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(54) **METHOD AND FORM ARRANGEMENT FOR 3-DIMENSIONAL CONCRETE SURFACE**

VERFAHREN UND FORMANORDNUNG FÜR DREIDIMENSIONALE BETONOBERFLÄCHE

PROCÉDÉ ET AGENCEMENT DE COFFRAGE POUR SURFACE TRIDIMENSIONNELLE EN BÉTON

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EP 3 484 680 B1

## Description

FIELD

**[0001]** The present invention relates to a method for manufacturing a concrete element provided with a three-dimensional concrete surface and a form arrangement for implementing said method.

BACKGROUND ART

**[0002]** Concrete is one of the most durable building materials. In addition, the concrete, as a settable building material, offers a high level of design flexibility. Concrete structures may have many different shapes, a shape of a concrete structure being defined by cast surfaces inside a form whereto the concrete is poured to form the concrete structure. There are several ways to affect to the appearance of a concrete structure. For example, basic materials of the concrete, i.e. cement, water and aggregates, and their proportional amounts, aswell as possible admixtures, additives, colour pigments, etc., added during a concrete mix preparation, each have their impact to the appearance, such as colour, of the surface. Further, different surface treatment methods, applied either to a cured concrete structure or while the concrete is curing, create different surfacetextures. Also surfaces, against which the concrete is poured in the form may be provided with different 3 dimensional shapes, or astructured material, likeapattern transfer mat disclosed in US 5330694, to create a 3-dimensional surface for a concrete structure. JP S51 57710 A discloses a process for manufacturing an inorganic molded article by pressure molding, wherein a rubber sheet is placed between the upper surface of the material poured in a lower mold and the upper die of the press preventing therefore the material from adhering to the upper die. It discloses also a form arrangement according to the preamble of claim 7.

BRI EF DESCRIPTION

**[0003]** A general aspect of the invention is to provide a way to obtain a 3-dimensional concrete surface to a concrete structure by using a rigid form, an auxiliary form and a non-rigid sheet that is to be placed between an upper surface of concrete poured to the rigid form and the auxiliary form before pressing the auxiliary form with the sheet at least partly into the concrete. The auxiliary form, together with the sheet, provide versatile possibilities to profile and/or structure a surface of a concrete structure. Hence it is possible to create, and easy to manufacture, concrete structures with surfaces providing different visual, acoustic and/or haptic characteristics.

**[0004]** The invention isdefined in a method according to claim 1 and form arrangement according to claim 7.

**[0005]** The preferred embodiments of the invention are disclosed in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

**[0006]** In the following, exemplary embodiments will be described in greater detail with reference to accompanying drawings, in which

Figures 1 and 2 illustrate an exemplified form arrangement;
Figures 3A and 3B illustrateexemplified form arrangements from bird's eye view;
Figure 4 is a flow chart illustrating an exemplary functionality;
Figure 5 is a block diagram illustrating an exemplary fastening means; and
Figures 6 and 7 are flow charts illustrating exemplary functionalities.

DEFAILED DESCRIPTION OF SOME EMBODIMENTS

**[0007]** The following embodiments are exemplary. Although the specification may refer to "an", "one", or "some" embodiment(s) in several locations, this does not necessarily mean that each such reference is to the same embodiment(s), or that the feature only applies to a single embodiment. All words and expressions should be interpreted broadly and they are intended to illustrate, not to restrict, the embodiment. Single features of different embodiments may also be combined to provide other embodiments without departing from the scope of the appended claims.

**[0008]** Further more, words "comprising" and "including" should be understood as not limiting the described embodiments to consist of only those features that have been mentioned and such embodiments may contain also features/ structures that have not been specifically mentioned.

**[0009]** The present invention is applicable to a manufacturing process of any precast concrete element (structure) and any cast-in-place concrete structure that uses a form in which at least part of an upper surface of a concrete poured to the form is not covered by the form. Below different examples are described using a form having an open upper surface, i.e. the upper surface of the concrete poured to the form is not at all covered by theform, without restricting the examplesto such a solution. It is a straightforward solution for one skilled in the art to implement the examples to a solution in which the upper surface of the concrete is also partly covered by the form; the examples are applied to part(s) not covered by theform. Further, concrete means herein any mixture that comprises as raw materials at least aggregates, a paste of binder material, such as cement, and water, the mixture being fluid/ pourableto a form when the raw materials are mixed together, but the mixture hardening (curing) over time. The non-limiting examples include conventional concrete, light weight concrete, micro concrete, fiber reinforced concrete, steel reinforced concrete, and self-compacting concrete.

**[0010]** Across section of an exemplified form arrangement is illustrated in Figures 1 and 2, Figure 1 before the 3-dimensional upper pour surface is created and Figure 2 when it is created. It should be appreciated that the upper pour surface means herein a surface that is in the upper position when the concrete is poured, but once the concrete structure is in use the upper pour surface may be a side surface, upper surface or a bottom surface of the concrete structure.

**[0011]** The exemplified form arrangement 100 is illustrated in Figure 1 in a situation in which concrete 140 has just been poured to a rigid form 110, the form 110 and the concrete is covered by anon-rigid sheet (membrane) 120, and an auxiliary form 130 is to be placed on the sheet 120.

**[0012]** In the illustrated example, the rigid form 110 comprises a frame, i.e. a frame part, illustrated by sidewalls 111 and 111', and a bottom 112, i.e. a bottom part. The form 110, also called a mould, or a form work, defines a space into which concrete is poured, and affects, in addition to the shape of the concrete structure, to the surfaces of the concrete structure that face the form 110. Such surfaces may be called cast surfaces. To hold poured green (fresh) concrete within theform 110, the frame needs be a closed frame, and to maintain the intended shape, the form 110 needs be rigid. Term rigid means herein capability to maintain the shape of the formasintended. That meansthat if pouring is planned to cause some deformation of the shape, as is the case with fabric formworks, that is allowed to happen, but not any unintended deformation of the shape. Another example of a form 110 includes a casting on flat form. A casting on flat form may be used for concrete structures regardless of their size, and regardless of their final erection direction. For example, concrete wall elements, floor elements, columns, and beams, paving elements, concrete structures for furniture etc., may be manufactured using casting on flat forms.

**[0013]** Although in Figure 1 the frame and the bottom of theform 110 are integrated together that need not be the case; the frame and the bottom may be separatefrom each other, and of different material. Theform 110, or removable part of the form, may comprise only the frame; the bottom part may be any slab, such as a thin-shell slab, or a composite steel slab, or any material that will not be removed, i.e. that remains as part of the concrete structure or below the concrete structure in the final product. When concrete is poured to be directly in touch with a soil surface, the form 110 may comprise only the frame.

**[0014]** Although in the example illustrated in Figures 1 and 2 the bottom part 112 is even (flat) that needs not be the case. There are no restrictions to the material and shape of the form, as long as the form, i.e. at least the bottom part, if such exists, and the frame part, is rigid enough to carry the load caused by the concrete and its pouring, and not to reshape when the auxiliary form with the sheet is pressed into the concrete, as will be described in detail below, and the shape of the form 110 has an upper opening to accommodate at least sheet contacting portions of the auxiliary form and displaced concrete. For example, the inner surface of the form 110 facing the concrete, or part of the inner surface of the form 110 may be covered, before the concrete 140 is poured to the form, by anything that creates a 3-dimensional structureto the concrete surface, or creates another kind of finishing to the concrete surface. For example, a pattern mat, a foil for graphic concrete, etc. may be used. Combining a form 110 providing a3-dimensional surface with a 3-dimensional surface created by means of the sheet 120 and the auxiliary form 130 it ispossibleto manufacture concrete structures, such as walls, that once cured haveat least on opposite sides 3-dimensional surfacesnot requiring additional finishing of the surfaces.

**[0015]** The non-rigid sheet 120 may be made of any material that allows adoption of the shape from a shape it was laid to cover the upper surface of theconcrete, illustrated in Figure 1, to a 3-dimensional shape that may comprise one or more curvature portions and/or one or more double-curvature portions and/or one or more straight portions. An example of the 3-dimensional shape is a curvy-like shape illustrated in Figure 2. The non-rigid sheet 120 is preferably made of aflexible/ductile material, either plastic or elastic. If the non-rigid sheet is asingle-use sheet, it may be made of a plastic material or elastic material, whereas a reusable non-rigid sheet may be made of an elastic material. However, even a non-flexible/ non-ductile material may beused, if thesheet 120 is sufficiently larger than the area of the upper surface of the concrete 140 facing the sheet 120 before pressing the auxiliary form. In such a case, in the situation illustrated in Figure 1, a sheet made of anon-ductile material is in afolded (or folded-like) state, and in the situation illustrated in Figure 2, in a non-folded (smooth/less wrinkled) state.

**[0016]** Minimum prerequisites for the sheet material includes that its strength (resistance to tension or tensile breaking force) is big enough for the deformation so that tension caused by downward movement of the auxiliary form 130 stretching the sheet, or more precisely sheet portions having contact with the auxiliary form, and down and upward and sideward movement of displaced concrete stretching the sheet, or more precisely sheet portions having no contact with the auxiliary form, will not break the sheet 120. The tension caused, and hence the minimum strength required, depends on characteristics of the concrete and characteristics of the 3-dimensional structure, which in turn depends on the bottom part design of the auxiliary form and how deep into the concrete the auxiliary form with thesheet is pressed. The characteristics of the concrete depends on thechosen concrete type, its workability (plasticity), how long it will be allowed to cure, etc. Further, the roughness and coarseness of aggregate used in the concrete, as well as concrete batch size, may affect to the minimum strength required. For example, if theform 110 is filled to it supper level (full to the prim) with concrete, the tension caused to the sheet

120 may be bigger compared to a situation in which aconcrete batch size is a smaller than the pouring volume defined by the inner side of the form 110 when the sheet is placed on the upper level of the form. Naturally, if the surface is created by pressing the auxiliary form 110 even after the sheet 120 does not stretch any more, and hence does not provide space to the concrete 140, the sheet 120 has to be strength enough to carry in the stretched state forces caused by the concrete compacting against the sheet 120. It should be appreciated that any fabric used for fabric framework may be used as the sheet, but since the strength requirements are different, for example there is no need for the sheet to carry the weight of the poured concrete, fabrics not suitable for the fabric framework, may also be used.

**[0017]** In implementations in which the sheet is to be fastened to the form directly or indirectly and/or to the auxiliary form, said latter implementation not forming part of the invention, the sheet has to be fastenable.

**[0018]** One characteristic of the sheet that affects the shape of the 3-dimensional surface is the thickness of the sheet: a thinner the sheet is the more closely it follows the shapes of the portions of the bottom part of the auxiliary form that contact the sheet during pressing.

**[0019]** Water- and air permeability of the sheet material affects the finished surface of the concrete structure, for example to the amount of air bubbles (voids, blisters, blowholes), and to thewater-cement ratio near the surface. With asuitable selection of the sheet material, concrete characteristics, bottom part design of the auxiliary form, and pressing depth a smooth surface without visible voids may be obtained. Further, with suitable water permeability of the sheet material, surface finishing fluids, such as surface retarding agents or colour pigments mixed with water, for example, may seep (pass) through the sheet to intended places, for example by adding them to specific spots in the bottom part of the auxiliary form before pressing the auxiliary form, or by adding them to cavities created to the sheet during the pressing. By varying these factorsdifferent appearances of surfaceswill be obtained.

**[0020]** The texture of the sheet surface 120 that faces the concrete 140 affects the texture of the concrete surface. This in turn increases the possibilities to design various concrete surface textures. Naturally the sheet surface facing the concrete may be treated as if it were a surface in the form. For example, a special foil comprising areas with a surface retarder to create graphical concrete, may be placed on the sheet surface facing the concrete, or on the upper concrete surface, before the sheet is mounted on the fresh concrete. Further examples include providing the sheet 120 with one or more pigment dyes and/or inlays and/or surface retarder. It should be appreciated that any method to texture the surface may be used.

**[0021]** Examples of sheet materials that may be used include flexible non-adherent syntheticwoven fabrics, like polyamide (nylon) with weight of 65-70 g/ m2, and interlock polyester with weight of 110 g/m2, and flexible non-woven fabrics, such as geotextiles. A fabric for a sheet, woven or non-woven, may comprise synthetic fibers, natural fibers or both of them. The fabric may be surface treated with a release agent, if needed, to ensure that the fabric does not adhere to the concrete.

**[0022]** Although in the example illustrated in Figures 1 and 2, the sheet 120 is solid, the sheet may comprise one or more holes (apertures) with same or different shapes. That further enhances appearance design possibilities. Still another feature enhancing appearance design possibilities is "stretchability" ratio of the sheet material; if it is one, it stretches equally in each direction, if it is less or morethan one, the sheet stretches differently in different directions.

**[0023]** It is also possible to use two or more sheets, with the same or different characteristics, instead of the one illustrated in Figures 1 and 2. The two or more sheets may together form a kind of "combination sheet" that covers together the whole upper surface of the concrete (that is not covered by the form), and herein the term "sheet" also covers the "combination sheet" unless otherwise expressed. One or more of the two or more sheets may be an "additional sheet", i.e. a sheet placed over another sheet. The additional sheet may be smaller than thesheet over which is placed, and the additional sheet may be placed, for example, so that only proportion(s) of the sheet contacting portions of the auxiliary form will contact the additional sheet. Having different sheet thicknesses obtained this way creates further variationsin the shape of the concrete surface.

**[0024]** The auxiliary form 130 may be made of any material that is strong enough to cause displacement of the concrete 140, the required strength hence depending on concrete properties, like its consistency factor or value, also called workability. Preferably the material does not soften if the auxiliary form, or more precisely part(s) of the auxiliary form, come into contact with water. Further, the auxiliary form 130 needs to bear the pressing force it is exposed to. However, the pressing force may be only the gravity and theweight of the auxiliary form with a high-slump mix of concrete. In addition to that, to avoid unplanned colouring of the concrete surface, the material should be colour-proof.

**[0025]** The auxiliary form 130 may be one piece, as illustrated in the bird's eye views in Figure 3A, or comprise two or more pieces, as illustrated in the bird's eye view in Figure 3B. More precisely, assuming that the sheet facing surface, or at least thesheet contacting portions when the auxiliary form is pressed into its final position, of the auxiliary form 130 has the shape illustrated in exampleof Figures 1 and 2, the three protrusions 131a, 131b and 131c are connected to each other by aplate in the example of Figure 3A and by arodding 130' in the exampleof Figure 3B.

**[0026]** The sheet facing surface of the auxiliary form 130 may comprise one or more protrusions 131a, 131b, 131c, as illustrated in Figures 1 and 2, and/or one or more

recesses (not illustrated in Figures 1 and 2), each protrusion/recess having any outward extension length/ inward depth and shape, independent of each other. Naturally the surface facing the sheet (the sheet facing surface of the auxiliary form 130) may be smooth. In other words, there are no restrictions on the shape of the sheet facing surface of the auxiliary form 130. However, any dimension of theauxiliary form that relate to the sheet contacting portions has to be such that it is possible to press the auxiliary form with the sheet into the concrete. Hence, the only restriction relating to the shape of the auxiliary form 130 is for its size: the cross cut area of the sheet contacting portions should be smaller than the cross cut area of the concrete upper surface covered or coverable by the sheet, and each of the crosscut dimensions of the sheet contacting portions is smaller than a corresponding dimension of the concrete upper surface covered or coverable by the sheet. In other words, the area defined by the upper inside surfaces of the form, depicted by the rectangle 111ain Figures 3A and 3B has to be larger than the contact area of the auxiliary form 130, so that there are one or more auxiliary form - free areas 350, 350', 350" for the sheet to extend (stretch) upwards to occupy the displaced concrete, and the lengths of longer sides of the protrusions 131a and 131c in Figure 3B haveto be smaller than the length of the shorter side walls of the frame. Other wise the auxiliary form 130 may be shaped freely so that the sheet contacting portions, when in the final pressed position, creates with the sheet the desired 3-dimensional surface, or 3-dimensional figure to the concrete surface. Naturally, when the desired concrete surface is designed, one has to take into account different requirements that apply also to conventionally manufactured surfaces, such as a minimum distance of reinforcement steel bars from the surface.

**[0027]** According to the invention and as shown in Figures 3A and 3B the upper part of the auxiliary form is smaller than the upper inside surface of the form.

**[0028]** The auxiliary form 130 may be used for manufacturing a single concrete structure or it may be repeatedly used for manufacturing similar or in praxis identical concrete structures, depending on the shape of the rigid form 110, and the reusability of the sheet 120 used with the auxiliary form, and naturally depending on pressing depth (different depth with other factors remaining the same creates another structure).

**[0029]** Figures 4 and 6 illustrate alternative functionality for a manufacturing phase and 7 illustrates different phase of the manufacturing: Figures 4 and 6 describing "adding" phase and Figure 7 "removal" phase.

**[0030]** In the example illustrated in Figure 4, it is assumed that preliminary preparations, including possible surface treatments to surfaces that are to be faced with the concrete and protection of the form, or upper parts of the form, against splashed, if needed, have been performed.

**[0031]** Referring to Figure 4, after fresh concrete is poured in step 401 to a form for a concrete structure, possible vibrated or otherwise handled, a sheet selected for the concrete structure is laid (mounted, spread) in step 402 to cover the upper surface of the concrete, and the sheet is fastened in step 403 to the form. There are several ways to perform the laying and fastening. For example, the sheet may be rolled over the upper surface of the concrete and the form parts limiting the upper surface area of the concrete that is not covered by the form, and then the sheet, whose end portions may hang on the outer surfaces of the frame, is fastened to the form by fastening means that holds the sheet. Examples of fastening means include band, rope with tighter, and rivets. It should be appreciated that any fastening means that can hold the sheet in its place so that no unplanned flow of concreteout of theform during the pressing (step 405) takes place. In another example the sheet is fastened to a frame work (rack/skeleton) that is dimensioned to fit either inside the upper surface area of the concrete that is not covered by the form, or outside theform, and by placing and fastening, separately if needed, the frame work to the form the sheet is laid to cover the upper surface of the concrete and fastened to the form. Yet another example is illustrated in Figure 5, in which a fastening means 550, such as a balk, or joist, is attached to a sidewall 111 of theform once the concrete 140 has been poured and the sheet laid to cover the concrete and extending at least between the sidewall 111 and the fastening means. The fastening means may be added to theform using screws or bolts, for example.

**[0032]** Then the auxiliary form is placed in step 404 on the sheet, on a predetermined position, so that the shape to be created will be created according to design of the final concrete structure. It should appreciated that if the sheet is fastened to a framework, and the framework is also asupport framework for the auxiliary form, and/or otherwise connected to the auxiliary form, so that the framework with the sheet and the auxiliary form are placeable on/ above the upper surface of the concrete pour, step 404 is integrated with steps 402 and 403, i.e. they all are placed in one go to cover the upper surface of the concrete pour. This last implementation does however not form part of the invention.

**[0033]** When the auxiliary form is placed (step 404) on the sheet, it will be pressed in step 405, according to a pressing direction, towards the form. Using the example illustrated in Figures 1 and 2, the auxiliary form is pressed towards the bottom surface of the form. In other words, in the example of Figures 1 and 2, the pressing direction of the auxiliary form is vertical, i.e. the angle to a plane defined by the sheet before the auxiliary form touches the sheet is 90 degrees. However, any other pressing direction angle may be used, as long as it causes displacement of concrete when the auxiliary form is pressed with thesheet into the concrete.

**[0034]** Referring to Figure 5, assuming that the upper surface of the auxiliary form has such a size and shape that at least part of the upper surface will overlap with

theform'sframewhen the auxiliary form is in its intended position, by dimensioning the fastening means 550 according to the intended pressing depth and dimensions of the auxiliary form, the fastening means may be used also as guide means for the intended pressed position of the auxiliary form: when the auxiliary form touches the upper part of the fastening means, the intended position is achieved.

**[0035]** The pressing may be performed immediately, i.e. to the fresh concrete, or later to a concrete that has cured enough, for example cured a predetermined time, or determined other ways, as those currently used to determine for manual surface finishing when the concrete has cured enough. Further, the pressing may be performed in a step-wise way. For example, using the auxiliary form illustrated in Figures 1 and 2, the auxiliary form may be pressed down so that the protrusions denoted by 131aand 131c will cause, with corresponding sheet portions entering to the concrete, displacement of the concrete but the pressing is stopped before the protrusion denoted by 131b will enter with the sheet to the concrete; and after a predetermined time, the pressing is continued so that the auxiliary form with the sheet will reach its intended penetration depth into the concrete.

**[0036]** The pressing of the auxiliary mold causes displacement of concrete: the sheet contacting portions of the auxiliary mold and corresponding portions of the sheet push the concrete away to have space for themselves. Naturally this stretches, or at least creates stretching forces, to the sheet portions contacting the auxiliary form, while they enter into the concrete. Further, the displaced concrete stretches, or at least creates stretching forces, that are in opposite direction than the pressing to sheet portions having no contact with the auxiliary form. Basically one can say that part of the sheet is pushed downwards by the auxiliary form and part of the sheet is pushed upwards and pressed (tightened) against the concrete by the pressure caused by the displaced concrete, creating thereby a curvy-like shape to the corresponding concrete surface.

**[0037]** If the sheet is made of water and air permeable material, tightening of the sheet against the concrete, for example in the situation illustrated in Figure 2, in which the upper surface of the concrete 140 is pressed against the sheet 120, air bubbles and water raising to the upper surface of the concrete 140 are pressed through the sheet 120 resulting to a more condensed, smoother, higher-quality concrete surface, as explained above. That has the advantage that it is possible to use the concrete structure without any further surface finishing, or only by minimum surface finishing, thereby reducing the time required to manufacture, and increasing productivity.

**[0038]** Figure 6 illustrates the same phase as Figure 4 but for a solution in which only part of the upper part of the concrete not covered by the form is designed to have the 3-dimensional structure, the other parts having a conventional structure, for example.

**[0039]** Referring to Figure 6, after fresh concrete is poured in step 601 to a form for a concrete structure, possible vibrated or otherwise handled, a sheet selected and the auxiliary form are place in step 602 above the upper surface of the concrete pour, in the intended location so that the sheet is between the auxiliary form and the concrete. The sheet may be replaced separately, or with the auxiliary form, and the sheet may be fastened to portions of the auxiliary form that are to be entered into the concrete with the sheet, which does not form part of the invention.

**[0040]** Once the sheet and the auxiliary form are place, the process is the same as in Figure 4, i.e. the auxiliary form is pressed in step 603, according to a pressing direction, towards the form, step 603 corresponding to step 405 in Figure 4.

**[0041]** Referring to Figure 7, once the auxiliary form is pressed into its intended position, the concrete is let to cure (step 701: no). Depending on the designed appearance of the surface, the concrete may be let to cure totally or partially before the form arrangement is touched. When the concrete is cured enough (step 701: yes), the auxiliary form is removed in step 702. It should be appreciated that any removal method may beused. For example, the auxiliary form may beremoved by lifting it up, or removing piece by piece. For example, using the structure illustrated in Figure 3B, each protrusion may be removed separately from each other. That facilitates creation of so called undercut shapes. The removal may also be performed in a step-like manner. Depending on the curing stage, the removal of the auxiliary form may or may not affect to the pressure with which the concrete is forced against the sheet.

**[0042]** In the example illustrated in Figure 7, the sheet is not in a rack moving in one go with the auxiliary form. Therefore, when the auxiliary form is removed, it is checked in step 703, whether the sheet is to be removed when the auxiliary form isremoved. If yes (step 703: yes), thesheet is removed in step 704 at the same time as the auxiliary form. If not (step 703: no), it is waited until it is time to remove the sheet (step 703: yes), and the sheet is removed. For example, thesheet may act as a transport cover sheet that is to be removed only after the concrete structure has been erected. Another example include that the auxiliary form is removed when the concrete is partially cured, and the sheet when the concrete is cured, or at least more cured than when the auxiliary form is removed.

**[0043]** Naturally the concrete surface, after the sheet has been removed, may undergo a further finishing, like polishing, sandblasting, painting, etc. to further affect the appearance.

**[0044]** Although in the above examples it is assumed that the auxiliary form is pressed downwards, it should be appreciated that the auxiliary form may be pressed with the sheet into the concrete by moving theform, for example by lifting the form towards a stationary auxiliary form.

**[0045]** Although in the above examples it is assumed that one auxiliary form is used for one concrete structure/ one concrete upper surface, it should be appreciated that two or more separate auxiliary forms may be used and pressed, in the same manner or by different manners, to one concrete upper surface that is not covered by the form.

**[0046]** As is evident from the above, the auxiliary form, its sheet facing surface design, pressing angle and pressing depth, measured from the plane defined by the sheet towards the bottom surface of the fresh concrete, the pressing method, the selected sheet materials, or more precisely, selected sheet material characteristics, the removal time and removal method of the auxiliary form, the removal time of the sheet, possible sheet treatments, and characteristics of the fresh concrete, as well as materials used for the concrete mix, each affect to the appearance of the concrete surface, and hence provide in praxis limitless possibilities to design and manufacture 3-dimensional structures. Thereby it is possible to design concrete structures with versatile haptic and/or acoustic and/or visual characteristics. The invention and its embodiments are not limited to the examples described above but may vary within the scope of the claims.

## Claims

1. A method for manufacturing a concrete element provided with a three-dimensional concrete surface comprising:

   pouring (401, 601) concrete to a form comprising at least a closed rigid frame;
   placing (402, 404, 602) a non-rigid sheet and an auxiliary form above the upper surface of the concrete that is not covered by the form, the non-rigid sheet being between the upper surface of the concrete and the auxiliary form, the non-rigid sheet covering the upper surface of the concrete that is not covered by the form;
   the auxiliary form being sized such that the cross cut area of sheet contacting portions being smaller than the cross cut area of the concrete upper surface covered or coverable by the sheet, and such that each of the cross cut dimensions of the sheet contacting portions being smaller than a corresponding dimension of the concrete upper surface covered or coverable by the sheet;
   fastening (403) the sheet to the form;
   pressing (405, 603) the auxiliary form to the form to a predetermined depth in which there are one or more areas in which the sheet is in contact with the concrete but not with the auxiliary form, the pressing causing at least part of a sheet facing surface of the auxiliary form with corresponding one or more sheet portions, which the at least part of the sheet facing surface of the auxiliary form contacts during pressing, to enter into the concrete by displacing some of the concrete, the displacing causing the upper surface of the concrete move upwards and pressing against the sheet in areas that are not in contact with the at least part of the sheet facing surface of the auxiliary form creating thereby a curvy-like shape to the three-dimensional concrete surface of the concrete element; and
   curing (701) at least partly the concrete before removing (702) the auxiliary form.

2. A method as claimed in claim 1, wherein the pressing causes reshaping of the sheet.

3. A method as claimed in claim 1, further comprising at least one of the following:

   pressing the auxiliary form to the form in a step-wise way; and
   removing the auxiliary form in a step-wise way.

4. A method as claimed in any preceding claim, further comprising:

   removing (704) the sheet at the same time as the auxiliary form, or later than the auxiliary form.

5. A method as claimed in any preceding claim, further comprising at least one of the following:

   treating the surface of the sheet that faces the concrete before placing the sheet on at least part of the upper surface of the concrete; and
   adding a surface finishing fluid on one or more spots on the sheet on the side facing the auxiliary mold to let the surface finishing fluid to seep through the sheet onto the concrete surface .

6. A method as claimed in any preceding claim, further comprising at least one of the following:
   treating one or more inner surfaces of the form before pouring the concrete to the form.

7. A form arrangement (100) for implementing a method according to any of the preceding claims, the form arrangement (100) comprising at least

   a form (110) comprising at least a closed rigid frame (111a) defining a first area;
   a non-rigid sheet (120), layable on the top of the form (110), fastenable to the form, and dimensioned to cover at least the first area;
   fastening means for holding the sheet (120) fastened to the form; and
   an auxiliary form (130), placeable on the sheet (120) and at least partly pressable to the form

(110) with the sheet (120), a cross sectional area of the part of the auxiliary form (130) that is pressable to the form (110) being smaller than the first area that is covered by the non-rigid sheet (120) and dimensioned in such a way that there will be one or more areas within the first area in which the sheet will touch a concrete in the form but not the auxiliary form when the auxiliary form and the non-rigid sheet are pressed to a predetermined depth to the form;
**characterized in that** the upper part of the auxiliary form (130) is smaller than the upper inside surface of the form (110).

**8.** A form arrangement (100) as claimed in claim 7, wherein the part of the auxiliary form (130) that is pressable to the form comprises one or more protrusions (131a, 131b, 131c) extending from the surface facing the sheet.

**Patentansprüche**

**1.** Verfahren zur Herstellung eines Betonelements, das mit einer dreidimensionalen Betonoberfläche versehen ist, umfassend:

Gießen (401, 601) von Beton in eine Form, die zumindest einen geschlossenen starren Rahmen umfasst;
Aufbringen (402, 404, 602) einer nicht starren Folie und einer Hilfsform über der oberen Oberfläche des Betons, die nicht von der Form bedeckt ist, wobei sich die nicht starre Folie zwischen der oberen Oberfläche des Betons und der Hilfsform befindet und die nicht starre Lage die obere Oberfläche des Betons bedeckt, die nicht von der Form bedeckt ist;
wobei die Hilfsform so bemessen ist, dass die Querschnittfläche der Abschnitte, die mit der Folie in Kontakt kommen, kleiner ist als die Querschnittfläche der oberen Betonoberfläche, die von der Folie bedeckt oder abdeckbar ist, und so, dass jede der Querschnittabmessungen der Abschnitte, die mit der Folie in Kontakt kommen, kleiner ist als eine entsprechende Abmessung der oberen Betonoberfläche, die von der Folie bedeckt oder abdeckbar ist;
Befestigen (403) der Folie an der Form;
Pressen (405, 603) der Hilfsform an die Form auf eine vorbestimmte Tiefe, in der es einen oder mehrere Bereiche gibt, in denen die Folie in Kontakt mit dem Beton, aber nicht mit der Hilfsform kommt, wobei das Pressen veranlasst, dass zumindest ein Teil einer der Folie zugewandten Oberfläche der Hilfsform mit einem oder mehreren entsprechenden Folienabschnitten, mit denen zumindest ein Teil der der Folie zugewandten Oberfläche der Hilfsform beim Pressen in Kontakt kommt, in den Beton eindringt, indem ein Teil des Betons verdrängt wird, wobei die Verdrängung bewirkt, dass sich die obere Oberfläche des Betons nach oben bewegt und in Bereichen, die nicht in Kontakt mit dem mindestens einen Teil der der Folie zugewandten Oberfläche der Hilfsform kommen, gegen die Folie presst, wodurch die dreidimensionale Betonoberfläche des Betonelements eine kurvenartige Form erhält; und
Aushärten (701) zumindest eines Teils des Betons vor dem Entfernen (702) der Hilfsform.

**2.** Verfahren nach Anspruch 1, wobei das Pressen eine Umformung der Folie veranlasst.

**3.** Verfahren nach Anspruch 1, weiter umfassend mindestens eines der Folgenden:

schrittweises Pressen der Hilfsform in die Form; und
schrittweises Entfernen der Hilfsform.

**4.** Verfahren nach einem der vorstehenden Ansprüche, weiter umfassend:
Entfernen (704) der Folie gleichzeitig mit der Hilfsform oder später als die Hilfsform.

**5.** Verfahren nach einem der vorstehenden Ansprüche, weiter umfassend mindestens eines der Folgenden:

Behandeln der Oberfläche der Folie, die dem Beton zugewandt ist, bevor die Folie auf mindestens einen Teil der oberen Oberfläche des Betons aufgebracht wird; und
Zugeben eines Fluids zur Oberflächenendbearbeitung an einer oder mehreren Stellen der Folie auf der der Hilfsform zugewandten Seite, um das Fluid zur Oberflächenendbearbeitung durch die Folie auf die Betonoberfläche sickern zu lassen.

**6.** Verfahren nach einem der vorstehenden Ansprüche, weiter umfassend mindestens eines der Folgenden:
Behandeln einer oder mehrerer Innenoberflächen der Form, bevor der Beton in die Form gegossen wird.

**7.** Formanordnung (100) zur Implementierung eines Verfahrens nach einem der vorstehenden Ansprüche, wobei die Formanordnung (100) zumindest

eine Form (110), die mindestens einen geschlossenen starren Rahmen (111a) umfasst, der einen ersten Bereich definiert;
eine nicht starre Folie (120), die auf die Oberseite der Form (110) auflegbar ist, die an der

Form befestigbar ist und die so dimensioniert ist, dass sie zumindest den ersten Bereich abdeckt;
Befestigungsmittel, um die Folie (120) an der Form befestigt zu halten; und
eine Hilfsform (130) umfasst, die auf die Folie (120) aufbringbar ist und zumindest teilweise mit der Folie (120) an die Form (110) pressbar ist, wobei ein Querschnittsbereich des Teils der Hilfsform (130), der an die Form (110) pressbar ist, kleiner ist als der erste Bereich, der von der nicht starren Folie (120) bedeckt ist, und so bemessen ist, dass es einen oder mehrere Bereiche innerhalb des ersten Bereichs gibt, in denen die Folie einen Beton in der Form, aber nicht die Hilfsform berührt, wenn die Hilfsform und die nicht starre Folie bis zu einer vorbestimmten Tiefe an die Form gepresst werden;
**dadurch gekennzeichnet, dass** der obere Teil der Hilfsform (130) kleiner ist als die obere innenseitige Oberfläche der Form (110).

**8.** Formanordnung (100) nach Anspruch 7, wobei der Teil der Hilfsform (130), der an die Form pressbar ist, einen oder mehrere Vorsprünge (131a, 131b, 131c) umfasst, die sich von der der Folie zugewandten Oberfläche erstrecken.

## Revendications

**1.** Procédé de fabrication d'un élément en béton pourvu d'une surface tridimensionnelle en béton comprenant les étapes consistant à :

verser (401, 601) du béton dans un coffrage comprenant au moins un cadre rigide fermé ;
placer (402, 404, 602) une feuille non rigide et un coffrage auxiliaire au-dessus de la surface supérieure du béton qui n'est pas recouverte par le coffrage, la feuille non rigide étant entre la surface supérieure du béton et le coffrage auxiliaire, la feuille non rigide recouvrant la surface supérieure du béton qui n'est pas recouverte par le coffrage ;
le coffrage auxiliaire étant dimensionné de sorte que la zone de découpe de portions de contact de feuille est plus petite que la zone de découpe de la surface supérieure en béton recouverte ou pouvant être recouverte par la feuille, et de sorte que chacune des dimensions de découpe des portions de contact de feuille est plus petite qu'une dimension correspondante de la surface supérieure en béton recouverte ou pouvant être recouverte par la feuille ;
fixer (403) la feuille au coffrage ;
presser (405, 603) le coffrage auxiliaire sur le coffrage jusqu'à une profondeur prédéterminée dans laquelle il y a une ou plusieurs zones dans lesquelles la feuille est en contact avec le béton mais pas avec le coffrage auxiliaire, le pressage amenant au moins une partie d'une surface faisant face à la feuille du coffrage auxiliaire avec une ou plusieurs portions de feuille correspondantes, avec lesquelles la au moins une partie de la surface faisant face à la feuille du coffrage auxiliaire entre en contact durant le pressage, à entrer dans le béton en déplaçant une partie du béton, le déplacement amenant la surface supérieure du béton à se déplacer vers le haut et pressant contre la feuille dans des zones qui ne sont pas en contact avec la au moins une partie de la surface faisant face à la feuille du coffrage auxiliaire créant ainsi une forme incurvée sur la surface tridimensionnelle en béton de l'élément en béton ; et
faire durcir (701) au moins partiellement le béton avant de retirer (702) le coffrage auxiliaire.

**2.** Procédé selon la revendication 1, dans lequel le pressage provoque le remodelage de la feuille.

**3.** Procédé selon la revendication 1, comprenant en outre au moins l'une des étapes suivantes consistant à :

presser le coffrage auxiliaire sur le coffrage de manière progressive ; et
retirer le coffrage auxiliaire de manière progressive.

**4.** Procédé selon une quelconque revendication précédente, comprenant en outre l'étape consistant à : retirer (704) la feuille au même moment que le coffrage auxiliaire, ou plus tard que le coffrage auxiliaire.

**5.** Procédé selon une quelconque revendication précédente, comprenant en outre au moins l'une des étapes suivantes consistant à :

traiter la surface de la feuille qui fait face au béton avant de placer la feuille sur au moins une partie de la surface supérieure du béton ; et
ajouter un fluide de finition de surface sur un ou plusieurs endroits sur la feuille sur le côté faisant face au coffrage auxiliaire pour laisser le fluide de finition de surface s'infiltrer à travers la feuille sur la surface en béton.

**6.** Procédé selon une quelconque revendication précédente, comprenant en outre au moins l'une des étapes suivantes consistant à :
traiter une ou plusieurs surfaces intérieures du coffrage avant de verser le béton dans le coffrage.

**7.** Agencement de coffrage (100) pour mettre en œuvre un procédé selon l'une quelconque des revendications précédentes, l'agencement de coffrage (100) comprenant au moins

un coffrage (110) comprenant au moins un cadre rigide fermé (111a) définissant une première zone ;
une feuille non rigide (120), pouvant être mise en couche sur le dessus du coffrage (110), pouvant être fixée sur le coffrage, et dimensionnée pour recouvrir au moins la première zone ;
un moyen de fixation pour maintenir la feuille (120) fixée au coffrage ; et
un coffrage auxiliaire (130), pouvant être placé sur la feuille (120) et pouvant au moins partiellement être pressé sur le coffrage (110) avec la feuille (120), une section transversale de la partie du coffrage auxiliaire (130) qui peut être pressée sur le coffrage (110) étant plus petite que la première zone qui est recouverte par la feuille non rigide (120) et dimensionnée de sorte qu'il y ait une ou plusieurs zones dans la première zone dans lesquelles la feuille touchera du béton dans le coffrage mais pas le coffrage auxiliaire lorsque le coffrage auxiliaire et la feuille non rigide sont pressés jusqu'à une profondeur prédéterminée sur le coffrage ;
**caractérisé en ce que** la partie supérieure du coffrage auxiliaire (130) est plus petite que la surface intérieure supérieure du coffrage (110).

**8.** Agencement de coffrage (100) selon la revendication 7, dans lequel la partie du coffrage auxiliaire (130) qui peut être pressée sur le coffrage comprend une ou plusieurs saillies (131a, 131b, 131c) s'étendant depuis la surface faisant face à la feuille.

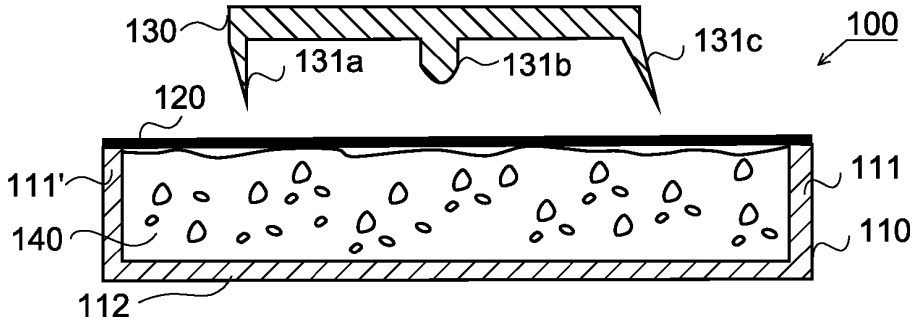



FIG.1

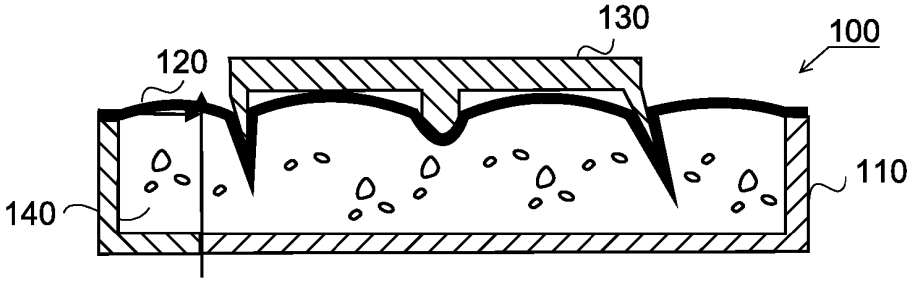



FIG.2

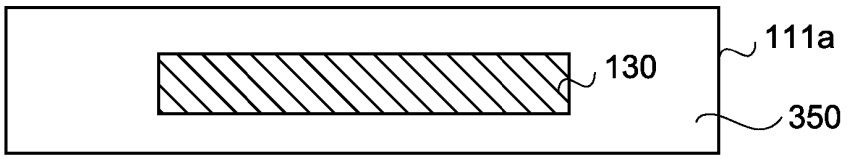



FIG.3A

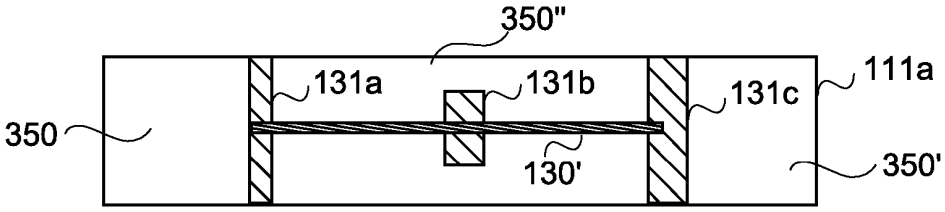



FIG.3B

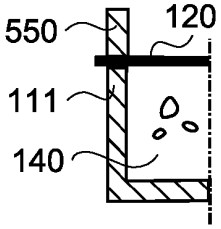



FIG.5

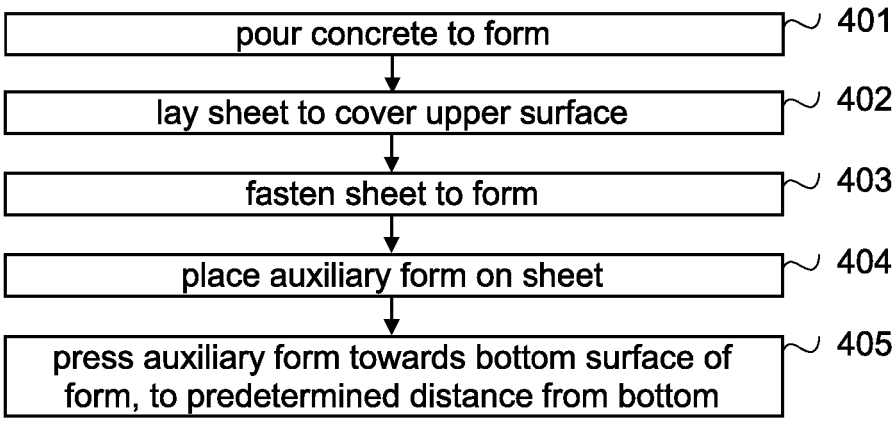



FIG.4

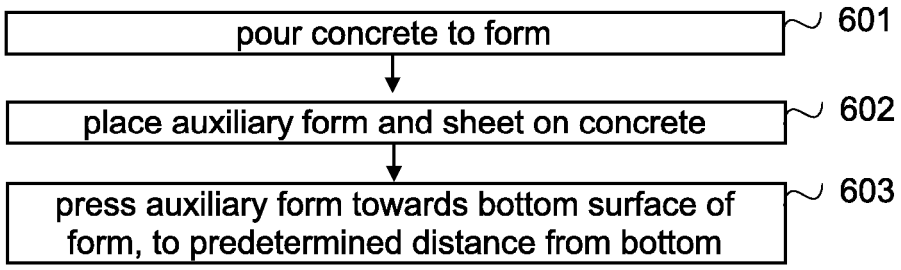



FIG.6

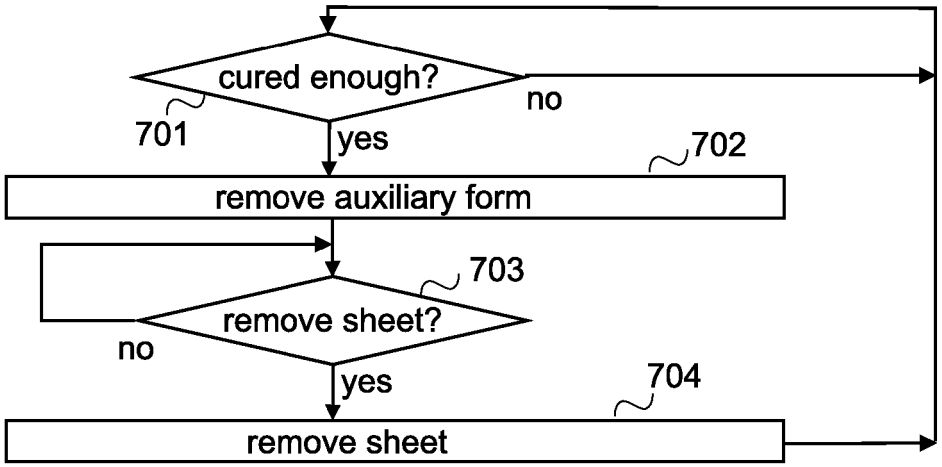



FIG.7

## REFERENCES CITED IN THE DESCRIPTION

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### Patent documents cited in the description


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