Title: METHOD FOR MANUFACTURING SPLIT-FACED CONCRETE PIECES, A SPLIT-FACED CONCRETE PIECE, AND MEANS FOR APPLYING THE METHOD

Abstract: The invention relates to a method for manufacturing a split-faced concrete piece, a split-faced concrete piece, and a means for applying the method. During casting, a reactive material is added to the concrete to form the desired split-faced surface, the reactive material being of a type that causes a splitting pressure in the concrete piece, due to expansion or some other reaction.
Method for manufacturing split-faced concrete pieces, a split-faced concrete piece, and a means for applying the method

The present invention relates to a method for manufacturing split-faced concrete pieces, a split-faced concrete piece, and a means for applying the method. The invention particularly relates to concrete pieces that are the size of or bigger than garden slabs and similar.

Existing methods can be used to give many different kinds of structure to concrete surfaces. The structure is most easily achieved by leaving untouched a concrete surface that has been against a smooth mould. This is termed a plasterless concrete surface. The mould material may also be shaped. The structure in question is then copied onto the cast concrete surface. This leaves a so-called cement paste, i.e. a material comprising cement and fines, on the surface.

The concrete surface can also be broken, to reveal the coarser particles, such as stones, contained in the concrete. The simplest way to create such a surface structure is to use a so-called surface retardant, which retards the setting of the concrete, between the mould material and the concrete material being cast. When the rest of the concrete piece has already set, the surface concrete is still plastic. After the mould has been removed, the plastic surface concrete is then washed off, for example, using a water jet. This surface is called exposed-aggregate concrete and is typified by the coarser aggregate particles, such as stones, in the concrete becoming fully visible in the surface of the concrete.

Concrete surfaces can be mechanically broken, for example, by sand-blasting or chipping. Chemical means, such as acid washing, are also used, as are thermal treatments, such as flame treatment. In all of these methods, the treatment of the surface is laborious; i.e. it demands work-time and energy and produces a great deal of waste. All of these methods are also characterized by a great need for labour, and a high consumption of material, such as water. They also create a great deal of sludge and other waste.

Split-faced concrete products can also be manufactured by mechanically striking
or bending the set concrete. Small concrete products, like wall masonry, are manufactured by cracking set concrete slabs into two or more parts. This reveals the split-faced surface structure. This method is in widespread use and is disclosed in, for example, patents DE 2921432 and CH 595588. In practice, the method is limited to the manufacture of small surfaces, because cracking in large surfaces has been uncontrolled. As it has been impossible to make large surfaces, if extensive surfaces are required, it has been necessary to set several small split-surface pieces next to each other, for example, in retaining walls and in brick-faced units.

Besides cracks that occur under mechanical stress, chemical mechanisms that create cracks are also known in concrete technology. Such mechanisms cause cracks if, for example, the cement contains an excess of free lime (CaO) or magnesium oxide, i.e. periclase (MgO). In such cases, the compounds referred to react in the set concrete to form expanding hydroxides. If concrete made from normal Portland cement must set in an environment containing sulphate, or, alternatively, if the reaction between the tricalcium aluminate contained in the cement and the gypsum is disturbed during setting, ettringite crystals, which expand and thus break the structure, may form in the set concrete. The aggregate in the concrete may also react with alkali metal compounds in the concrete, to form an expanding layer between the aggregate particle and the hardened cement paste. A common feature of these chemical damage mechanisms is that the expansion and resulting cracking of the concrete is uncontrolled and therefore always detrimental.

Desirable expansion is used in commercial applications, for example, to break stones and concrete pieces. The trade name of one product marketed in Finland is Betonamit. According to its instructions for use, the material is mixed with water and used to fill a hole drilled in the stone or concrete. Within a few days, the material in the hole has expanded, causing a pressure that breaks the structure. The instructions for use state that the material contains lime (CaO). Such methods are typified by tending to break the concrete or stone piece into small pieces and by uncontrolled cracking. The present invention is intended to achieve such a method that can be also applied to large concrete pieces. The intention is also to
achieve a method, by means of which large concrete pieces can be split controllably into two or more parts, so that the split faces can be used as such or processed for any purpose whatever, for which split-faced concrete has been traditionally used. The cracking is controlled and can be planned in advance and carried out repeatably.

These and other benefits and advantages of the invention are achieved by means of a method, products, and means, the characteristic features of which are stated in the accompanying Claims.

In brief, it can be stated that, the method according to the invention permits the creation of large split-faced concrete products, which are cracked in a controlled manner. According to the method, a significant part of the energy needed for cracking is produced by a reactive agent, which is placed during casting in the face to be split during casting, and which expands when it reacts. This expansion creates an internal pressure in the concrete, cracking the concrete along the boundary surface, in which the reactive agent has been placed.

The reactive material can be manufactured to be such that expansion starts only once the concrete has achieved a sufficient strength. This achieves the advantage that the stones in the boundary surface will have adhered so tightly to the concrete, that they split when the concrete cracks. These split stones give the surface structure their own special character, which differs, for example, from a plasterless concrete surface or other treated surfaces. Apart from the cracking being controllable, another significant difference is that the reactive material is introduced to the unset concrete, where it reacts with the aid of the moisture of the concrete material or with other compounds to cause cracking.

A clear advantage of the method according to the invention over old methods of producing a concrete surface with large visible aggregate particles is that the method according to the invention can be used to split thick cast concrete into two or more thin units. Thus it practically eliminates the waste created by all other methods that are intended to make a surface structure that at all similar, for example, when making a plasterless concrete surface. The reactive material can
be placed freely in the cast concrete, or it can be attached before casting to a mesh or other support structure, by means of which it is placed in the concrete structure. As it expands, it cracks the concrete surface from within. An application of this kind is especially beneficial in in-situ cast applications and in cases in which the aim is to have both the cast and the splitting boundary surface in a vertical position. It is also possible to make shaped split-shaped concrete structures, if the reactive material is attached to a sturdy support structure that can be shaped.

Casting can also be arranged so that the first unit being cast is allowed to set, before casting the next unit. The surface of the first unit cast should be treated so that the concrete that is cast later will adhere to the concrete that is cast first. In addition, to create a genuine split face, the surface that is cast first should contain raised aggregate particles that are split by the expanding material. The reactive material is placed before casting a second layer on top of the surface of the concrete that was cast first.

At present, the durability of façade concretes is ensured by using strong and dense concrete. This has been problematical, in that the retention of surfacings on the dense and smooth surface becomes uncertain. For example, slabs or rendering sprayed on the surface have often become detached. A split-faced unit manufactured according to the method eliminates this problem, as its good mechanical adhesion, also provides an excellent base for any surfacing materials used on the unit.

As units can be made to split precisely at a desired location, the method according to the invention can be used to manufacture large split-faced concrete units meeting the requirement to adequately cover reinforcement.

Tests were made to find the correct material, the optimal amount of it, and a work technique adaptable to different applications. The initial estimate of the amount of the commercial reactive material required was made using the diagram in the instructions for use, which shows the relationship between the pressure created and the time elapsed. According to a simple formula, about one kilogram of the material is enough to split in two a surface of about one square metre.
Example 1

1 kg of the reactive material containing free lime, in the form of approximately 10-mm diameter pellets, was sprinkled evenly over a freshly-cast horizontal concrete unit 10-cm thick and one metre square. K40 concrete, with a maximum aggregate particle size of 16 mm, was used. The consistency class of the concrete was 1sVB. Before the Betonamit was sprinkled, a few 30-mm granite stones were added to the boundary surface. After sprinkling, a new 15-cm layer of the same concrete used in the lower layer was cast and compacted on top of the original layer. When the unit was removed from the mould four days later, it could be seen that it had split as planned. When the split surface was examined, it could also be seen that most of the stones had split as previously planned.

Example 2

A test was made of how the reactive material containing free lime would function, if it was attached to a 10-cm gauge steel mesh. Otherwise, the test procedure was exactly the same as in Example 1. When the mould was removed at four-days age, it was seen that the unit had split as planned. The mesh could be easily removed from the split surface.

Example 3

A slab, with a 60-cm side, was cast in stiff slab concrete. About 100g of quicklime (CaO), with a particle size of 1 – 5 mm, was sprinkled on top of the first slab, which was about 5-cm thick.

A similar layer of the same concrete was cast and compacted on top of the said slab. When the mould was removed the next day, only a small external force was needed to easily separate the slabs. Some stones in the boundary surface had split.

Example 4
In one test investigating working techniques, four cardboard tubes containing the reactive material were placed parallel to each other at intervals of about half a metre on the surface of the cast concrete. The unit used was 2 m x 2 m, both cast layers being 20-cm thick. The concrete was the same grade as that used in tests 1 and 2. As the concrete set, the moisture travelled through the cardboard tube to start an expanding reaction, which broke the concrete along the row of tubes. This created a concrete surface that looked very much like a surface created in quarrying, i.e. the tubes left traces in the concrete looking like drill holes.

As could be clearly decided from the previous examples, the method according to the invention creates products with an very wide area of application. Concrete products created according to the invention can be used as such for many purposes, to create a lively and aesthetically pleasing surface. In addition, the products are very suitable for further processing, due, for example, to the excellent adhesion of surfacing materials to the surface created.

The means developed to apply the method comprises a suitable support structure, such as a steel mesh, a mesh of a plastic material, or even a mesh of paper string, which is impregnated with the reactive substance or to which the reactive substance is attached using a generally known method. Glue-like materials, for example, can be used for the attachment, which in certain cases can also rely purely on the reactive material’s own properties. Obviously, it is not necessary for the support material to be a mesh. As stated above, one embodiment was to put the reactive material inside a tube permeable by moisture. Many other applications can also be envisaged.

Besides it being possible to use the method according to the invention to create large surfaces, the invention can also be applied to create curved or shaped surfaces. This means that the reactive material must be set in the desired shape in the concrete cast. If a stiff or relatively stiff mesh or other support structure for the reactive substance is used, curved or shaped surfaces can be easily created. For example, if the material to be spread is used in granular form, the concrete to be cast will need a certain amount of stiffness, to permit curved surfaces.
The invention is not limited to the above examples of embodiments, but is adaptable in many ways, while still remaining within the scope of the protection defined by the accompanying Claims and the inventive idea.
Claims

1. A method for manufacturing a split-faced concrete piece, characterized in that, during casting, a reactive material is added to the concrete to form the desired split-faced surface and that the reactive material is of a type that causes a cracking pressure in the concrete piece through expansion or some other reaction.

2. A method according to Claim 1, characterized in that the reactive material is added to the cast concrete layer essentially over its entire area and a second layer of concrete is cast on top of it.

3. A method according to Claim 2, characterized in that the reactive material is added to the set concrete layer, after which a second layer of concrete is cast on top of it.

4. A method according to Claim 1, characterized in that the reactive material is added to the surface to be cast attached to a support material or placed in containers, such a tubes.

5. A method according to Claim 1, characterized in that such a material that contains free lime (CaO), free magnesium oxide (MgO), a material containing sulphate, tricalcium aluminate, and gypsum, or other expanding materials.

6. A method according to one of the above Claims, characterized in that an amount of reactive material, sufficient to carry out the splitting only if external additional energy is applied, is added.

7. A method according to one of the above Claims, characterized in that the action of the reactive material is retarded in such a way that its principal action takes place only after the concrete has set.

8. A method according to Claim 7, characterized in that the reactive material is retarded by treating it with a material that permits moisture to slowly permeate.
9. A split-faced concrete unit, characterized in that it is created by placing, in the
location of the splitting surface, a reactive material intended to split the concrete
unit along the splitting surface, through expansion of some other reaction.

10. A means for creating a split-faced concrete unit, characterized in that it
comprises a support material, to which a reactive material is attached or in which it
is placed, and which it intended to be placed in the location of the split face to be
formed, to react in a manner that will create a splitting force.

11. A means according to Claim 10, characterized in that the means is a mesh,
fabric, or similar structure, to which the reactive material is attached.

12. A means according to Claim 10, characterized in that the means has a bag-
like, tubular, or similar structure, containing a wall permitting moisture to permeate,
and inside which the reactive material is placed.

13. A means according to Claim 10, characterized in that it is formed of tubular
structures impermeable by moisture, to be placed in the cast to form a split face
and to be filled after casting with a reactive material, which is made to react
afterwards.
A. CLASSIFICATION OF SUBJECT MATTER

IPC7: B28B 11/08, B28B 23/00
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: B28B, B32B, E04C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE, DK, FI, NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<tr>
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<td>US 4089924 A (MANN), 16 May 1978 (16.05.78), figure 5, abstract</td>
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<tr>
<td>Y</td>
<td>US 4409030 A (MINEGISHI ET AL), 11 October 1983 (11.10.83), abstract</td>
<td>1, 9, 10</td>
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<tr>
<td>A</td>
<td>US 3789759 A (JONES), 5 February 1974 (05.02.74), figure 1, abstract</td>
<td>1-13</td>
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<tr>
<td>A</td>
<td>US 4316583 A (KAWANO ET AL), 23 February 1982 (23.02.82), abstract</td>
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Further documents are listed in the continuation of Box C. See patent family annex.

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<table>
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<th>Publication date</th>
<th>Patent family member(s)</th>
<th>Publication date</th>
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<tbody>
<tr>
<td>US 4089924 A</td>
<td>16/05/78</td>
<td>NONE</td>
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<tr>
<td>US 4409030 A</td>
<td>11/10/83</td>
<td>GB 2095657 A,B</td>
<td>06/10/82</td>
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<td>JP 2016347 B</td>
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<td>JP 57130559 A</td>
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<td>23/02/82</td>
<td>AU 530113 B</td>
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<td>CA 1136652 A</td>
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<td>DE 3061392 D</td>
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<td>EP 0017398 A,B</td>
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<td>SE 0017398 T3</td>
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<td>JP 1436041 C</td>
<td>25/04/88</td>
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<td>JP 55142894 A</td>
<td>07/11/80</td>
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<td>JP 60001904 B</td>
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