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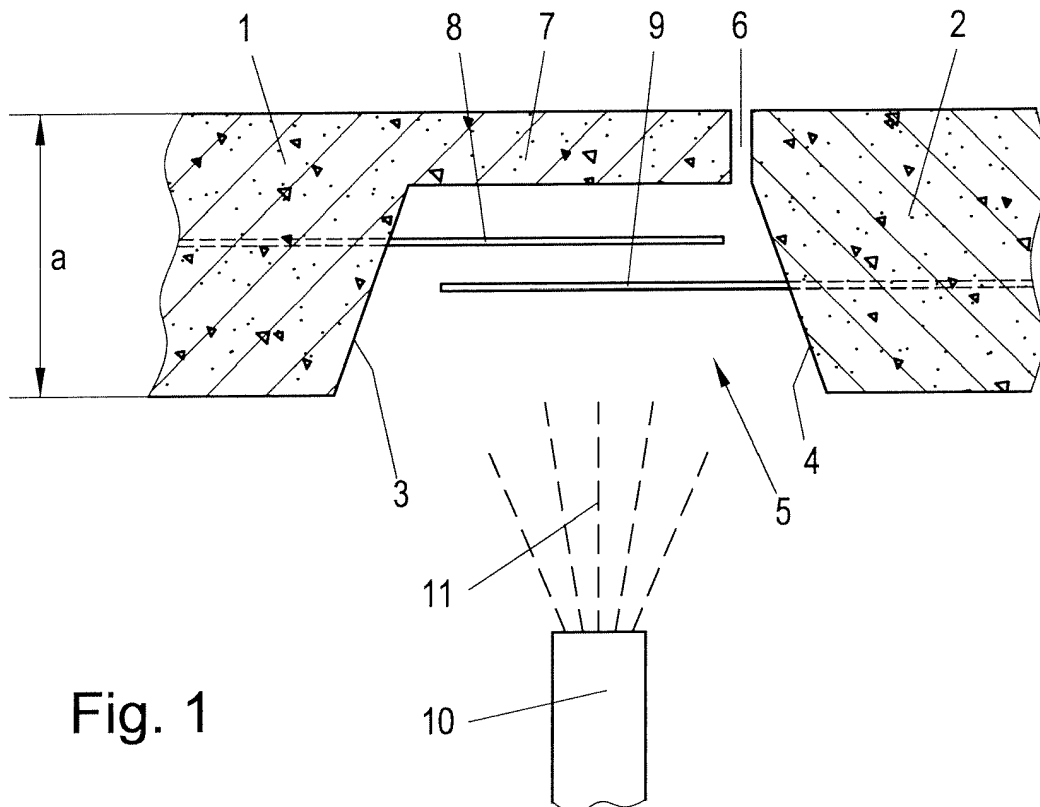
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(54) METHOD FOR JOINING TWO ELEMENTS

(57) In a method for joining two elements (1,2), such as reinforced concrete elements or steel elements, with each other along a vertical joint, wherein the elements comprise protruding parts (8,9) that protrude from the elements along the vertical joint, the method comprises the steps of arranging elements with the face sides facing

each other, wherein the elements define a pocket (5) extending in a vertical direction along the vertical joint, wherein the pocket comprises an opening extending in the vertical direction along the joint, pneumatically applying fresh concrete or mortar into the pocket via the opening and allowing the concrete or mortar to harden.

**Fig. 1**

Description

[0001] The invention refers to a method for joining two elements, such as two reinforced concrete elements or two steel elements, with each other along a vertical joint, the elements comprising protruding parts that protrude from the elements along the vertical joint.

[0002] Further, the invention refers to precast concrete elements for use in the above method, two of said concrete elements being joinable along a vertical joint.

[0003] Precast reinforced concrete elements are widely used in the building industry. Precast concrete elements are produced by casting concrete in a reusable mould, which is then cured in a controlled environment. The precast concrete elements are then transported to the construction site and lifted into place.

[0004] Concrete towers for wind turbines are normally built from precast concrete segments. These segments (usually three to five segments) are assembled to create cylindrical tower sections, which are later stacked on top of each other to create a tower.

[0005] Towers for wind turbines may alternatively be built using only steel, or combination of steel and concrete elements, the latter towers being commonly called hybrid towers. The steel elements can be entire sections, or segments that are then assembled together at the construction site to form sections. In the case of hybrid towers, the concrete elements, the segments, are typically assembled together to form sections, onto which steel sections are attached, usually by bolting.

[0006] Various techniques exist for connecting adjoining precast concrete elements with each other. In the case of towers for wind turbines, the concrete segments must be connected with each other along a vertical joint. Prior art joining methods comprise arranging the concrete elements with their face sides facing each other, wherein the face sides are configured to define a pocket extending in a vertical direction along the vertical joint. Rebars are inserted into the pocket between two segments and then the pocket is either filled with cement-based grout from above, or filled from the bottom by pumping. The latter method requires high-end pumping equipment on the construction site because of the high pressure required to fill the pocket. In order to prevent the grout from flowing out of the pocket, the pocket is closed with the exception of at least one opening for filling the pocket with grout. Further, at least one sealing element is provided between the adjoining concrete elements in order to seal the pocket.

[0007] This prior art method has numerous drawbacks. First, a high hydrostatic pressure is observed in the pocket once it has been filled with the cement-based grout. The vertical joint and thus the vertical pocket can be as high as 20-30m, which creates a high pressure within the pocket. The concrete parts delimiting the pocket as well as the sealing must withstand this pressure. Second, the sealing must be tight to prevent any leakage of the highly flowable grout. Installing the sealing creates complexity

on the building site.

[0008] Further, the need for closed pockets results in a complex manufacturing process of such segments, because the required formwork and the reinforcement are difficult to realize. In addition, the protrusions required for creating closed pockets are relatively fragile during transportation and installation.

[0009] Another drawback is the possible segregation of the grout due to free-fall when it is grouted from the top.

[0010] Once the vertical joint has been realized by filling a closed pocket with cement-based grout, the joint is not-accessible from neither sides, which makes any quality control very complicated and practically eliminates any possibility of repair, both during installation and during service time.

[0011] Therefore, it is an object of the invention to provide an improved method for joining two reinforced concrete elements with each other along a vertical joint. In particular, it is an object of the invention to overcome the above drawbacks.

[0012] For this purpose, the present invention generally provides a method for joining two elements, such as reinforced concrete elements or steel elements, with each other along a vertical joint, wherein the elements comprise protruding parts that protrude from the elements along the vertical joint, the method comprising:

- arranging the elements with face sides facing each other and the elements defining a pocket extending in a vertical direction along the vertical joint, wherein the pocket comprises an opening extending in the vertical direction along the joint and wherein the protruding parts of the elements protrude into the pocket,
- pneumatically applying fresh concrete or mortar into the pocket via the opening,
- allowing the concrete or mortar to harden.

[0013] In case the elements to be joined are reinforced concrete elements, the concrete elements having rebar embedded therein, wherein the rebar comprises protruding rebar sections that protrude from the concrete elements on face sides thereof, the method comprises:

- arranging the concrete elements with the face sides facing each other, the face sides being configured to define a pocket extending in a vertical direction along the vertical joint, wherein the pocket comprises an opening extending in the vertical direction along the joint and wherein the protruding rebar sections of the concrete elements protrude into the pocket,
- pneumatically applying fresh concrete or mortar into the pocket via the opening,
- allowing the concrete or mortar to harden.

[0014] Alternatively, in case the elements to be joined are steel elements, preferably steel segments, the steel elements comprising steel nuts that are welded or bolted

to the steel segments in a region along the vertical joint, wherein the method comprises:

- arranging the elements with face sides facing each other and the elements having bordering elements for defining between them a pocket extending in a vertical direction along the vertical joint, wherein the pocket comprises an opening extending in the vertical direction along the joint and wherein the steel nuts protrude into the pocket,
- pneumatically applying fresh concrete or mortar into the pocket via the opening,
- allowing the concrete or mortar to harden
- optionally removing the bordering elements.

[0015] Therefore, the invention is based on the idea to realize vertical joints between adjoining concrete or steel elements by pneumatically applying fresh concrete or mortar into a pocket that is formed between the concrete or steel elements along the vertical joint. Pneumatically applying, i.e. wet or dry spraying, fresh concrete or mortar is often referred to as "shotcreting" and is a well-known construction technique for applying fast hardening concrete for stabilization and support of structures. Shotcreting comprises conveying concrete or mortar through a hose and pneumatically projecting the same at high velocity onto a surface. In order to pneumatically project the concrete or mortar, the hose typically has a nozzle at its outlet end, into which a compressed air line opens, wherein the compressed air atomizes and ejects the concrete or mortar. Preferably, a wet spraying process is used, which means that the fresh concrete is conveyed as a ready-mixed concrete already mixed with water to the spraying nozzle. For spraying, the wet concrete is mixed with air and optionally with shotcrete accelerators and then applied.

[0016] In order to pneumatically apply the fresh concrete or mortar into the pocket, the pocket is configured as an open pocket having an opening extending in the vertical direction along the joint, wherein the concrete or mortar enters the pocket via said opening so as to at least partially fill the pocket with fresh concrete or mortar. In other words, the pocket is used as a mould for the concrete applied by shotcreting. According to a preferred embodiment, the shotcreting process is carried out so as to essentially completely fill the pocket with fresh concrete or mortar.

[0017] When filling the pocket with fresh concrete or mortar, the protruding parts, in particular the protruding rebar sections of the concrete elements or the protruding nuts of the steel elements, that protrude into the pocket from both sides should be embedded into the concrete or mortar as completely as possible. Therefore, according to a preferred embodiment of the invention, fresh concrete or mortar is pneumatically applied into the pocket so as to completely cover the protruding parts.

[0018] Shotcreting preferably comprises ejecting fresh concrete or mortar from a shotcrete nozzle in a direction

essentially perpendicular to the vertical direction of the vertical joint and vertically moving the shotcrete nozzle along the vertical joint. According to a preferred embodiment, the concrete or mortar is pneumatically applied into the pocket from the bottom to the top, or from the top to the bottom.

[0019] Fresh concrete or mortar used for shotcreting is most often characterized by an accelerated setting so that it essentially remains in place after its application.

[0020] Realizing a vertical joint between adjoining concrete elements by shotcreting solves various problems connected with prior art methods. Because no grout is used that is poured into a closed pocket from above, problems connected with a high hydrostatic pressure within the pocket are avoided. Because there is no high pressure prevailing within the pocket, one can do without sealing the pocket. Further, since the pocket is not a closed pocket, but an open pocket, the profile of the face sides of the concrete elements does not need to be designed with a view to obtain a closed structure, but with a view to be able to realize simple and robust precast elements. In this way, the complexity of the formwork is greatly reduced.

[0021] Further, shotcreting prevents a segregation of the fresh concrete, which would otherwise occur due to the free-fall of grout into the closed pocket from the top.

[0022] Most importantly, the method of the invention allows an immediate quality control of the joint as well as a repair if required. In particular, an inspection of the joint is made possible with the invention before or after installation due to the open access to the joint via the opening of the pocket.

[0023] Although the pocket does not necessarily need a sealing, an embodiment of the invention provides that the pocket is sealed on a back side thereof opposite the opening by arranging a sealing element between the face sides of the concrete elements.

[0024] The pocket can have any cross sectional shape that comprises an opening on one side of the joint. The term "cross-section" refers to a cross section in a plane that is perpendicular to the vertical direction of the vertical joint. When seen in a cross sectional view of the pocket, the opening, on one surface of the concrete elements, forms a gap or groove between the adjoining concrete elements. In contrast, on the opposite side of the concrete elements, the pocket is closed.

[0025] According to a preferred embodiment of the invention, the pocket has a trapezoidal or triangular cross section. In case of a triangular cross section, the opening is arranged on one side of the three sides of the triangular form. In case of a trapezoidal cross section, the opening is arranged on the longer side of the two parallel sides of the trapezoidal form.

[0026] The main purpose of the joint is to transfer the load from one concrete or steel element to the adjoining concrete or steel element so as to create a monolithic structure. To this end, the elements have protruding parts that protrude into the pocket that is formed between two

adjoining concrete elements. The fresh concrete or mortar pneumatically applied into the pocket adheres to the protruding parts that protrude into the pocket and thereby creates a connection between the protruding parts of the one element and the protruding parts of the other element.

[0027] In case of concrete elements, the protruding parts consist of protruding rebar sections. The term "rebar" as used herein is understood to define reinforcement steel, such as, e.g., steel bars or a mesh of steel wires.

[0028] In order that the fresh concrete applied into the pocket ensures a strong connection between the protruding rebar sections, according to a preferred embodiment, the protruding rebar sections protruding into the pocket from opposite sides of the pocket are overlapping each other when seen in a vertical direction.

[0029] In another embodiment, the protruding rebar sections protruding into the pocket from opposite sides of the pocket are directly connected with or fixed to each other.

[0030] Preferably, additional reinforcing elements are placed in the pocket before applying the fresh concrete or mortar. In particular, said additional reinforcing elements are arranged to connect with each other the protruding parts, in particular the protruding rebar sections, protruding into the pocket from opposite sides of the pocket.

[0031] The term "concrete" as used herein is understood to define a mixture of a hydraulic binder (e.g. cement), aggregate, water, optionally additives, and optionally mineral additions. Generally, any type of concrete that is suitable for shotcreting may be used within the scope of the instant invention, in particular any structural concrete that complies with the standard NF EN 1992-1-1 of October 2005. Structural concrete generally has a compressive strength measured at 28 days of greater than or equal to 12 MPa, in particular 12-300 MPa.

[0032] The concrete may contain a shotcrete accelerator, in order to accelerate the setting once it has been applied into the pocket.

[0033] The term "hydraulic binder" as used herein is understood to define a material, which sets by hydration, for example a cement.

[0034] The concrete pneumatically applied into the pocket may comprise metal fibers and/or organic fibers and/or glass fibers. The quantity by volume of fibers is generally from 0.5 to 8% relative to the volume of the hardened concrete. The quantity of metal fibers, expressed in terms of volume of the final hardened concrete is generally less than 4%, for example from 0.5 to 3.5%, preferably approximately 2%. The quantity of organic fibers, expressed on the same basis, is generally from 1 to 8%, preferably from 2 to 5%. The metal fibers are generally chosen from the group including steel fibers, such as high strength steel fibers, amorphous steel fibers or stainless steel fibers. The steel fibers may optionally be coated with a non-ferrous metal such as copper, zinc, nickel (or alloys thereof).

[0035] The individual length (1) of the metal fibers is generally at least 2 mm and is preferably 6 to 30 mm. The ratio l/d (d being the diameter of the fibers) is generally from 10 to 300, preferably from 30 to 300, preferably from 30 to 100.

[0036] The organic fibers comprise polyvinyl alcohol (PVA) fibers, polyacrylonitrile (PAN) fibers, fibers of polyethylene (PE), high-density polyethylene (HDPE) fibers, polypropylene (PP) fibers, homo- or copolymers, polyamide or polyimide fibers. Mixtures of these fibers may be used. The organic reinforcing fibers used in the invention may be classified as follows: high modulus reactive fibers, low modulus non-reactive fibers and low modulus reactive fibers. The presence of organic fibers makes it possible to modify the behavior of the concrete in relation to heat or fire.

[0037] The individual length of the organic fibers is preferably from 5 to 40 mm, preferably from 6 to 30 mm, more preferably from 6 to 12 mm. The organic fibers are preferably PVA fibers.

[0038] In order to resist high loads, the fresh concrete is selected so as to obtain a 28d compressive strength of > 70 MPa, and to develop high strength at early ages in order to increase the efficiency of the construction process.

[0039] Preferably, a ultra high performance concrete (UHPC) or high performance concrete (HPC) is used as said fresh concrete. A ultra-high performance concrete, such as, e.g. Ductal® supplied by LafargeHolcim, is a particular type of high-performance concrete and generally has a resistance to compression at 28 days greater than 100 MPa and generally greater than 120 MPa.

[0040] According to a preferred embodiment, a ultra high performance concrete is used that is optimized for being applied by spraying. Such a ultra high performance concrete is disclosed in WO 2015/193419 A1 and in WO 2015/193444 A1, the disclosure of which is incorporated herein by reference. A particular advantage of these applications is that they enable shotcreting of ultra high performance concrete without the use of shotcrete accelerators, as the rheology of the fresh concrete prevents it from flowing down after it is shotcreted.

[0041] Accordingly, an ultra high performance concrete is used, which comprises in relative parts by mass with respect to the cement:

- 100 parts of cement, the particles of which have a BET specific surface area comprised from 1.20 to 5 m^2/g ;
- 32 to 42 parts of water;
- 5 to 50 parts of a mineral addition A1, the particles of which have a D50 less than or equal to 6 μm and selected from silica fume, metakaolin, slag, pozzolans or mixtures thereof;
- 90 to 230 parts of sand the particles of, which have a D50 greater than or equal to 50 μm and a D90 less than or equal to 3 mm;
- 0.0001 to 10 parts of a superplasticizer, the active

material concentration of which is 15% by mass.

[0042] Preferably, an ultra high performance concrete is used, which comprises in relative parts by mass with respect to the cement:

- 100 parts of cement, the particles of which have a BET specific surface area comprised from 1.20 to 1.7 m²/g;
- 38 to 42 parts of water;
- 8 to 20 parts of a mineral addition A1, the particles of which have a D50 less than or equal to 6 μm and selected from silica fume, metakaolin, slag, pozzolans or mixtures thereof;
- 90 to 180 parts of sand, the particles of which have a D50 comprised from 100 μm to 400 μm and a D90 less than or equal to 800 μm;
- 0.0001 to 10 parts of a superplasticizer, the active material concentration of which is 15% by mass.

[0043] Preferably, an ultra high performance concrete is used, which comprises a hydraulic binder comprising in mass per cent:

- from 20 to 82% of a Portland cement the particles of which have a D50 comprised from 2 μm to 11 μm;
- from 15 to 56% of a non-pozzolanic mineral addition A1, the particles of which have a D50 comprised from 1 to 150 μm and selected from among limestone additions, siliceous additions, siliceous limestone mineral additions, calcined shales, zeolites, burnt plant ashes, and mixtures thereof;
- from 4 to 30% of pozzolanic mineral addition A2, the particles of which have a D50 comprised from 1 to 150 μm;
- a sum of the percentages of the Portland cement, the non-pozzolanic mineral addition A1 and the pozzolanic mineral addition A2 being comprised from 90 to 100%.

[0044] When using an ultra high performance concrete (UHPC) for joining the concrete elements, the concrete mix must not necessarily contain a shotcrete accelerator, because the UHPC may have a fast setting capability without such accelerator being added.

[0045] The cement used is a cement of the CEM I type, in particular a cement of the CEM I 52.5N strength class, according to the classification given in EN 197-1 of February 2001.

[0046] A particular advantageous application of the invention consists in joining concrete elements for building towers for wind turbines. Accordingly, a preferred embodiment of the method provides that the concrete elements are configured as segments of concrete towers, such as concrete towers for wind turbines, and the concrete elements are arranged with their face sides facing each other so as to form a tower or a tower section having

a cylindrical or polygonal cross section.

[0047] Preferably, the opening of the pocket is directed to the interior of the tower. This enables the pneumatic application of the fresh concrete from the interior of the tower. While conventional shotcreting may require complex and bulky equipment due to the large concrete volumes to apply, the volume of concrete to be applied is smaller when using a high performance concrete or a ultra high performance concrete. Therefore smaller equipment may be used that can easily be loaded onto a suspended platform or cradle that would then carry all the equipment and materials to shotcrete the UHPC or HPC to place a joint between adjoining tower segments.

[0048] The invention also refers to the use of a ultra high performance concrete (UHPC) or a high performance concrete (HPC) for joining two reinforced concrete elements with each other along a vertical joint, wherein the fresh concrete is pneumatically applied along the joint.

[0049] With regard to preferred features of the use aspect of the invention, reference is made to the description of the method of the invention. Preferably, UHPC as disclosed in WO 2015/193419 A1 or in WO 2015/193444 A1 is used within the scope of the use aspect of the invention.

[0050] The invention further refers to precast concrete elements that may be used in the method according to the invention, wherein two of said concrete elements are joinable along a vertical joint, each concrete element having rebar embedded therein, wherein the rebar comprises protruding rebar sections that protrude from the concrete elements on face sides thereof, wherein the face sides are configured to define a pocket extending in a vertical direction along the vertical joint, wherein the pocket comprises an opening extending in the vertical direction along the joint and wherein the protruding rebar sections of the concrete elements protrude into the pocket.

[0051] The invention also refers to steel elements that may be used in the method according to the invention, wherein two of said steel elements are joinable along a vertical joint, each steel element having metallic bars welded or bolted onto it, wherein the metallic bars form for example a 90° angle with the inner surface facing the pocket of the steel elements, and are positioned where the concrete joint would be pneumatically applied. A temporary or definitive border may be positioned at either side of the metallic bars to define a pocket that then comprises an opening on the interior of the tower.

[0052] In the following, the invention will be described in more detail by reference to an exemplary embodiment illustrated in the drawings.

[0053] Therein, Fig. 1 shows a first embodiment and Fig. 2 shows a second embodiment of the invention referring to vertical joints of concrete segments, and Fig. 3 shows an embodiment of the invention referring to vertical joints of steel elements.

[0054] In Fig. 1 a first precast concrete element is de-

noted by 1 and a second precast concrete element is denoted by 2. The first and the second precast concrete elements 1,2 are to be joined with each other along a vertical joint. Fig. 1 is a cross section, wherein the plane of the cross section extends perpendicular to the vertical direction of the vertical joint. Therefore, the vertical direction of the joint is perpendicular to the drawing plane.

[0055] The first and second precast concrete elements 1,2 have side faces 3 and 4 facing each other and delimiting a pocket 5 that is arranged along the vertical joint. The vertical joint, when seen in the cross section according to Fig. 1, extends over a thickness a , which in this example corresponds to the thickness of the concrete elements 1 and 2. The pocket 5 does not extend over the entire thickness a . Rather, along a partial extent of the thickness a denoted by 6, the precast concrete elements 1 and 2 are adjoining each other directly, i.e. without a pocket or any other element being interposed. In the directly adjoining region 6 the concrete element 1 has a protrusion 7, the thickness of which is smaller than the thickness a .

[0056] The pocket 5 has a trapezoidally shaped cross section comprising the inclined side faces 3 and 4 and two parallel sides, the longer of which constitutes an opening of the pocket 5. The shorter one of the parallel sides forms the closed back side of the pocket 5.

[0057] The concrete elements 1 and 2 have rebar embedded therein, wherein the rebar comprises protruding rebar sections 8 and 9 that protrude from the concrete elements 1 and 2 into the pocket 5.

[0058] In order to join the concrete elements 1 and 2 with each other, fresh concrete 11 is sprayed into the pocket by means of a shotcrete equipment, the outlet nozzle 10 of which is illustrated in Fig. 1. The fresh concrete 11 is applied so as to at least partially fill the pocket 5. After the fresh concrete has set, the protruding rebar sections 8 and 9 are embedded in the concrete.

[0059] The embodiment of Fig. 2 corresponds to the embodiment of Fig. 1, wherein the same reference signs have been used for corresponding parts, except that the pocket 5 has a V-shape, a U-shape, or a triangular shape. Further, unlike the embodiment of Fig. 1 the protruding rebar sections 8 protruding from the concrete element 1 and the protruding rebar sections 9 protruding from the concrete element 2 do not overlap each other in a vertical view. Therefore, additional rebar elements 12 are arranged in the pocket 5, wherein the additional rebar elements 12 overlap or cross the protruding rebar sections 8 and 9 when viewed in a vertical view.

[0060] Fig. 3 shows a third embodiment of the invention, for vertical joints of steel segments. The steel elements 13 and 14 have metallic bars 15, or nuts, welded or bolted onto its surface, wherein the metallic bars 15 form a 90° angle with the inner surface of the steel elements. The protruding metallic bars 15 are positioned close to the vertical joint and between temporary or permanent borders 16 that define a pocket 18, into which concrete is applied according to this invention. Optional-

ly, an additional reinforcement element 17 may be positioned parallel to the surface of the steel elements 13 and 14, and vertical to the direction of the steel joint, its centre being aligned with the vertical joint, and its length enabling to cover some or all of the metallic bars 15.

[0061] In order to join the steel elements 13 and 14 with each other, fresh concrete is sprayed into the pocket 18 by means of a shotcrete equipment, the outlet nozzle 10 of which is illustrated in Fig. 3. The fresh concrete is applied so as to at least partially fill the pocket 18, and cover the additional reinforcement steel element 17 if it is used. After the fresh concrete has set, the protruding metallic bars 15 are embedded in the concrete.

Claims

1. Method for joining two elements, such as reinforced concrete elements or steel elements, with each other along a vertical joint, wherein the elements comprise protruding parts that protrude from the elements along the vertical joint, the method comprising:

- arranging the elements with face sides facing each other and the elements defining a pocket extending in a vertical direction along the vertical joint, wherein the pocket comprises an opening extending in the vertical direction along the joint and wherein the protruding parts of the elements protrude into the pocket,
- pneumatically applying fresh concrete or mortar into the pocket via the opening,
- allowing the concrete or mortar to harden.

2. Method according to claim 1, wherein the reinforced concrete elements have rebar embedded therein, wherein the rebar comprises protruding rebar sections that protrude from the concrete elements on face sides thereof, the method comprising:

- arranging the concrete elements with the face sides facing each other, the face sides being configured to define a pocket extending in a vertical direction along the vertical joint, wherein the pocket comprises an opening extending in the vertical direction along the joint and wherein the protruding rebar sections of the concrete elements protrude into the pocket,
- pneumatically applying fresh concrete or mortar into the pocket via the opening,
- allowing the concrete or mortar to harden.

3. Method according to claim 2, wherein the pocket has a trapezoidal or triangular cross section.

4. Method according to claim 1, 2 or 3, wherein the concrete or mortar is pneumatically applied into the

- pocket from the bottom to the top, or from the top to the bottom.
5. Method according to claim 2, 3 or 4, wherein the protruding rebar sections protruding into the pocket from opposite sides of the pocket are overlapping each other when seen in a vertical direction. 5
 6. Method according to any one of claims 1 to 5, wherein additional reinforcing elements are placed in the pocket before applying the fresh concrete or mortar. 10
 7. Method according to claim 6, wherein the additional reinforcing elements are arranged to connect with each other the protruding parts, in particular the protruding rebar sections, protruding into the pocket from opposite sides of the pocket. 15
 8. Method according to any one of claims 1 to 7, wherein the fresh concrete is selected so as to obtain a 28d compressive strength of > 70 MPa. 20
 9. Method according to any one of claims 1 to 8, wherein ultra high performance concrete (UHPC) or high performance concrete (HPC) is used as said fresh concrete. 25
 10. Method according to claim 9, wherein an ultra high performance concrete is used, which comprises in relative parts by mass with respect to the cement: 30
 - 100 parts of cement, the particles of which have a BET specific surface area comprised from 1.20 to 5 m²/g;
 - 32 to 42 parts of water;
 - 5 to 50 parts of a mineral addition A1, the particles of which have a D50 less than or equal to 6 μm and selected from silica fume, metakaolin, slag, pozzolans or mixtures thereof;
 - 90 to 230 parts of sand the particles of, which have a D50 greater than or equal to 50 μm and a D90 less than or equal to 3 mm;
 - 0.0001 to 10 parts of a superplasticizer, the active material concentration of which is 15% by mass.
 11. Method according to claim 9 or 10, wherein an ultra high performance concrete is used, which comprises in relative parts by mass with respect to the cement: 50
 - 100 parts of cement, the particles of which have a BET specific surface area comprised from 1.20 to 1.7 m²/g;
 - 38 to 42 parts of water;
 - 8 to 20 parts of a mineral addition A1, the particles of which have a D50 less than or equal to 6 μm and selected from silica fume, metakaolin, slag, pozzolans or mixtures thereof;
 - 90 to 180 parts of sand, the particles of which have a D50 comprised from 100 μm to 400 μm and a D90 less than or equal to 800 μm;
 - 0.0001 to 10 parts of a superplasticizer, the active material concentration of which is 15% by mass.
 12. Method according to any one of claims 9 to 11, wherein an ultra high performance concrete is used, which comprises a hydraulic binder comprising in mass per cent:
 - from 20 to 82% of a Portland cement the particles of which have a D50 comprised from 2 μm to 11 μm;
 - from 15 to 56% of a non-pozzolanic mineral addition A1, the particles of which have a D50 comprised from 1 to 150 μm and selected from among limestone additions, siliceous additions, siliceous limestone mineral additions, calcined shales, zeolites, burnt plant ashes, and mixtures thereof;
 - from 4 to 30% of pozzolanic mineral addition A2, the particles of which have a D50 comprised from 1 to 150 μm;
 - a sum of the percentages of the Portland cement, the non-pozzolanic mineral addition A1 and the pozzolanic mineral addition A2 being comprised from 90 to 100%.
 13. Method according to any one of claims 10 to 12, wherein the concrete compositions further comprise organic and/or metal and/or glass fibers.
 14. Method according to any one of claims 1 to 13, wherein the concrete elements or the steel elements are configured as segments of towers, such as concrete and/or steel towers for wind turbines, and the concrete or steel elements are arranged, in particular with their face sides facing each other, so as to form a tower or a tower section having a cylindrical or polygonal cross section. 35
 15. Method according to claim 14, wherein the opening of the pocket is directed to the interior of the tower. 40
 16. Use of a ultra high performance concrete (UHPC) or a high performance concrete (HPC) for joining two elements, such as reinforced concrete elements or steel elements, with each other along a vertical joint, wherein the fresh concrete is pneumatically applied along the joint. 45
 17. Precast concrete elements for use in a method according to any one of claims 1 to 15, two of said concrete elements being joinable along a vertical joint, the concrete elements having rebar embedded therein, wherein the rebar comprises protruding re-

bar sections that protrude from the concrete elements on face sides thereof, wherein the face sides are configured to define a pocket extending in a vertical direction along the vertical joint, wherein the pocket comprises an opening extending in the vertical direction along the joint and wherein the protruding rebar sections of the concrete elements protrude into the pocket.

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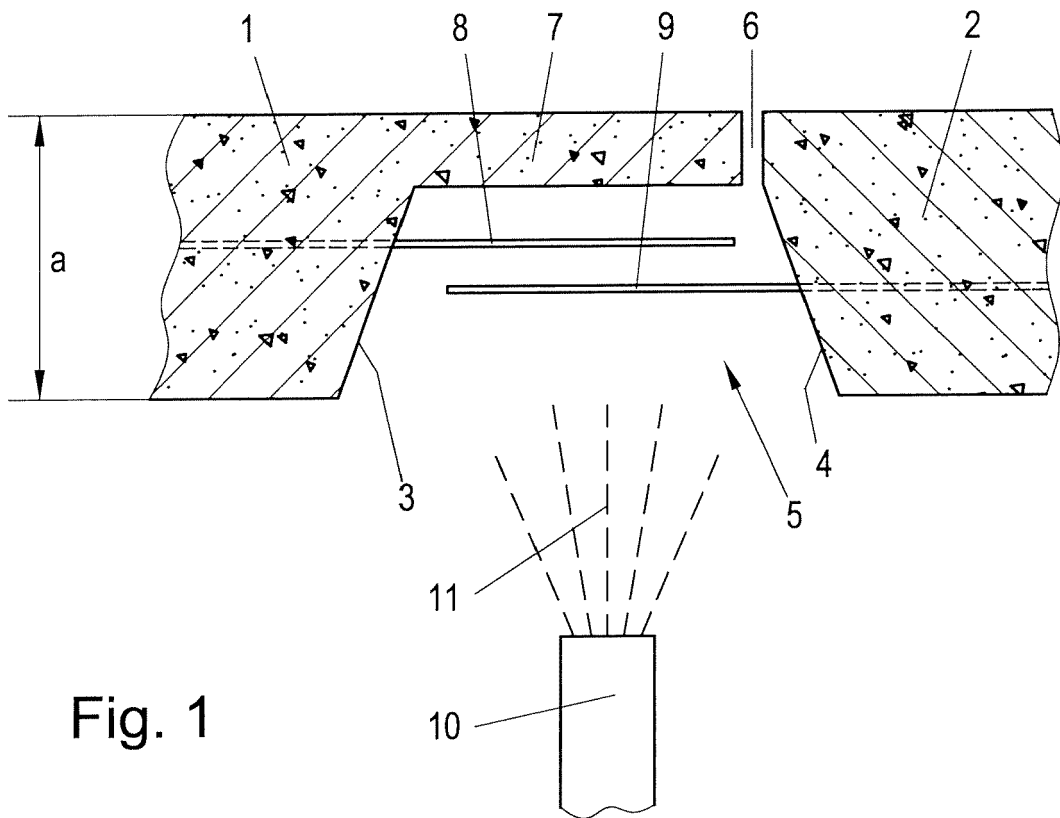


Fig. 1

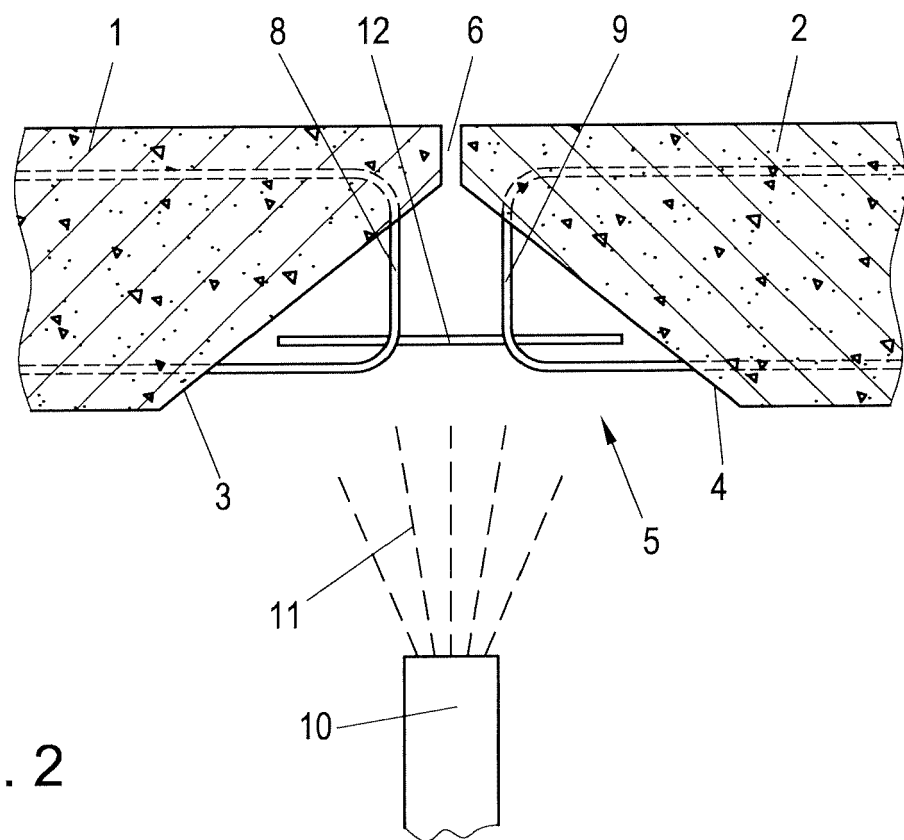


Fig. 2

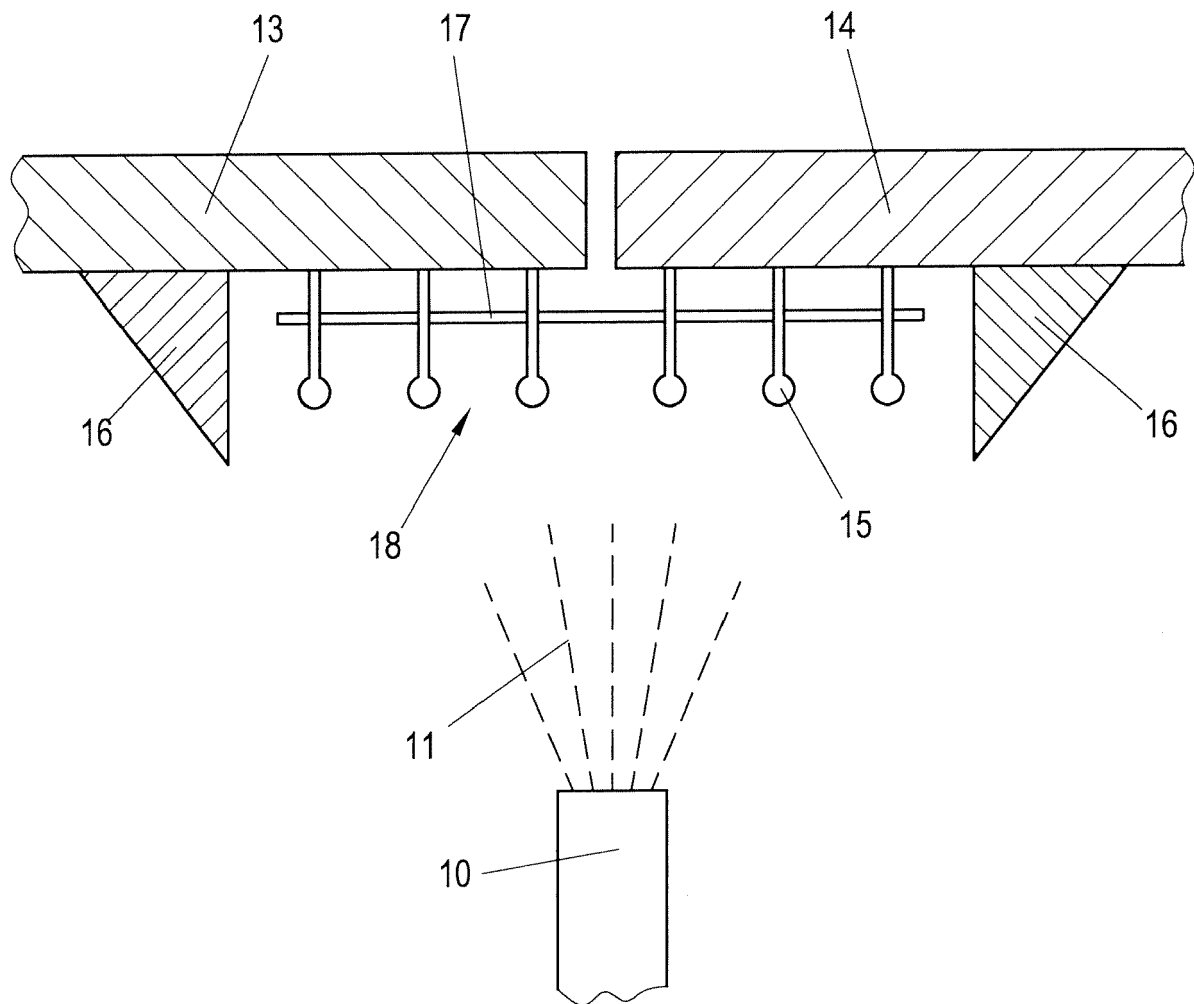


Fig. 3



PARTIAL EUROPEAN SEARCH REPORT

Application Number

under Rule 62a and/or 63 of the European Patent Convention.
This report shall be considered, for the purposes of
subsequent proceedings, as the European search report

EP 17 29 0127

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2016/348391 A1 (ZAVITZ BRYANT A [US] ET AL) 1 December 2016 (2016-12-01)	17	INV. E04H12/12 E04B1/61 E04B2/84
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INCOMPLETE SEARCH

The Search Division considers that the present application, or one or more of its claims, does/do not comply with the EPC so that only a partial search (R.62a, 63) has been carried out.

Claims searched completely :

Claims searched incompletely :

Claims not searched :

Reason for the limitation of the search:

see sheet C

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EPO FORM 1503 03.82 (P04E07)

Place of search	Date of completion of the search	Examiner
Munich	13 June 2018	Rosborough, John
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**INCOMPLETE SEARCH
SHEET C**

Application Number

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Claim(s) completely searchable:
1-15, 17

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Claim(s) not searched:
16

Reason for the limitation of the search:

15

According to Rule 62a EPC, the first independent claim in each category forms the basis of the search.

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