



(86) Date de dépôt PCT/PCT Filing Date: 2016/10/19  
 (87) Date publication PCT/PCT Publication Date: 2017/04/27  
 (45) Date de délivrance/Issue Date: 2023/09/19  
 (85) Entrée phase nationale/National Entry: 2018/04/04  
 (86) N° demande PCT/PCT Application No.: EP 2016/075022  
 (87) N° publication PCT/PCT Publication No.: 2017/067951  
 (30) Priorités/Priorities: 2015/10/20 (EP15190509.8);  
 2015/10/20 (EP15190508.0); 2015/10/20 (EP15190503.1)

(51) Cl.Int./Int.Cl. *C04B 40/06* (2006.01),  
*C04B 28/06* (2006.01)  
 (72) Inventeurs/Inventors:  
 PFEIL, ARMIN, DE;  
 SIRCH, VANESSA, DE;  
 GARBATSCHKECK, DOMINIK, DE  
 (73) Propriétaire/Owner:  
 HILTI AKTIENGESELLSCHAFT, LI  
 (74) Agent: ROBIC

(54) Titre : UTILISATION D'UN SYSTEME DE MORTIER 2K CONTENANT DU SULFATE DE CALCIUM, A BASE DE CIMENT ALUMINEUX, DANS DES APPLICATIONS D'ANCRAGE AFIN D'AUGMENTER LES VALEURS DE CHARGE ET DE REDUIRE LE RETRAIT  
 (54) Title: USE OF A CALCIUM SULFATE COMPRISING 2-K MORTAR SYSTEM BASED ON ALUMINOUS CEMENT IN ANCHORING APPLICATIONS TO INCREASE LOAD VALUES AND REDUCE SHRINKAGE

(57) **Abrégé/Abstract:**

The present invention pertains to a use of a calcium sulfate comprising 2-K mortar system for a chemical fastening of anchoring means in mineral surfaces. Besides the calcium sulfate, the mortar system comprises a curable aluminous cement component A and an initiator component B for initiating the curing process, component A further comprising at least one blocking agent selected from the group consisting of phosphoric acid, metaphosphoric acid, phosphorous acid and phosphonic acids, at least one plasticizer and water, and component B comprising an initiator, at least one retarder, at least one mineral filler and water. Due to the presence of the calcium sulfate the hardened mortar exhibits increased load values and reduced shrinkage. The mortar system is used for chemical fastening of anchoring means, preferably of metal elements, in mineral surfaces, such as structures made of brickwork, concrete, pervious concrete or natural stone.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property  
Organization  
International Bureau(10) International Publication Number  
**WO 2017/067951 A1**(43) International Publication Date  
27 April 2017 (27.04.2017)

## (51) International Patent Classification:

*C04B 40/06* (2006.01)      *C04B 111/28* (2006.01)  
*C04B 28/06* (2006.01)      *C04B 111/00* (2006.01)  
*C04B 103/00* (2006.01)

## (21) International Application Number:

PCT/EP2016/075022

## (22) International Filing Date:

19 October 2016 (19.10.2016)

## (25) Filing Language:

English

## (26) Publication Language:

English

## (30) Priority Data:

15190509.8	20 October 2015 (20.10.2015)	EP
15190508.0	20 October 2015 (20.10.2015)	EP
15190503.1	20 October 2015 (20.10.2015)	EP

(71) Applicant: **HILTI AKTIENGESELLSCHAFT** [LI/LI];  
Feldkircherstr. 100, 9494 Schaan (LI).(72) Inventors: **PFEIL, Armin**; Karlstrasse 5, 86916 Kaufering  
(DE). **SIRCH, Vanessa**; Bahnhofstr. 27, 86947 Schw-  
abhausen (DE). **GARBATSCHECK, Dominik**; Höfat-  
sweg 8, 86807 Buchloe-Lindenberg (DE).(81) Designated States (unless otherwise indicated, for every  
kind of national protection available): AE, AG, AL, AM,  
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,  
BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM,  
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,  
HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR,  
KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME,  
MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ,  
OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA,  
SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM,  
TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM,  
ZW.(84) Designated States (unless otherwise indicated, for every  
kind of regional protection available): ARIPO (BW, GH,  
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ,  
TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU,  
TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE,  
DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU,  
LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK,  
SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ,  
GW, KM, ML, MR, NE, SN, TD, TG).

## Published:

— with international search report (Art. 21(3))

(54) Title: USE OF A CALCIUM SULFATE COMPRISING 2-K MORTAR SYSTEM BASED ON ALUMINOUS CEMENT IN  
ANCHORING APPLICATIONS TO INCREASE LOAD VALUES AND REDUCE SHRINKAGE(57) Abstract: The present invention pertains to a use of a calcium sulfate comprising 2-K mortar system for a chemical fastening of  
anchoring means in mineral surfaces. Besides the calcium sulfate, the mortar system comprises a curable aluminous cement compon-  
ent A and an initiator component B for initiating the curing process, component A further comprising at least one blocking agent se-  
lected from the group consisting of phosphoric acid, metaphosphoric acid, phosphorous acid and phosphonic acids, at least one plas-  
ticizer and water, and component B comprising an initiator, at least one retarder, at least one mineral filler and water. Due to the  
presence of the calcium sulfate the hardened mortar exhibits increased load values and reduced shrinkage. The mortar system is used  
for chemical fastening of anchoring means, preferably of metal elements, in mineral surfaces, such as structures made of brickwork,  
concrete, pervious concrete or natural stone.

WO 2017/067951 A1

USE OF A CALCIUM SULFATE COMPRISING 2-K MORTAR SYSTEM BASED ON ALUMINOUS CEMENT IN ANCHORING APPLICATIONS TO INCREASE LOAD VALUES AND REDUCE SHRINKAGE

5

### FIELD OF THE INVENTION

10

The present invention pertains to a use of calcium sulfate in an inorganic mortar system for a chemical fastening of anchoring means in mineral surfaces, comprising a curable aluminous cement component A and an initiator component B for initiating the curing process, component A further comprising at least one blocking agent selected from the group consisting of phosphoric acid, metaphosphoric acid, phosphorous acid and phosphonic acids, at least one plasticizer and water, and component B comprising an initiator, at least one retarder, at least one mineral filler and water. In particular, the present invention pertains to the use of calcium sulfate in an inorganic mortar system for a chemical fastening of anchoring means in mineral surfaces to increase load values as well as to reduce shrinkage. Moreover, the present invention pertains to a method for a chemical fastening of anchoring means, preferably of metal elements, in mineral surfaces, such as structures made of brickwork, concrete, pervious concrete or natural stone.

25

### BACKGROUND OF THE INVENTION

Many mortar systems exist which provide a good chemical fastening of anchoring means in mineral surfaces. For example, organic systems based on free-radically polymerizable resins are used when fast curing is desired. However, such systems are generally known to be polluting, expensive, potentially hazardous and/or toxic for the environment and for the person who handles them and they often need to be specifically labelled. Moreover, organic systems often show a much reduced stability when thermally exposed to strong

30

sunlight or otherwise elevated temperatures, such as fire, thereby decreasing their mechanical performance when it comes to chemically fastening of anchoring means.

5 In order to overcome these drawbacks, predominantly mineral systems based on aluminous cement have been developed. Aluminous cement has as its major constituent monocalcium aluminate and is widely used in the building and construction industries as the final products evidence a high level of mechanical performance over extended periods of time. Also, aluminous cement is resistant to bases and attains its maximum strength more rapidly than Portland cement and is capable of withstanding solutions of  
10 sulfates. Hence, aluminous cement systems are preferably employed in the field of chemical anchoring.

When it comes to chemically fastening anchoring means in mineral surfaces, most of the known systems lack sufficient fluidity for most practical applications of the resultant  
15 compositions. Often such prior art compositions also evidence a tendency to crack in a relatively short time or do not exhibit the required mechanical performance, in particular under certain conditions such as under the influence of elevated temperatures, in diamond-drilled boreholes, or in wet boreholes as well as over a long period of time. Moreover, known systems tend to exhibit a large extend of shrinkage when applied in a  
20 borehole which results in an insufficient anchoring of the anchoring means.

Therefore, there is a need for an inorganic mortar system, preferably a two-component inorganic mortar system, which is superior over the prior art systems. In particular, it is of interest to provide a system that can be used for a chemical fastening of anchoring  
25 means in mineral surfaces without adversely affecting the handling, characteristics and the mechanical performance of the chemical anchoring system, especially when applied in diamond-drilled boreholes, in wet boreholes and over a long period of time. Especially, there is a need for a system that provides increased load values when compared to the known systems. In addition, there is a long felt need to compensate shrinkage of the  
30 mortar in the borehole to secure anchoring of the anchoring means, such as anchor rods, threaded anchor rods, bolts or steel reinforcement bars.

In view of the above, it is an object of the present invention to provide an inorganic mortar system, preferably a multiple-component mortar system, in particular a two-component  
35 inorganic mortar system, which has an excellent mechanical performance, in particular

under certain conditions such as in diamond-drilled boreholes, in wet boreholes and over a long period of time and at the same time having increased load values when compared to the known systems. Further, the inorganic mortar system should exhibit low shrinkage to guarantee secure anchoring application.

5

Moreover, it is an object of the present invention to provide a method for a chemical fastening of anchoring means, preferably of metal elements, in mineral surfaces, such as structures made of brickwork, concrete, pervious concrete or natural stone.

10

### **SUMMARY OF THE INVENTION**

In one aspect, the present invention pertains to a use of calcium sulfate in an inorganic mortar system for a chemical fastening of anchoring means in mineral surfaces, comprising a curable aluminous cement component A and an initiator component B for initiating the curing process, component A further comprising at least one blocking agent selected from the group consisting of phosphoric acid, metaphosphoric acid, phosphorous acid and phosphonic acids, at least one plasticizer and water, and component B comprising an initiator, at least one retarder, at least one mineral filler and water.

20

In another aspect, the present invention pertains to a use of calcium sulfate in an inorganic mortar system for a chemical fastening of anchoring means in mineral surfaces to increase load values.

25

In yet another aspect, the present invention pertains to a use of calcium sulfate in an inorganic mortar system for a chemical fastening of anchoring means in mineral surfaces to reduce shrinkage.

30

Finally, in another aspect, the present invention pertains to a method for a chemical fastening of anchoring means, preferably of metal elements, in mineral surfaces, such as structures made of brickwork, concrete, pervious concrete or natural stone.

## DETAILED DESCRIPTION OF THE INVENTION

The following terms and definitions will be used in the context of the present invention:

5 As used in the context of present invention, the singular forms of “a” and “an” also include the respective plurals unless the context clearly dictates otherwise. Thus, the term “a” or “an” is intended to mean “one or more” or “at least one”, unless indicated otherwise.

10 The term “aluminous cement” in the context of the present invention refers to a calcium aluminate cement that consists predominantly of hydraulic active calcium aluminates. Alternative names are “high-alumina cement” or “Ciment fondu” in French. The main active constituent of calcium aluminate cements is monocalcium aluminate ( $\text{CaAl}_2\text{O}_4$ ,  $\text{CaO} \cdot \text{Al}_2\text{O}_3$ , or CA in the cement chemist notation).

15 The term “initiator” in the context of the present invention refers to a compound or composition that modifies the chemical environment to start a particular chemical reaction. In the present invention the initiator modifies the pH-value of the mortar suspension thereby de-blocking the hydraulic binder in the final mixture.

20 The term “retarder” in the context of the present invention refers to a compound or composition that modifies the chemical environment to delay a particular chemical reaction. In the present invention the retarder modifies the hydration ability of the calcium aluminate cement of the mortar suspension thereby delaying the hydraulic binder action in the final mixture.

25 The term “initial set-time” in the context of the present invention refers to the time at which the mixture of component A and component B starts to set after mixing. During the time period after mixing, the mixture stays in the form of a more or less fluid aqueous suspension or paste of solid products.

30 It has been surprisingly found out by the inventors, that the addition of a calcium sulfate to an inorganic mortar system for a chemical fastening of anchoring means in mineral surfaces, comprising a curable aluminous cement component, preferably based on calcium aluminate cement, results in a significant increase of load values when  
35 compared to a system not comprising calcium sulfate. Moreover, the addition of calcium

sulfate reduces shrinkage to a significant extent thereby guaranteeing secure anchoring application. It has also been found out that the addition of calcium aluminate does not adversely affect the handling, characteristics and the mechanical performance of the chemical anchoring system, especially when applied in diamond-drilled boreholes, in wet  
5 boreholes and over a long period of time.

In particular, it has been found out, that the ratio of calcium sulfate to the aluminous cement component plays an important role in the increase of load values as well in the application of the inorganic mortar system in diamond-drilled boreholes and in wet  
10 boreholes.

Therefore, the present invention pertains to a use of calcium sulfate in an inorganic mortar system for a chemical fastening of anchoring means in mineral surfaces, comprising a curable aluminous cement component A and an initiator component B in  
15 for initiating the curing process. In particular, component A further comprises at least one blocking agent selected from the group consisting of phosphoric acid, metaphosphoric acid, phosphorous acid and phosphonic acids, at least one plasticizer and water, and component B comprises an initiator, at least one retarder, at least one mineral filler and water.

20 Component A as used in the present invention is based on an aluminous cement (CA) or a calcium sulfoaluminate cement (CAS). The aluminous cement component which can be used in the present invention is preferably an aluminous cement component based on an aqueous-phase calcium aluminate cement (CAC). The aluminous cement to be  
25 used in the present invention is characterized by rapid set and rapid hardening, rapid drying, excellent resistance to corrosion and shrinkage. Such a calcium aluminate cement suitable to be used in the present invention is for example Ternal<sup>®</sup> White (Kerneos, France).

30 It has been found that if component A comprises a mixture of calcium aluminate cement (CAC) and calcium sulfate ( $\text{CaSO}_4$ ), rapid ettringite formation takes place during hydration. In concrete chemistry hexacalcium aluminate trisulfate hydrate, represented by the general formula  $(\text{CaO})_6(\text{Al}_2\text{O}_3)(\text{SO}_3)_3 \cdot 32 \text{H}_2\text{O}$  or  $(\text{CaO})_3(\text{Al}_2\text{O}_3)(\text{CaSO}_4)_3 \cdot 32\text{H}_2\text{O}$ , is formed by the reaction of calcium aluminate with calcium sulfate, resulting in quick setting  
35 and hardening as well as in shrinkage compensation or even expansion.

The calcium sulfate used in an inorganic mortar system for a chemical fastening of anchoring means in mineral surfaces according to the present invention, is in the form of calcium sulfate anhydrite, calcium sulfate hemihydrate or calcium sulfate dihydrate. In a preferred embodiment of the present invention the calcium sulfate used is in the form of calcium sulfate hemihydrate.

The calcium sulfate used according to the present invention, is comprised in the curable aluminous cement component A of the inorganic mortar system. In a preferred embodiment of the present invention, the calcium sulfate is comprised in a curable aluminous cement component based on an aqueous-phase calcium aluminate cement of the inorganic mortar system.

In particular, the calcium sulfate comprised in the curable aluminous cement component A is present in a ratio of calcium sulfate to aluminous cement in a range of from 5/95 to 30/70, preferably from 15/85 to 25/75, most preferably in a ratio of 15/85. In a particular preferred embodiment of the present invention, the calcium sulfate is present in the curable aluminous cement component based on an aqueous-phase calcium aluminate cement in a ratio of calcium sulfate to calcium aluminate cement in a range of from 5/95 to 30/70, preferably from 15/85 to 25/75, most preferably in a ratio of 15/85. In a most preferred embodiment of the present invention, calcium sulfate hemihydrate is present in the curable aluminous cement component based on an aqueous-phase calcium aluminate cement in a ratio of calcium sulfate hemihydrate to calcium aluminate cement in a range of from 5/95 to 30/70, preferably from 15/85 to 25/75, most preferably in a ratio of 15/85.

Component A as used in the present invention comprises at least about 40 wt.-%, preferably at least about 50 wt.-%, more preferably at least about 60 wt.-%, most preferably at least about 65 wt.-%, from about 40 wt.-% to about 80 wt.-%, preferably from about 50 wt.-% to about 80 wt.-%, more preferably from about 60 wt.-% to about 75 wt.-%, most preferably from about 65 wt.-% to about 70 wt.-% of aluminous cement, preferably calcium aluminate cement, based on the total weight of component A.

In a preferred embodiment, component A comprises at least about 53 wt.-%, more preferably at least about 58 wt.-%, most preferably at least about 65 wt.-%, from about

53 wt.-% to about 74 wt.-%, preferably from about 58 wt.-% to about 70 wt.-%, more preferably from about 63 wt.-% to about 68 wt.-%, most preferably from about 64 wt.-% to about 77 wt.-% of calcium aluminate cement, based on the total weight of component A and at least about 3 wt.-%, preferably at least about 15 wt.-%, more preferably at least about 10 wt.-%, most preferably at least about 15 wt.-%, from about 3 wt.-% to about 25 wt.-%, preferably from about 4 wt.-% to about 30 wt.-%, more preferably from about 6 wt.-% to about 20 wt.-%, most preferably from about 10 wt.-% to about 15 wt.-% of calcium sulfate, preferably calcium sulfate hemihydrate, based on the total weight of component A. In a most preferred embodiment, component A comprises about 65 wt.-% of calcium aluminate cement and about 11 wt.-% calcium sulfate, preferably calcium sulfate hemihydrate, based on the total weight of component A.

The blocking agent comprised in component A as used in the present invention is selected from the group consisting of phosphoric acid, metaphosphoric acid, phosphorous acid and phosphonic acids, preferably is phosphoric acid or metaphosphoric acid, most preferably is phosphoric acid, in particular an 85% aqueous solution of phosphoric acid. Component A comprises at least about 0.1 wt.-%, preferably at least about 0.3 wt.-%, more preferably at least about 0.4 wt.-%, most preferably at least about 0.5 wt.-%, from about 0.1 wt.-% to about 20 wt.-%, preferably from about 0.1 wt.-% to about 15 wt.-%, more preferably from about 0.1 wt.-% to about 10 wt.-%, most preferably from about 0.3 wt.-% to about 10 wt.-% of said blocking agent, based on the total weight of component A. In a preferred embodiment, component A comprises from about 0.3 wt.-% to about 10 wt.-% of 85% aqueous solution of phosphoric acid, based on the total weight of component A. Preferably, the amounts of aluminous cement and/or calcium sulfoaluminate cement by weight relative to the hydraulic binder total weight are higher than any of the following values: 50%, 60%, 70%, 80%, 90%, 95%, 99% or are 100%.

The plasticizer comprised in component A as used in the present invention is selected from the group consisting of low molecular weight (LMW) polyacrylic acid polymers, superplasticizers from the family of polyphosphonate polyox and polycarbonate polyox, and ethacryl superplasticizers from the polycarboxylate ether group, and mixtures thereof, for example Ethacryl™ G (Coatex, Arkema Group, France), Acumer™ 1051 (Rohm and Haas, U.K.), or Sika® ViscoCrete®-20 HE (Sika, Germany). Suitable plasticizers are commercially available products. Component A comprises at least about

0.2 wt.-%, preferably at least about 0.3 wt.-%, more preferably at least about 0.4 wt.-%, most preferably at least about 0.5 wt.-%, from about 0.2 wt.-% to about 20 wt.-%, preferably from about 0.3 wt.-% to about 15 wt.-%, more preferably from about 0.4 wt.-% to about 10 wt.-%, most preferably from about 0.5 wt.-% to about 5 wt.-% of said plasticizer, based on the total weight of component A.

In an advantageous embodiment, component A further comprises the following characteristics, taken alone or in combination.

Component A may additionally comprise a thickening agent. The thickening agents which can be used in the present invention may be selected from the group consisting of organic products, such as xanthan gum, welan gum or DIUTAN® gum (CPKelco, USA), starched-derived ethers, guar-derived ethers, polyacrylamide, carrageenan, agar agar, and mineral products, such as clay, and their mixtures. Suitable thickening agents are commercially available products. Component A comprises at least about 0.01 wt.-%, preferably at least about 0.1 wt.-%, more preferably at least about 0.2 wt.-%, most preferably at least about 0.3 wt.-%, from about 0.01 wt.-% to about 10 wt.-%, preferably from about 0.1 wt.-% to about 5 wt.-%, more preferably from about 0.2 wt.-% to about 1 wt.-%, most preferably from about 0.3 wt.-% to about 0.7 wt.-% of said thickening agent, based on the total weight of component A.

Component A may further comprise an antibacterial or biocidal agent. The antibacterial or biocidal agents which can be used in the present invention may be selected from the group consisting of compounds of the isothiazolinone family, such as methylisothiazolinone (MIT), octylisothiazolinone (OIT) and benzoisothiazolinone (BIT) and their mixtures. Suitable antibacterial or biocidal agents are commercially available products. Exemplarily mentioned are Ecocide K35R (Progiven, France) and Nuosept OB 03 (Ashland, The Netherlands). Component A comprises at least about 0.001 wt.-%, preferably at least about 0.005 wt.-%, more preferably at least about 0.01 wt.-%, most preferably at least about 0.015 wt.-%, from about 0.001 wt.-% to about 1.5 wt.-%, preferably from about 0.005 wt.-% to about 0.1 wt.-%, more preferably from about 0.01 wt.-% to about 0.075 wt.-%, most preferably from about 0.015 wt.-% to about 0.03 wt.-% of said antibacterial or biocidal agent, based on the total weight of component A. In a preferred embodiment, component A comprises from about 0.015 wt.-% to about 0.03 wt.-% of Nuosept OB 03, based on the total weight of component A.

In an alternative embodiment, component A comprises at least one filler, in particular an organic or mineral filler. The filler which can be used in the present invention may be selected from the group consisting of quartz powder, preferably quartz powder having an averaged grain size (d50%) of about 16  $\mu\text{m}$ , quartz sand, clay, fly ash, fumed silica, carbonate compounds, pigments, titanium oxides, light fillers, and their mixtures. Suitable mineral fillers are commercially available products. Exemplarily mentioned is quartz powder Millisil W12 or W6 (Quarzwerke GmbH, Germany). Component A comprises at least about 1 wt.-%, preferably at least about 2 wt.-%, more preferably at least about 5 wt.-%, most preferably at least about 8 wt.-%, from about 1 wt.-% to about 50 wt.-%, preferably from about 2 wt.-% to about 40 wt.-%, more preferably from about 5 wt.-% to about 30 wt.-%, most preferably from about 8 wt.-% to about 20 wt.-% of said at least one filler, based on the total weight of component A.

The water content comprised in component A is at least about 1 wt.-%, preferably at least about 5 wt.-%, more preferably at least about 10 wt.-%, most preferably at least about 20 wt.-%, from about 1 wt.-% to about 50 wt.-%, preferably from about 5 wt.-% to about 40 wt.-%, more preferably from about 10 wt.-% to about 30 wt.-%, most preferably from about 15 wt.-% to about 25 wt.-%, based on the total weight of component A.

The presence of a plasticizer, thickening agent as well as an antibacterial or biocidal agent does not change the overall inorganic nature of the cementitious component A.

Component A comprising the aluminous cement or calcium sulfoaluminate cement is present in aqueous-phase, preferably in form of a slurry or paste.

Component B as used in the present invention comprises an initiator, at least one retarder, at least one mineral filler and water. To ensure a sufficient processing time, whereby the initial-set time is at least 5 min or more, at least one retarder, which prevents premature hardening of the mortar composition, is used in a distinct concentration in addition to the initiator component.

The initiator present in component B is comprised of an activator component and an accelerator component which comprise a mixture of alkali and/or alkaline earth metal salts.

In particular, the activator component is constituted of at least one alkali and/or alkaline earth metal salt selected from the group consisting of hydroxides, chlorides, sulfates, phosphates, monohydrogen phosphates, dihydrogen phosphates, nitrates, carbonates and mixtures thereof, preferably the activator component is an alkali or alkaline earth metal salt, more preferably is a calcium metal salt, such as calcium hydroxide, calcium sulfate, calcium carbonate or calcium phosphate, a sodium metal salt, such as sodium hydroxide, sodium sulfate, sodium carbonate or sodium phosphate, or a lithium metal salt, such as lithium hydroxide, lithium sulfate, lithium carbonate or lithium phosphate, most preferably is lithium hydroxide. In one preferred embodiment the lithium hydroxide used in component B is a 10% aqueous solution of lithium hydroxide.

Component B comprises at least about 0.01 wt.-%, preferably at least about 0.02 wt.-%, more preferably at least about 0.05 wt.-%, most preferably at least about 1 wt.-%, from about 0.01 wt.-% to about 40 wt.-%, preferably from about 0.02 wt.-% to about 35 wt.-%, more preferably from about 0.05 wt.-% to about 30 wt.-%, most preferably from about 1 wt.-% to about 25 wt.-% of said activator, based on the total weight of component B. In a particular preferred embodiment, the activator is comprised of water and lithium hydroxide. The water content comprised in component B is at least about 1 wt.-%, preferably at least about 5 wt.-%, more preferably at least about 10 wt.-%, most preferably at least about 20 wt.-%, from about 1 wt.-% to about 60 wt.-%, preferably from about 5 wt.-% to about 50 wt.-%, more preferably from about 10 wt.-% to about 40 wt.-%, most preferably from about 15 wt.-% to about 30 wt.-%, based on the total weight of component B. The lithium hydroxide content comprised in component B is at least about 0.1 wt.-%, preferably at least about 0.5 wt.-%, more preferably at least about 1.0 wt.-%, most preferably at least about 1.5 wt.-%, from about 0.1 wt.-% to about 5 wt.-%, preferably from about 0.5 wt.-% to about 4 wt.-%, more preferably from about 1.0 wt.-% to about 3 wt.-%, most preferably from about 1.5 wt.-% to about 2.5 wt.-%, based on the total weight of component B. In a most preferred embodiment, component B comprises from about 2.0 wt.-% to about 20 wt.-% of a 10% aqueous solution of lithium hydroxide, based on the total weight of component B.

The accelerator component is constituted of at least one alkali and/or earth alkaline metal salt selected from the group consisting of hydroxides, chlorides, sulfates, phosphates, monohydrogen phosphates, dihydrogen phosphates, nitrates, carbonates and mixtures

thereof, preferably the accelerator component is an alkali or earth alkaline metal salt, still preferably is a water-soluble alkali or earth alkaline metal salt, more preferably is a calcium metal salt, such as calcium hydroxide, calcium sulfate, calcium carbonate, calcium chloride, calcium formate or calcium phosphate, a sodium metal salt, such as  
5 sodium hydroxide, sodium sulfate, sodium carbonate, sodium chloride, sodium formate or sodium phosphate, or a lithium metal salt, such as lithium hydroxide, lithium sulfate, lithium sulfate monohydrate, lithium carbonate, lithium chloride, lithium formate or lithium phosphate, most preferably is lithium sulfate or lithium sulfate monohydrate. Component B comprises at least about 0.01 wt.-%, preferably at least about 0.05 wt.-%, more  
10 preferably at least about 0.1 wt.-%, most preferably at least about 1.0 wt.-%, from about 0.01 wt.-% to about 25 wt.-%, preferably from about 0.05 wt.-% to about 20 wt.-%, more preferably from about 0.1 wt.-% to about 15 wt.-%, most preferably from about 1.0 wt.-% to about 10 wt.-% of said accelerator, based on the total weight of component B.

15 In a particular preferred embodiment of component B as used in the present invention, the ratio of 10% aqueous solution of lithium hydroxide/lithium sulfate or lithium sulfate monohydrate is 7/1 or 6/1.

The at least one retarder comprised in component B as used in the present invention is  
20 selected from the group consisting of citric acid, tartaric acid, lactic acid, salicylic acid, gluconic acid and mixtures thereof, preferably is a mixture of citric acid and tartaric acid. Component B comprises at least about 0.1 wt.-%, preferably at least about 0.2 wt.-%, more preferably at least about 0.5 wt.-%, most preferably at least about 1.0 wt.-%, from about 0.1 wt.-% to about 25 wt.-%, preferably from about 0.2 wt.-% to about 15 wt.-%,  
25 more preferably from about 0.5 wt.-% to about 15 wt.-%, most preferably from about 1.0 wt.-% to about 10 wt.-% of said retarder, based on the total weight of component B.

In a particular preferred embodiment of component B as used in the present invention, the ratio of citric acid/tartaric acid is 1.6/1.

30 The at least one mineral filler comprised in component B as used in the present invention is selected from the group consisting of limestone fillers, sand, crushed stones, gravels, pebbles and mixtures thereof, preferred are limestone fillers, such as various calcium carbonates. The at least one mineral filler is preferably selected from the group  
35 consisting of limestone fillers or quartz fillers, such as quartz powder Millisil W12 or W6

(Quarzwerke GmbH, Germany) and quartz sand. The at least one mineral filler of component B is most preferably a calcium carbonate or a mixture of calcium carbonates. Component B comprises at least about 30 wt.-%, preferably at least about 40 wt.-%, more preferably at least about 50 wt.-%, still more preferably at least about 60 wt.-%, most preferably at least about 70 wt.-%, from about 30 wt.-% to about 95 wt.-%, preferably from about 35 wt.-% to about 90 wt.-%, more preferably from about 40 wt.-% to about 85 wt.-%, still more preferably from about 45 wt.-% to about 80 wt.-%, most preferably from about 50 wt.-% to about 75 wt.-% of at least one mineral filler, based on the total weight of component B. The at least one mineral filler is chosen to obtain a particle size complementary to that of the aluminous cement.

It is preferred that the at least one mineral filler has an average particle size of not more than 500  $\mu\text{m}$ , more preferably of not more than 400  $\mu\text{m}$ , most preferably not more than 350  $\mu\text{m}$ .

In a particular preferred embodiment, the at least one mineral filler comprised in component B is mixture of three different calcium carbonates, i.e. calcium carbonate fines, such as different Omycarb<sup>®</sup> types (Omya International AG, Germany). Most preferably, the first calcium carbonate has an average particle size (d50%) of about 3.2  $\mu\text{m}$  and a residue of 0.05% on a 45  $\mu\text{m}$  sieve (determined according to ISO 787/7). The second calcium carbonate has an average particle size (d50%) of about 7.3  $\mu\text{m}$  and a residue of 0.5% on a 140  $\mu\text{m}$  sieve (determined according to ISO 787/7). The third calcium carbonate has an average particle size (d50%) of about 83  $\mu\text{m}$  and a residue of 1.0% on a 315  $\mu\text{m}$  sieve (determined according to ISO 787/7). In a particular preferred embodiment of component B, the ratio of first calcium carbonate/second calcium carbonate/third calcium carbonate is 1/1.5/2 or 1/1.4/2.2.

In a particular preferred alternative embodiment, the at least one mineral filler comprised in component B is mixture of three different quartz fillers. Most preferably, the first quartz filler is a quartz sand having an average particle size (d50%) of about 240  $\mu\text{m}$ . The second quartz filler is a quartz powder having an average grain size (d50%) of about 40  $\mu\text{m}$ . The third quartz filler is a quartz powder having an average grain size (d50%) of about 15  $\mu\text{m}$ . In a particular preferred embodiment of component B as used in the present invention, the ratio of first quartz filler/second quartz filler/third quartz filler is 3/2/1.

In an advantageous embodiment, component B further comprises the following characteristics, taken alone or in combination.

- 5 Component B may additionally comprise a thickening agent. The thickening agent to be used in the present invention may be selected from the group consisting of bentonite, silicon dioxide, quartz, thickening agents based on acrylate, such as alkali-soluble or alkali-swallowable emulsions, fumed silica, clay and titanate chelating agents. Exemplarily mentioned are polyvinyl alcohol (PVA), hydrophobically modified alkali soluble emulsions  
10 (HASE), hydrophobically modified ethylene oxide urethane polymers known in the art as HEUR, and cellulosic thickeners such as hydroxymethyl cellulose (HMC), hydroxyethyl cellulose (HEC), hydrophobically-modified hydroxy ethyl cellulose (HMHEC), sodium carboxymethyl cellulose (SCMC), sodium carboxymethyl 2-hydroxyethyl cellulose, 2-hydroxypropyl methyl cellulose, 2-hydroxyethyl methyl cellulose, 2-hydroxybutyl methyl  
15 cellulose, 2-hydroxyethyl ethyl cellulose, 2-hydroxypropyl cellulose, attapulgite clay, and mixtures thereof. Suitable thickening agents are commercially available products, such as Optigel WX (BYK-Chemie GmbH, Germany), Rheolate 1 (Elementis GmbH, Germany) and Acrysol ASE-60 (The Dow Chemical Company). Component B comprises at least about 0.01 wt.-%, preferably at least about 0.05 wt.-%, more preferably at least  
20 about 0.1 wt.-%, most preferably at least about 0.3 wt.-%, from about 0.01 wt.-% to about 15 wt.-%, preferably from about 0.05 wt.-% to about 10 wt.-%, more preferably from about 0.1 wt.-% to about 5 wt.-%, most preferably from about 0.3 wt.-% to about 1 wt.-% of said thickening agent, based on the total weight of component B.
- 25 The presence of a retarder and thickening agent does not change the overall inorganic nature of the cementitious component B.

Component B comprising the initiator and retarder is present in aqueous-phase, preferably in form of a slurry or paste.

30

It is preferred that the pH-value of component B is above 10, more preferably above 11 and most preferably is above 12, in particular in the range between 10 and 14, preferably between 11 and 13.

It is particular preferred that the proportions of water in the two components, namely component A and component B, are chosen so that the water to aluminous cement ratio (W/CAC) or water to calcium sulfoaluminate cement (W/CAS), in the product obtained by mixing components A and B is lower than 1.5, preferably between 0.3 and 1.2, most preferably between 0.4 and 1.0. In a preferred embodiment, the ratio of water to calcium aluminate cement comprising calcium sulfate (W/(CAC+CaSO<sub>4</sub>)) in the product obtained by mixing components A and B is lower than 1.0.

Moreover, it is particular preferred that the proportion of lithium in component B is chosen so that the lithium to aluminous cement ratio (Li/CAC) and lithium to calcium sulfoaluminate cement (Li/CAS), in the product obtained by mixing components A and B is lower than 0.05, preferably between 0.001 and 0.05, most preferably between 0.005 and 0.01. In a particular preferred embodiment, the proportion of lithium hydroxide in component B is chosen so that the ratio of calcium aluminate cement comprising calcium sulfate to lithium hydroxide ((CAC+CaSO<sub>4</sub>)/LiOH) in the product obtained by mixing components A and B is in the range of from 1.3:1 to 12.5:1.

It is particular preferred that the calcium sulfate in the product obtained by mixing components A and B is present in the range of from about 0.95 wt.-% to 18.0 wt.-%, preferably from about 1.5 wt.-% to 14.0 wt.-%, more preferably from about 2.5 wt.-% to 10.0 wt.-%, most preferably from about 3.0 wt.-% to 8.5 wt.-%.

Moreover, it is particular preferred that the proportion of retarder in component B is chosen so that the citric acid/tartaric acid to aluminous cement ratio and citric acid/tartaric acid to calcium sulfoaluminate cement, in the product obtained by mixing components A and B is lower than 0.5, preferably between 0.01 and 0.4, most preferably between 0.1 and 0.2.

In a most preferred embodiment, component A comprises or consists of the following components:

- 65 to 70 wt.-% of aluminous cement,
- 5 to 15 wt.-% calcium sulfate,
- 0.5 to 1.5 wt.-% of phosphoric acid,
- 0.5 to 1.5 wt.-% of plasticizer,
- 0.001 to 0.05 wt.-% of an antimicrobial or biocidal agent,

optionally 5 to 20 wt.-% of mineral fillers, and  
15 to 25 wt.-% of water.

5 In a most preferred embodiment, component B comprises or consists of the following components:

- 0.1 wt.-% to 4 wt.-% of lithium hydroxide,
- 0.1 wt.-% to 5 wt.-% of lithium sulfate or lithium sulfate monohydrate,
- 0.05 wt.-% to 5 wt.-% of citric acid,
- 0.05 wt.-% to 4 wt.-% of tartaric acid,
- 10 35 wt.-% to 45 wt.-% of a first mineral filler,  
15 wt.-% to 25 wt.-% of a second mineral filler,  
10 wt.-% to 20 wt.-% of a third mineral filler,  
0.01 wt.-% to 0.5 wt.-% of a thickening agent, and  
15 wt.-% to 25 wt.-% of water.

15

Component A as used in the present invention may be prepared as follows: The phosphor-containing blocking agent is mixed with water, so that the pH-value of the resulting mixture is about 2. Plasticizer is added and the mixture homogenized. Aluminous cement, optionally calcium sulfate, and optionally mineral filler are premixed  
20 and added stepwise to the mixture whilst increasing the stirring speed, so that the pH-value of the resulting mixture is about 4. Finally, thickening agent and antibacterial/biocidal agent are added and mixed until complete homogenization of the mixture.

25 Component B as used in the present invention may be prepared as follows: The accelerator is dissolved in an aqueous solution of an activator, followed by subsequent addition of retarder and homogenization of the mixture. The filler(s) is/are added stepwise whilst increasing the stirring speed until the mixture homogenizes. Finally, the thickening agent is added until complete homogenization of the mixture.

30

Component A and B are present in aqueous phase, preferably in form of a slurry or paste. In particular, components A and B have a pasty to fluid aspect according to their respective compositions. In one preferred embodiment, component A and component B are in paste form thereby preventing sagging at the time of mixing the two components.

35

The weight ratio between component A and component B (A/B) is preferentially comprised between 7/1 and 1/3, preferably is 3/1. Preferably, the composition of the mixture comprises 75 wt.-% of component A and 25 wt.-% of component B. In an alternative embodiment, the composition of the mixture comprises 25 wt.-% of component A and 75 wt.-% of component B.

The inorganic mortar system, preferably the two-component inorganic mortar system, is of mineral nature, which is not affected by the presences of additional thickening agents of other agents.

It is preferred that the inorganic mortar system has an initial set-time of at least 5 min, preferably of at least 10 min, more preferably of at least 15 min, most preferably of at least 20 min, in particular in the range of from about 5 to 25 min, preferably in the range of about 10 to 20 min, after mixing of the two components A and B.

In the multi-component inorganic mortar system, especially the two-component inorganic mortar system, the volume ratio of cementitious component A to initiator component B is 1:1 to 7:1, preferably is 3:1. In an alternative embodiment, the volume ratio of cementitious component A to initiator component B is 1:3 to 1:2.

After being produced separately, component A and component B are introduced into separate containers, from which they are ejected by means of mechanical devices and are guided through a mixing device. The inorganic mortar system is preferably a ready-for-use system, whereby component A and B are separately arranged from each other in a multi-chamber device, such as a multi-chamber cartridge and/or a multi-chamber cylinder or in two-component capsules, preferably in a two-chamber cartridge or in two-component capsules. The multi-chamber system preferably includes two or more foil bags for separating curable component A and initiator component B. The contents of the chambers or bags which are mixed together by a mixing device, preferably via a static mixer, can be injected into a borehole. The assembly in multiple chamber cartridges or pails or sets of buckets is also possible.

The hardening aluminous cement composition existing from the static mixer is inserted directly into the borehole, which is required accordingly for fastening the anchoring means, and has been initially introduced into the mineral surface, during the chemical

fastening of anchoring means, whereupon the construction element to be fastened, for example an anchor rod, is inserted and adjusted, whereupon the mortar composition sets and hardens. In particular, the inorganic mortar system is to be considered as a chemical anchor for fastening metal elements.

5

Without being bound by theory, the blocking agent present in component A inhibits the solubilization of the calcium aluminate(s) in water, thereby stopping cement hydration which leads to the curing of the mixture. Upon adding the initiator component B, the pH-value is changed and the cementitious component A is unblocked and hydration reaction of the calcium aluminate(s) is released. As this hydration reaction is catalyzed and accelerated by the presence of alkali metals salts, in particular lithium salts, it has an initial set-time of shorter than 5 min. In order to retard the fast curing time (initial-set time), it is preferred that the at least one retarder comprised in component B as used in the present invention is so chosen to obtain an initial set-time of at least 5 min, preferably of at least 10 min, more preferably of at least 15 min, most preferably of at least 20 min, in particular in the range of from about 5 to 25 min, preferably in the range of about 10 to 20 min, after mixing of the two components A and B.

The role of mineral fillers, in particular in component B, is to adjust the final performance with regard to mechanical strength and performance as well as long term durability. By optimizing the fillers, it is possible to optimize the water/aluminous cement ratio which allows for an efficient and fast hydration of the aluminous cement.

The inorganic mortar system comprising the calcium sulfate can be used for a chemical fastening of anchoring means, preferably of metal elements, such as anchor rods, in particular threaded rods, bolts, steel reinforcement bars or the like into mineral surfaces, such as structures made of brickwork, concrete, pervious concrete or natural stone. In particular, the inorganic mortar system can be used for a chemical fastening of anchoring means, such as metal elements, in boreholes. It has been found out, that the use of calcium sulfate in such an inorganic mortar system significantly increases the load values and hence load capacity in wet boreholes as well as in diamond drilled boreholes.

Hence, the use of calcium sulfate in an inorganic mortar system according to the present invention is particular to increase load values. Additionally, it is used to reduce shrinkage within the borehole.

35

5 The calcium sulfate comprised in the inorganic mortar is particularly applied in a method for a chemical fastening of anchoring means, preferably of metal elements, in mineral surfaces, such as structures made of brickwork, concrete, pervious concrete or natural stone.

10 Moreover, the inorganic mortar system comprising the calcium sulfate may be used for the attachment of fibers, scrims, fabrics or composites, in particular of high-modulus fibers, preferably of carbon fibers, in particular for the reinforcement of building structures, for example walls or ceilings or floors, or further for mounting components, such as plates or blocks, e.g. made of stone, glass or plastic, on buildings or structural elements. However, in particular it is used for fastening of anchoring means, preferably metal elements, such as anchor rods, in particular threaded rods, bolts, steel reinforcement bars or the like into recesses, such as boreholes, in mineral surfaces, such as structures made of brickwork, concrete, pervious concrete or natural stone, whereby the components of the two-component inorganic mortar system are prior mixed, for example by means of a static mixer or by destroying a cartridge or a plastic bag, or by mixing components of a multi-chamber pails or sets of buckets.

20 The following example illustrates the invention without thereby limiting it.

## EXAMPLES

### 1. Preparation of component A and component B

25

The cementitious component A as well as the initiator component B of the comparative example 1 and 2 and of inventive examples are initially produced by mixing the constituents specified in Tables 1 and 2, respectively. The proportions that are given are expressed in wt.-%.

30

A typical mixing protocol for component A is as follows: weighting out the necessary quantity of water, introducing the water into a mixing bowl and slowly adding phosphoric acid thereto under stirring with a dissolver plate at 150 rpm for 2 minutes; adding plasticizer and homogenizing at 150 to 200 rpm for 2-3 minutes; premixing the aluminous cement (Ternal White®) and the respective calcium sulfate in a big bucket and adding

35



Table 1 continued

		Inventive Examples							
Compound	Function	A8	A9	A10	A11	A12	A13	A14	A15
Deionized water		19.80	19.80	19.80	19.80	19.80	19.80	19.80	19.80
Phosphoric acid 85%	blocking agent	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
Ethacryl G	plasticizer	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17
Ternal White	aluminate cement	73.72	65.96	63.63	58.20	54.32	50.44	42.67	3.87
Micro C	ettringite former	-	-	-	-	-	-	-	-
Supraduro	ettringite former	3.88	11.64	13.97	19.40	23.28	27.16	34.93	73.73
Lenzin	ettringite former	-	-	-	-	-	-	-	-
Xanthan Gum	thickening agent	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Nuosept OB 03	biocidal agent	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
		Inventive Examples							
Compound	Function	A16	A17	A18	A19	A20	A21	A22	
Deionized water		19.80	19.80	19.80	19.80	19.80	19.80	19.80	19.80
Phosphoric acid 85%	blocking agent	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
Ethacryl G	plasticizer	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17
Ternal White	aluminate cement	73.72	65.96	63.63	58.20	54.32	50.44	42.67	
Micro C	ettringite former	-	-	-	-	-	-	-	-
Supraduro	ettringite former	-	-	-	-	-	-	-	-
Lenzin	ettringite former	3.88	11.64	13.97	19.40	23.28	27.16	34.93	
Xanthan Gum	thickening agent	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Nuosept OB 03	biocidal agent	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02

Phosphoric acid 85% marketed by Sigma-Aldrich Chemie GmbH, Germany; Ethacryl G marketed by Coatex S.A., France; Ternal White® marketed by Kerneos S.A., France; Micro C (CaSO<sub>4</sub> anhydrite) marketed by Casea GmbH, Germany; Supraduro (CaSO<sub>4</sub> hemihydrate) marketed by Saint Gobain Formula GmbH, Germany; Lenzin (CaSO<sub>4</sub> dihydrate) marketed by Kremer Pigmente GmbH & CO. KG, Germany; Xanthan Gum marketed by Kremer Pigmente GmbH & CO. KG, Germany; Nuosept OB 03 marketed by Ashland Nederland B.V., The Netherlands.

A typical mixing protocol for component B is as follows: dissolving lithium sulfate monohydrate in a 10% aqueous solution of lithium hydroxide followed by dissolving citric acid and tartaric acid in this mixture and fully homogenizing it at 400 rpm; adding stepwise filler, starting with the roughest filler and ending with the finest one, while increasing stirring speed from 250 rpm to 1700 rpm and continuing homogenizing it at 1700 rpm for 2-3 min; finally adding thickening agent whilst stirring, and increasing stirring speed to 2200 rpm; finally continuing homogenizing at 2200 rpm for 5 min.

**Table 2:** Composition of component B.

Compound	Function	B
LiOH 10% (water)	activator	18.68
Li <sub>2</sub> SO <sub>4</sub> monohydrate	accelerator	3.28
Citric acid	retarder	1.58
Tartaric acid	retarder	0.99
Filler 1	filler	35.97 <sup>1</sup>
Filler 2	filler	22.60 <sup>2</sup>
Filler 3	filler	16.67 <sup>3</sup>
Optigel WX	thickening agent	0.23

LiOH 10% (water) marketed by Bernd Kraft GmbH, Germany; Li<sub>2</sub>SO<sub>4</sub> monohydrate marketed by Alfa Aesar GmbH & Co. KG, Germany; Citric acid marketed by Sigma-Aldrich Chemie GmbH, Germany; Tartaric acid marketed by BCD Chemie GmbH, Germany; <sup>1</sup>Omyacarb 130-AI marketed by Omya International AG, Germany; <sup>2</sup>Omyacarb 15-H AI marketed by Omya International AG, Germany; <sup>3</sup>Omyacarb 2-AI marketed by Omya International AG, Germany; Optigel WX marketed by BYK Chemie GmbH, Germany.

## 2. Determination of mechanical performance

After being produced separately, the cementitious component A and initiator component B are mixed in a speed mixer in a volume ratio of 3:1 or 1:3 and are introduced into a prepared borehole in concrete C20/25 having a diameter of 14 or 18 mm. The borehole was created by hammer drilling.

Load values of the cured mortar composition are determined by introducing an M12 threaded anchor rod, having an anchoring depth of 72 mm, into a borehole, having a diameter of 14 or 18 mm, in differently conditioned concrete C20/25 (Table 3).

**Table 3:** Condition of concrete C20/25 tested.

Sample number	Concrete condition	Borehole diameter in mm
1	dry concrete, dust completely removed, room temperature	14, hammer drilling
2	water-saturated concrete, dust 50% removed, room temperature	14, hammer drilling
3	dry concrete, dust completely removed, room temperature	18, hammer drilling

The average failure load is determined by centrally pulling out the threaded anchor rod with tight support using high-strength steel rods using a hydraulic tool. Three threaded anchor rods are doweled in place in each case and their load values are determined after curing for 24 hours as mean value. Ultimate failure loads are calculated as bond strengths and given in N/mm<sup>2</sup> in Table 4.

**Table 4:** Bond strengths in N/mm<sup>2</sup>.

Mixing ratio A:B 1:3	Comparative Example 1	Inventive Examples						
		2	3	4	5	6	7	8
Example No.	1							
Sample number	A0 + B	A1 + B	A2 + B	A3 + B	A4 + B	A5 + B	A6 + B	A7 + B
1	6.40	6.65	6.72	6.66	6.52	6.20	6.24	5.37
2	7.80	8.26	8.59	8.15	8.02	7.91	7.67	6.59
3	5.56	5.64	5.84	5.62	5.60	5.58	5.30	4.37

10 **Table 4 continued**

Mixing ratio A:B 1:3	Inventive Examples							
	9	10	11	12	13	14	15	16
Example No.								
Sample number	A8 + B	A9 + B	A10 + B	A11 + B	A12 + B	A13 + B	A14 + B	A15 + B
1	7.70	10.11	9.50	8.56	7.02	6.46	4.84	0.55
2	10.55	12.33	11.85	9.28	8.55	7.33	6.05	0.32
3	6.46	9.88	8.64	7.65	6.93	5.31	4.06	0.20

Table 4 continued

Mixing ratio A:B 1:3	Inventive Examples						
Example No.	17	18	19	20	21	22	23
Sample number	A16 + B	A17 + B	A18 + B	A19 + B	A20 + B	A21 + B	A22 + B
1	6.57	8.60	8.46	6.42	6.41	4.02	3.00
2	8.69	10.05	9.26	7.95	7.82	4.47	1.84
3	5.61	7.48	7.14	6.37	5.63	2.88	2.18

Table 4 continued

Mixing ratio A:B 3:1	Inventive Examples					Comparative Example 2
Example No.	24	25	26	27	28	29
Sample number	A8 + B	A9 + B	A11 + B	A12 + B	A13 + B	A0 + B
1	12.53	16.00	12.87	12.61	10.65	11.2

### 3. Determination of chemical shrinkage

5

The chemical shrinkage is determined by using the device for measuring a shrinkage "Schwindkegel Schleibinger Device" (Schleibinger Geräte Teubert und Greim GmbH, Buchbach, Germany). The sample was applied at a defined height and positioned under the laser beam on a plate instead of a cone. An aluminum plates serving as a reflector for the laser beam. 2.5 g of the sample are applied to a steel plate and covered with an aluminum plate. The height of the sample is adjusted to 1.9 mm. The shrinkage is determined by measuring the difference in length of the reflected laser-beam according to standard practice. Table 5 depicts the shrinkage compared to the initial inorganic mortar, i.e. the value -2.30 means a shrinkage of 2.30% when compared to the initial material.

15

**Table 5:** Chemical Shrinkage.

<b>Mixing ratio A:B 1:3</b>	<b>Comparative Example</b>	<b>Inventive Examples</b>							
<b>Example No.</b>	<b>30</b>	<b>31</b>	<b>32</b>	<b>33</b>	<b>34</b>	<b>35</b>	<b>36</b>	<b>37</b>	<b>38</b>
	<b>A0 + B</b>	<b>A8 + B</b>	<b>A9 + B</b>	<b>A10 + B</b>	<b>A11 + B</b>	<b>A12 + B</b>	<b>A13 + B</b>	<b>A14 + B</b>	<b>A15 + B</b>
<b>Chemical shrinkage [%]</b>	-2.30	-1.61	-1.20	-0.87	-0.74	-0.61	-0.94	-1.23	-3.06

As it can be seen from Table 4, almost all inventive systems show considerable bond strengths after 24 hours of curing as well as increased load values and hence, improved mechanical strength when it comes to a chemical fastening of anchoring means, in comparison to the comparative system does not comprising any calcium sulfate. The addition of calcium sulfate, in particular in a ratio of ratio of calcium sulfate to aluminous cement in a range of from 5/95 to 30/70, preferably from 15/85 to 25/75, results in a significant increase of load values when compared to systems not comprising any calcium sulfate. Moreover, it has been shown that the performance improves in wet and diamond drilled boreholes. In particular, it has been shown that the addition of calcium sulfate hemihydrate results in a significant improvement of load values in diamond drilled boreholes (also referred to as oversize) proportionally to its shrinkage effect. Furthermore, it was found that the inventive systems comprising calcium sulfate do not show any micro-cracks after curing. Hence, the inventive systems provide for a dense, sealed anchoring system which is an important pre-condition for obtaining improved corrosion and freeze-thaw resistance.

As it has been shown above, the use of calcium sulfate of the present invention, in particular in a ratio of ratio of calcium sulfate to aluminous cement in a range of from 5/95 to 30/70, preferably from 15/85 to 25/75, provides for an increase in load values and hence mechanical strength when compared to systems not comprising any calcium sulfate.

25

\*\*\*

In some aspects, one or more of the following embodiments are disclosed:

1. Use of calcium sulfate in an inorganic mortar system for a chemical fastening of anchoring means in mineral surfaces, comprising a curable aluminous cement component A and an initiator component B for initiating the curing process, component A further comprising at least one blocking agent selected from the group consisting of  
5 phosphoric acid, metaphosphoric acid, phosphorous acid and phosphonic acids, at least one plasticizer and water, and component B comprising an initiator, at least one retarder, at least one mineral filler and water.
2. Use according to item 1, wherein the aluminous cement component A is an  
10 aluminous cement component based on an aqueous-phase calcium aluminate cement.
3. Use according to item 1 or 2, wherein the calcium sulfate is in the form of calcium sulfate anhydrite, calcium sulfate hemihydrate or calcium sulfate dihydrate.
- 15 4. Use according to item 1, 2 or 3, wherein the calcium sulfate is in the form of calcium sulfate hemihydrate.
5. Use according to any one of items 1 to 4, wherein the calcium sulfate is comprised in the curable aluminous cement component A of the inorganic mortar  
20 system.
6. Use according to item 5, wherein the calcium sulfate comprised in the curable aluminous cement component A is present in a ratio of calcium sulfate to aluminous cement in a range of from 5/95 to 30/70.  
25
7. Use according to item 5, wherein the calcium sulfate comprised in the curable aluminous cement component A is present in a ratio of calcium sulfate to aluminous cement in a range of from 15/85 to 25/75.
- 30 8. Use according to any one of items 1 to 7, wherein the initiator comprises a mixture of alkali and/or alkaline earth metal salts, the at least one retarder is selected from the group consisting of citric acid, tartaric acid, lactic acid, salicylic acid, gluconic acid and mixtures thereof, and the at least one mineral filler is selected from the group consisting of limestone fillers, sand, corundum, dolomite, alkaline-resistant glass,  
35 crushed stones, gravels, pebbles and mixtures thereof.

9. Use according to any one of items 1 to 8, wherein the initiator comprises a mixture of lithium metal salts.
- 5 10. Use according to any one of items 1 to 9, wherein the ratio of water to calcium aluminate cement comprising calcium sulfate ( $W/(CAC+CaSO_4)$ ) in the product obtained by mixing components A and B is lower than 1.0.
11. Use according to any one of items 1 to 10, wherein the ratio of calcium aluminate cement comprising calcium sulfate to lithium hydroxide ( $(CAC+CaSO_4)/LiOH$ ) in the product obtained by mixing components A and B is in the range of from 1.3:1 to 12.5:1.
- 10 11. Use according to any one of items 1 to 10, wherein the ratio of calcium aluminate cement comprising calcium sulfate to lithium hydroxide ( $(CAC+CaSO_4)/LiOH$ ) in the product obtained by mixing components A and B is in the range of from 1.3:1 to 12.5:1.
12. Use according to any one of items 1 to 11, wherein the calcium sulfate in the product obtained by mixing components A and B is present in the range of from 0.95 wt.-% to 18.0 wt.-%.
- 15 12. Use according to any one of items 1 to 11, wherein the calcium sulfate in the product obtained by mixing components A and B is present in the range of from 0.95 wt.-% to 18.0 wt.-%.
13. Use according to any one of items 1 to 12, wherein the anchoring means are anchor rods, threaded anchor rods, bolts or steel reinforcement bars.
- 20 13. Use according to any one of items 1 to 12, wherein the anchoring means are anchor rods, threaded anchor rods, bolts or steel reinforcement bars.
14. Use according to any one of items 1 to 13, wherein the mineral surfaces are structures made of brickwork, concrete, pervious concrete or natural stone.
15. Use according to any one of items 1 to 14, wherein the mineral surface is a wet borehole.
- 25 15. Use according to any one of items 1 to 14, wherein the mineral surface is a wet borehole.
16. Use according to any one of items 1 to 15, wherein the mineral surface is a diamond drilled borehole.
17. An inorganic mortar system for a chemical fastening of an anchor in a mineral surface, the inorganic mortar system comprising:  
calcium sulfate,  
a curable aluminous cement component A, and  
an initiator component B for initiating a curing process,
- 30 17. An inorganic mortar system for a chemical fastening of an anchor in a mineral surface, the inorganic mortar system comprising:  
calcium sulfate,  
a curable aluminous cement component A, and  
an initiator component B for initiating a curing process,

- wherein component A comprises water, a calcium aluminate cement, at least one plasticizer, and at least one blocking agent selected from the group consisting of phosphoric acid, metaphosphoric acid, phosphorous acid, and a phosphonic acid,
- 5 component B comprises an initiator comprising LiOH, at least one retarder, at least one mineral filler, and water,
- component A and component B are separate,
- a ratio of calcium aluminate cement comprising calcium sulfate to lithium hydroxide ((CAC+CaSO<sub>4</sub>)/LiOH) in the product obtained by mixing components
- 10 A and B is in the range of from 1.3:1 to 12.5:1,
- the calcium sulfate in the product obtained by mixing components A and B is present in the range of from 0.95 wt.-% to 18.0 wt.-% and
- a mortar prepared from said inorganic mortar system has a chemical shrinkage of from -0.61 to -1.61.
- 15
18. The inorganic mortar system according to item 17, wherein component A comprising an aqueous-phase calcium aluminate cement.
19. The inorganic mortar system according to item 17 or 18, wherein
- 20 the calcium sulfate is in the form of calcium sulfate anhydrite, calcium sulfate hemihydrate or calcium sulfate dihydrate.
20. The inorganic mortar system according to any one of items 17 to 19, wherein the calcium sulfate is present in component A.
- 25
21. The inorganic mortar system according to item 20, wherein the calcium sulfate is present in component A in a ratio of calcium sulfate to calcium aluminate cement in a range of from 5/95 to 30/70.
- 30 22. The inorganic mortar system according to any one of items 17 to 21, wherein the initiator comprises a mixture of at least two of an alkali metal salt, an alkaline earth metal salt, and a combination thereof,
- the at least one retarder is selected from the group consisting of citric acid, tartaric acid, lactic acid, salicylic acid, gluconic acid, and a mixture thereof, and

the at least one mineral filler is selected from the group consisting of a limestone filler, sand, corundum, dolomite, alkaline-resistant glass, crushed stone, gravel, pebble, and a mixture thereof.

- 5 23. The inorganic mortar system according to any one of items 17 to 22, wherein the initiator comprises a mixture of at least two lithium metal salts.
24. The inorganic mortar system according to any one of items 17 to 23, wherein the ratio of water to calcium aluminate cement comprising calcium sulfate ( $W/(CAC+CaSO_4)$ ) in the product obtained by mixing components A and B is lower than 1.0.
- 10
25. The inorganic mortar system according to any one of items 17 to 24, wherein the anchor is an anchor rod, a threaded anchor rod, a bolt, or a steel reinforcement bar.
- 15
26. The inorganic mortar system according to any one of items 17 to 25, wherein the mineral surface is a structure comprising brickwork, concrete, pervious concrete, or natural stone.
- 20
27. The inorganic mortar system according to any one of items 17 to 26, wherein the mineral surface is a wet borehole.
28. The inorganic mortar system according to any one of items 17 to 27, wherein the mineral surface is a diamond drilled borehole.
- 25
29. A method of chemical fastening of an anchor in a mineral surface, the method comprising:  
setting the anchor in a borehole present in the mineral surface in the presence of the inorganic mortar system as defined in any one of items 17 to 28; and curing the inorganic mortar system, thereby increasing a load value of the borehole filled with a cured inorganic mortar system compared to a load value of a borehole without the cured inorganic mortar system.
- 30

30. A method of chemical fastening of an anchor in a mineral surface, the method comprising:
- 5 setting the anchor in a borehole present in the mineral surface in the presence of the inorganic mortar system as defined in any one of items 17 to 28; and curing the inorganic mortar system, thereby increasing a load value of the borehole filled with a cured inorganic mortar system, thereby decreasing shrinkage of a cured inorganic mortar system in the borehole compared to a load value of a borehole without the cured inorganic mortar system.
- 10 31. The method according to item 29 or 30, wherein the anchor is a metal element; and the mineral surface is at least one member selected from the group consisting of brickwork, concrete, pervious concrete, and natural stone.

## CLAIMS

1. Use of calcium sulfate in an inorganic mortar system for a chemical fastening of anchoring means in mineral surfaces, comprising a curable aluminous cement component A and an initiator component B for initiating the curing process,  
5 component A further comprising at least one blocking agent selected from the group consisting of phosphoric acid, metaphosphoric acid, phosphorous acid and phosphonic acids, at least one plasticizer and water, and component B comprising an initiator, at least one retarder, at least one mineral filler and water.  
10
2. Use according to claim 1, wherein the aluminous cement component A is an aluminous cement component based on an aqueous-phase calcium aluminate cement.
- 15 3. Use according to claim 1 or 2, wherein the calcium sulfate is in the form of calcium sulfate anhydrite, calcium sulfate hemihydrate or calcium sulfate dihydrate.
4. Use according to claim 1, 2 or 3, wherein the calcium sulfate is in the form of calcium sulfate hemihydrate.
- 20 5. Use according to any one of claims 1 to 4, wherein the calcium sulfate is comprised in the curable aluminous cement component A of the inorganic mortar system.
- 25 6. Use according to claim 5, wherein the calcium sulfate comprised in the curable aluminous cement component A is present in a ratio of calcium sulfate to aluminous cement in a range of from 5/95 to 30/70.
7. Use according to claim 5, wherein the calcium sulfate comprised in the curable aluminous cement component A is present in a ratio of calcium sulfate to aluminous cement in a range of from 15/85 to 25/75.  
30
8. Use according to any one of claims 1 to 7, wherein the initiator comprises a mixture of alkali and/or alkaline earth metal salts, the at least one retarder is selected from the group consisting of citric acid, tartaric acid, lactic acid, salicylic acid, gluconic acid and mixtures thereof, and the at least one mineral filler is  
35

selected from the group consisting of limestone fillers, sand, corundum, dolomite, alkaline-resistant glass, crushed stones, gravels, pebbles and mixtures thereof.

- 5 9. Use according to any one of claims 1 to 8, wherein the initiator comprises a mixture of lithium metal salts.
- 10 10. Use according to any one of claims 1 to 9, wherein the ratio of water to calcium aluminate cement comprising calcium sulfate ( $W/(CAC+CaSO_4)$ ) in the product obtained by mixing components A and B is lower than 1.0.
- 15 11. Use according to any one of claims 1 to 10, wherein the ratio of calcium aluminate cement comprising calcium sulfate to lithium hydroxide ( $(CAC+CaSO_4)/LiOH$ ) in the product obtained by mixing components A and B is in the range of from 1.3:1 to 12.5:1.
- 20 12. Use according to any one of claims 1 to 11, wherein the calcium sulfate in the product obtained by mixing components A and B is present in the range of from 0.95 wt.-% to 18.0 wt.-%.
- 25 13. Use according to any one of claims 1 to 12, wherein the anchoring means are anchor rods, threaded anchor rods, bolts or steel reinforcement bars.
- 30 14. Use according to any one of claims 1 to 13, wherein the mineral surfaces are structures made of brickwork, concrete, pervious concrete or natural stone.
- 35 15. Use according to any one of claims 1 to 14, wherein the mineral surface is a wet borehole.
16. Use according to any one of claims 1 to 15, wherein the mineral surface is a diamond drilled borehole.
17. An inorganic mortar system for a chemical fastening of an anchor in a mineral surface, the inorganic mortar system comprising:  
calcium sulfate,  
a curable aluminous cement component A, and  
an initiator component B for initiating a curing process,

wherein component A comprises water, a calcium aluminate cement, at least one plasticizer, and at least one blocking agent selected from the group consisting of phosphoric acid, metaphosphoric acid, phosphorous acid, and a phosphonic acid,

5 component B comprises an initiator comprising LiOH, at least one retarder, at least one mineral filler, and water,

component A and component B are separate,

a ratio of calcium aluminate cement comprising calcium sulfate to lithium hydroxide ((CAC+CaSO<sub>4</sub>)/LiOH) in the product obtained by mixing components

10 A and B is in the range of from 1.3:1 to 12.5:1,

the calcium sulfate in the product obtained by mixing components A and B is present in the range of from 0.95 wt.-% to 18.0 wt.-% and

a mortar prepared from said inorganic mortar system has a chemical shrinkage of from -0.61 to -1.61.

15

18. The inorganic mortar system according to claim 17, wherein component A comprising an aqueous-phase calcium aluminate cement.

19. The inorganic mortar system according to claim 17 or 18, wherein  
20 the calcium sulfate is in the form of calcium sulfate anhydrite, calcium sulfate hemihydrate or calcium sulfate dihydrate.

20. The inorganic mortar system according to any one of claims 17 to 19, wherein the calcium sulfate is present in component A.

25

21. The inorganic mortar system according to claim 20, wherein the calcium sulfate is present in component A in a ratio of calcium sulfate to calcium aluminate cement in a range of from 5/95 to 30/70.

30 22. The inorganic mortar system according to any one of claims 17 to 21, wherein the initiator comprises a mixture of at least two of an alkali metal salt, an alkaline earth metal salt, and a combination thereof,  
the at least one retarder is selected from the group consisting of citric acid, tartaric acid, lactic acid, salicylic acid, gluconic acid, and a mixture thereof, and

the at least one mineral filler is selected from the group consisting of a limestone filler, sand, corundum, dolomite, alkaline-resistant glass, crushed stone, gravel, pebble, and a mixture thereof.

- 5    23.    The inorganic mortar system according to any one of claims 17 to 22, wherein the initiator comprises a mixture of at least two lithium metal salts.
24.    The inorganic mortar system according to any one of claims 17 to 23, wherein the ratio of water to calcium aluminate cement comprising calcium sulfate ( $W/(CAC+CaSO_4)$ ) in the product obtained by mixing components A and B is lower than 1.0.
- 10
25.    The inorganic mortar system according to any one of claims 17 to 24, wherein the anchor is an anchor rod, a threaded anchor rod, a bolt, or a steel reinforcement bar.
- 15
26.    The inorganic mortar system according to any one of claims 17 to 25, wherein the mineral surface is a structure comprising brickwork, concrete, pervious concrete, or natural stone.
- 20
27.    The inorganic mortar system according to any one of claims 17 to 26, wherein the mineral surface is a wet borehole.
28.    The inorganic mortar system according to any one of claims 17 to 27, wherein the mineral surface is a diamond drilled borehole.
- 25
29.    A method of chemical fastening of an anchor in a mineral surface, the method comprising:  
setting the anchor in a borehole present in the mineral surface in the presence of  
the inorganic mortar system as defined in any one of claims 17 to 28; and  
curing the inorganic mortar system, thereby increasing a load value of the  
borehole filled with a cured inorganic mortar system compared to a load value of  
a borehole without the cured inorganic mortar system.
- 30

30. A method of chemical fastening of an anchor in a mineral surface, the method comprising:  
setting the anchor in a borehole present in the mineral surface in the presence of the inorganic mortar system as defined in any one of claims 17 to 28; and  
5 curing the inorganic mortar system, thereby increasing a load value of the borehole filled with a cured inorganic mortar system, thereby decreasing shrinkage of a cured inorganic mortar system in the borehole compared to a load value of a borehole without the cured inorganic mortar system.
- 10 31. The method according to claim 29 or 30, wherein  
the anchor is a metal element; and  
the mineral surface is at least one member selected from the group consisting of brickwork, concrete, pervious concrete, and natural stone.