to react with each other in the boundary surface between the two substances. No matter how the cartridge is constructed, the intention appears to be that the hardener and synthetic resin shall be mixed by means of the element being rotated as it is inserted into the borehole. Even in this case, it will be impossible to control the quality of the hardener and binder mixture. Thus, it is possible that strength will not be as great as intended.

A further disadvantage is that costs for such cartridges are rather high, plus the fact that such cartridges can have a relatively short storage time. This should be especially true as regards cartridges which do not have any special membrane between the synthetic resin and the hardener.

The present invention relates to a method of embedding elements intended for said purpose in surrounding material, said embedment being able to be carried out in a simple but reliable manner. The invention eliminates many of the disadvantages inherent in previously proposed methods. At the same time, the invention offers a flexibility which previous methods have not been able to provide.

According to the present invention, there is provided a method of anchoring elements in rock, concrete and similar material by means of embedding a portion of the element which is to be anchored in a borehole, characterized in that a binder mixture is introduced into the borehole in cartridges provided with a brittle or otherwise yielding rigidifying member, which cartridges, prior to being inserted into the borehole, are immersed in a liquid which activates the binder mixture for a time period of more than 30 seconds, whereby the activating liquid penetrates through a cartridge casing and into the binder mixture so that a substantially fully uniform mixture of the binder mixture and activating liquid is obtained, and in that when the element is inserted into the borehole, the activated binder mixture in the cartridge is pressed out of it simultaneously as the rigidifying member is destroyed or yields in some other manner without giving rise to any spring forces.

The invention also provides a cartridge for use in carrying out the method and which is characterized in that it consists of a casing surrounding the binder mixture and permeable to the activating liquid but impermeable to the binder mixture in the cartridge, and in that the cartridge is provided with a rigidifying member which is destroyed or yields in some other manner without producing any spring forces when the element is inserted into the borehole.

If desired, the binder mixture can include a filler, for example fine-grain sand, silica ash, or fly ash. The cartridge is preferably designed as a cylinder whose both ends are sealed. The binder can consist of hydraulic binder, but other types of binder can be used as well. The binder can also consist of a mixture of different binders, for example hydraulically-bonding agents such as

Portland cement, aluminous cement, or Keene's cement.

The casing of the cartridge consists of a material which is liquid-permeable, for example so-called wet-strength paper, perforated plastic material or the like, said material not being permeable to the binder mixture stored in the cartridge. In order to achieve good manageability, the cartridge should be rigid. This is achieved by means of the cartridge being provided with a rigidifying member being rigid but brittle or otherwise capable of yielding without generating any spring forces. The rigidifying member can, for example, consist of plastics material such as unsoftened styrene plastics as well as glass or other similar material. The rigidifying member can consist of netting, longitudinal rods connected by means of rings of the same material, or the like. The rigidifying member can be arranged so that it surrounds the binding mixture and lies immediately within the casing of the cartridge, so that it is placed inside the casing surrounded by the binder substance, or it can be incorporated in the casing of the cartridge.

The above-described cartridge is used when embedding elements intended for said purpose, said cartridge being placed in a binder-activating liquid if the binder consists of a hydraulically-bonding mixture such as water. The cartridge shall be stored in the activating liquid for a period of more than 30 seconds. During said period of time, the activating liquid is absorbed into the cartridge and into the binder substance. After said time period, the cartridge is removed from the liquid and, together with the required number of other cartridges treated in said manner, is inserted into the borehole, whereupon the element which is to be embedded in the borehole is inserted into the same. When the element is inserted into the borehole, the activated binder substance in the same will be pressed out of the cartridge at the same time as the member rigidifying the cartridge is destroyed or yields in some other manner. The binder substance pressed out of the cartridge does not then have to be mixed, as sufficient activating agent intended for bonding is present in all parts of the cartridge. Thus, the element does not have to be rotated while being inserted into the borehole in order to achieve a mixture of the binder mixture and the activating liquid. At the same time, that portion of the element which is inserted into the borehole will, despite this, be surrounded by a substance in which the bonding ability of the binder will be utilized totally and fully.

Accelerating, retarding, corrosion-inhibiting or frost-protective agents or mixtures thereof can be added to the binder mixture. In certain applications, expanding agents or gas developing agents can be added to the binder mixture. An expanding agent may be included in the binder mixture in such an amount that its swelling compensates the contraction which begins during hardening. A suitable expanding component is calcium sulphoaluminate or the like. Alternatively

the binder mixture may contain a component such as aluminium powder or the like which is capable of developing gas and expanding the binder.

- Accelerating, retarding, corrosion-inhibiting and frost-protective agents can also be added to the activating liquid so that they become incorporated in the binder mixture when the cartridge is immersed into the activating liquid. For certain purposes and in certain binder mixtures, hydrophobing agents (agents which render substances unwettable by water) or plasticizing substances can be added.

- The invention provides a simple method of embedding elements in surrounding material such as concrete, rock, etc. The method is both simple and reliable and eliminates the weaknesses inherent in previous methods. Furthermore, the method provides a flexibility which is lacking in the previously proposed methods. If, when assembling an element, the intention is to subject it to load at a later point in time, a first cartridge having a brief hardening time can be used for said purpose. Further cartridges having normal or extended hardening time can thereafter be used for the main anchorage. If the element is to be subjected to stress after a short period of time, sufficient strength is achieved quickly by means of the addition of one or more accelerating agents. In certain cases, it can be worthwhile to extend the initial bonding time while a great strength is still relatively quickly achieved. This can be controlled by combining retarders and accelerators. As a large number of additives can be added to the binder by including them in the activating liquid so that they are incorporated in the binder when the cartridges are immersed in the activating liquid, the number of different cartridges which would be required to fill the various needs which can arise at the construction site can be reduced.

Example

- Cartridges containing a mixture of hydraulic binder, fine-grained ballast material and accelerators and having a liquid-permeable casing of wet-strength paper were manufactured. The cartridges were provided with a cover, consisting of a rigidifying member in the form of a net of rigid but brittle plastic material, said net surrounding the cartridges. The cartridges had a diameter of approx. 28 mm, a length of approx. 200 mm and a weight of between 180 and 200 grams.

- A hole having a diameter of 32 mm was bored for the embedment of a steel reinforcement rod having a diameter of 20 mm. Five cartridges of the kind described above were inserted into said borehole after having been totally immersed in activating liquid, in the present case water, for a period of 30 to 45 seconds. When the steel rod was inserted into the borehole, the mortar formed by the hydraulic binder mixture and the water was pressed out of the cartridge, whose casing was destroyed. The mortar filled up the space between the walls of the borehole and the steel rod. The

- embedment length was approx. 900 mm.

- After 2.3 hours, the steel rod was subjected to a successively increasing tensile force until breakage occurred. The tensile force was 13.5 tons when breakage occurred. This corresponds to a breakage load of approx. 15 tons/m embedded bolt. The breakage took place in the steel rod.

Claims

1. A method of anchoring elements in rock, concrete and similar material by means of embedding a portion of the element which is to be anchored in a borehole, characterized in that a binder mixture is introduced into the borehole in cartridges provided with a brittle or otherwise yielding rigidifying member, which cartridges, prior to being inserted into the borehole, are immersed in a liquid which activates the binder mixture for a time period of more than 30 seconds, whereby the activating liquid penetrates through a cartridge casing and into the binder mixture so that a substantially fully uniform mixture of the binder mixture and activating liquid is obtained, and in that when the element is inserted into the borehole, the activated binder mixture in the cartridge is pressed out of it simultaneously as the rigidifying member is destroyed or yields in some other manner without giving rise to any spring forces.
2. A method according to claim 1, characterized in that the binder mixture consists of one or more hydraulically-bonding agents such as Portland cement, aluminous cement, or Keene's cement and in that filler such as fine-grain sand, silica ash, or fly ash, can be included in the binder mixture.
3. A method according to claim 1 or 2, characterized in that accelerating, retarding, freezing point reducing, plasticizing, hydrophobing agents or mixtures thereof are added to the binder mixture in the cartridge together with the activating liquid when the cartridge is immersed therein.
4. A method of anchoring elements in rock, concrete, etc. substantially as hereinbefore described.
5. A cartridge for carrying out the method according to claims 1—4, characterized in that it consists of a casing surrounding the binder mixture and permeable to the activating liquid but impermeable to the binder mixture in the cartridge, and in that the cartridge is provided with a rigidifying member which is destroyed or yields in some other manner without producing any spring forces when the element is inserted into the borehole.
6. A cartridge according to claim 5, characterized in that the casing surrounding the cartridge consists of so-called wet-strength paper, or perforated plastic.
7. A cartridge according to claim 5, characterized in that the binder mixture contains one or more accelerating, retarding, freezing point



the binder mixture may contain a component such as aluminium powder or the like which is capable of developing gas and expanding the binder.

- 5 frost-protective agents can also be added to the activating liquid so that they become incorporated in the binder mixture when the cartridge is immersed into the activating liquid. For certain purposes and in certain binder mixtures,
- 10 hydrophobing agents (agents which render substances unwettable by water) or plasticizing substances can be added.

- The invention provides a simple method of embedding elements in surrounding material such as concrete, rock, etc. The method is both simple and reliable and eliminates the weaknesses inherent in previous methods. Furthermore, the method provides a flexibility which is lacking in the previously proposed methods. If, when
- 20 assembling an element, the intention is to subject it to load at a later point in time, a first cartridge having a brief hardening time can be used for said purpose. Further cartridges having normal or extended hardening time can thereafter be used
- 25 for the main anchorage. If the element is to be subjected to stress after a short period of time, sufficient strength is achieved quickly by means of the addition of one or more accelerating agents. In certain cases, it can be worthwhile to extend the initial bonding time while a great strength is still relatively quickly achieved. This can be controlled by combining retarders and accelerators. As a large number of additives can be added to the binder by including them in the
- 35 activating liquid so that they are incorporated in the binder when the cartridges are immersed in the activating liquid, the number of different cartridges which would be required to fill the various needs which can arise at the construction site can be reduced.
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- 75 yielding rigidifying member, which cartridges, prior to being inserted into the borehole, are immersed in a liquid which activates the binder mixture for a time period of more than 30 seconds, whereby the activating liquid penetrates
- 80 through a cartridge casing and into the binder mixture so that a substantially fully uniform mixture of the binder mixture and activating liquid is obtained, and in that when the element is inserted into the borehole, the activated binder mixture in the cartridge is pressed out of it
- 85 simultaneously as the rigidifying member is destroyed or yields in some other manner without giving rise to any spring forces.

2. A method according to claim 1, characterized in that the binder mixture consists of one or more hydraulically-bonding agents such as Portland cement, aluminous cement, or Keene's cement and in that filler such as fine-grain sand, silica ash, or fly ash, can be included in the binder mixture.
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3. A method according to claim 1 or 2, characterized in that accelerating, retarding, freezing point reducing, plasticizing, hydrophobing agents or mixtures thereof are added to the binder mixture in the cartridge together with the activating liquid when the cartridge is immersed therein.
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4. A method of anchoring elements in rock, concrete, etc. substantially as hereinbefore described.
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5. A cartridge for carrying out the method according to claims 1—4, characterized in that it consists of a casing surrounding the binder mixture and permeable to the activating liquid but impermeable to the binder mixture in the cartridge, and in that the cartridge is provided with a rigidifying member which is destroyed or yields in some other manner without producing any spring forces when the element is inserted into the borehole.
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6. A cartridge according to claim 5, characterized in that the casing surrounding the cartridge consists of so-called wet-strength paper, or perforated plastic.

7. A cartridge according to claim 5, characterized in that the binder mixture contains one or more accelerating, retarding, freezing point
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reducing, plasticizing, hydrophobing and/or expanding components.

8. A cartridge according to claim 7, characterized in that the expanding component is included in the binder mixture in such an amount that its swelling compensates the contraction which begins during hardening.

9. A cartridge according to claim 8, characterized in that the swelling component

10 consists of calcium sulphoaluminate.

10. A cartridge according to claim 5, characterized in that the binder mixture also contains a component such as aluminium powder which is capable of developing gas and expanding the binder substance.

11. A cartridge substantially as hereinbefore described.