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(54) A reinforced concrete element additionally reinforced with steel fibres, having a spacer made of plastic

(57) A reinforced concrete element (10) comprising a body of concrete (24) and a reinforcing structure embedded in the body, the reinforcing structure comprising a plurality of spaced apart reinforcing bars (22). The reinforcing structure further comprises at least one spacer (30) made of a light weight material such as plastic. The spacer (30) comprises retainment means (38) for keeping the plurality of reinforcing bars (22) in the reinforcing structure in place before and during curing of said concrete. The concrete (24) is reinforced with steel fibres.

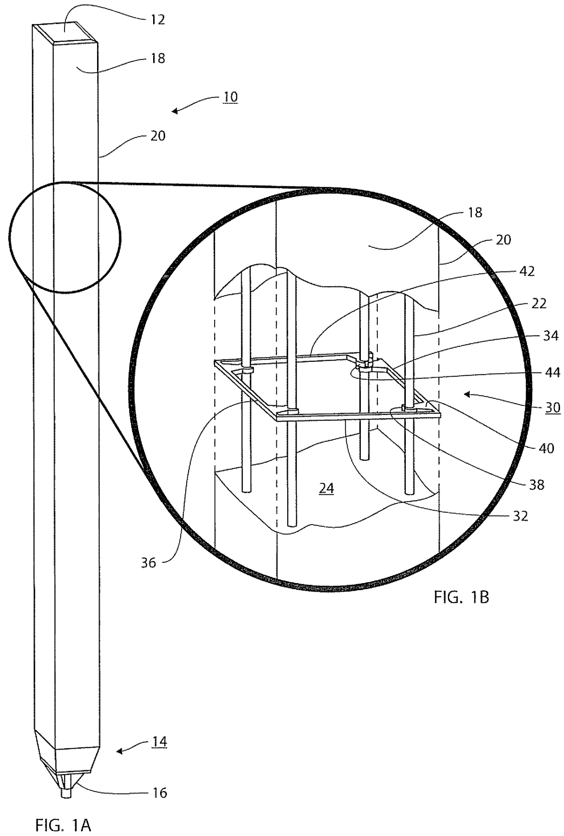

FIG. 1B

FIG. 1A

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Description

[0001] The present invention is related to a reinforced concrete element, a spacer for use in the reinforced concrete element, and a method of producing a reinforcing structure.

[0002] Reinforced concrete elements are used for constructing different types of buildings and constructions. One type of reinforced concrete elements are concrete piles. Concrete piles are elongated building elements used in the construction of a foundation for supporting a building or construction, where the soil on which the building or construction is to be placed is not stable enough to support the building's weight. By driving concrete piles through the soft soil down to more stable clay or rock layers, the weight of the building or construction can be transferred to the more stable clay or rock layers.

[0003] Reinforced concrete elements such as concrete piles are produced by casting concrete in a mould. The concrete pile may then be transported to the location where it is to be used, which in the case of a concrete pile involves being driven into the soil using a pile driver. Reinforcing bars, also known as rebar, reinforcing steel, reinforcement steel, or rerod, is commonly used to reinforce the concrete in the reinforced concrete element, e.g. concrete pile, to increase inter alia the load bearing capacity. For a concrete pile cast in a mould, reinforcing bars extending along the length of the mould are typically positioned parallel to each other in the mould. For maximum strength the bars should be positioned such that there is at least one bar extending along each longitudinal edge of the finished concrete pile.

[0004] For holding the reinforcing bars in a reinforced concrete element in place before and during curing of the concrete, secondary reinforcing is used. The secondary reinforcing serve as scaffolding to which the reinforcing bars are tied using steel wires. The finished reinforcing structure typically resembles a cage or box. The task of tying the reinforcing bars to the secondary reinforcing to form the reinforcing structure is performed by special workmen sometimes called rodbusters or reinforcing ironworkers.

[0005] For example, in a conventional concrete pile a spiral made of thinner steel wire is used as secondary reinforcing. The spiral has a square cross section with four straight sides when pulled out to the length of the concrete pile. The reinforcing bars are tied to the corners of the spiral using steel wire. The process results in a reinforcing structure in the shape of an elongated cage having a square cross section. The spiral, in addition to serving as scaffolding for positioning the reinforcing bars properly in the mould before and during the curing of the concrete, further provides some additional reinforcement of the finished concrete pile.

[0006] The reinforcing structure is then placed in the mould and the concrete is poured into the mould. Further details, such as loops for lifting the finished concrete pile, may be placed in the mould. After the concrete has cured the finished concrete pile is removed from the mould.

[0007] There exist several drawbacks with the conventional reinforced concrete element in general, and particularly with the conventional concrete pile, and the process by which it is produced.

[0008] Firstly, the positioning of reinforcing bars in the reinforcing structure, in the case of a concrete pile tying the bars to the spiral, is time consuming and requires specially trained workmen.

[0009] Secondly the finished reinforced concrete element will contain a large amount of secondary reinforcing, which, although having its purpose for creating the reinforcing structure, in the finished reinforced concrete element pile may be partly superfluous, because it may for example not contribute significantly to strength of the reinforced concrete element. This is particularly the case where the reinforced concrete element is designed to mainly be loaded in one direction, such as a concrete pile or concrete beam. This makes the reinforced concrete element unnecessary heavy and expensive. This also causes conventional reinforced concrete elements, in particular concrete piles, due to weight, to be difficult and expensive to transport.

[0010] In GB 904 766 is disclosed an X-shaped spacing device made as a single moulding of plastic. Each tip of the four arms of the X carries a gripping means adapted to resiliently grip a reinforcing bar for maintaining the reinforcing bar in predetermined relative position to other reinforcing bars gripped by the other gripping means of the spacing device prior to and during the pouring of concrete around the spacing device and the reinforcing bars.

[0011] In EP 0 794 296 is disclosed a support structure for a cage for reinforcing a concrete pile, the support structure comprising a collar comprising two transverse frames being formed of coiled steel bar, one of the frames carrying clamping means for engaging at least one reinforcing bar extending longitudinally of the cage.

[0012] In AU 725 449 is disclosed a unitary support for supporting a plurality of horizontally arranged reinforcement rods, the support comprising two vertically spaced apart beams carrying receptacles each for receiving and retaining one of the reinforcement rods.

[0013] It is an object of the present invention to provide a reinforced concrete element which is simpler and faster to produce.

[0014] It is a further object of the present invention to provide a reinforced concrete element which contains less reinforcing bars and/or steel wire with maintained or increased strength.

[0015] It is a further object of the present invention to provide a spacer allowing faster and simpler production of a reinforcing structure.

[0016] It is yet a further object of the present invention to provide a more efficient method of producing a reinforcing structure for a reinforced concrete element.

[0017] It is still yet a further object of the present invention to provide a more efficient method of producing a concrete pile.

[0018] At least one of the above objects, or at least one of further objects which will be evident from the below description, are according to a first aspect of the present invention achieved by the reinforced concrete element according to claim 1.

[0019] As the reinforcing structure comprises a spacer for keeping the plurality of reinforcing bars in the reinforcing structure in place before and during curing, the commonly used secondary reinforcing is not be needed for keeping the reinforcing bars in place. The spacer is made from a light weight material such as plastic and therefore decreases the weight of the reinforced concrete structure. The retainment means decrease the time and skill needed for producing the reinforcing structure and thereby also the time and skill needed for producing the reinforced concrete element.

[0020] The body may be shaped as a slab or as an elongated element such as a beam or pile.

[0021] The reinforcing structure may have different shapes but is preferably shaped as a cage or box in which the reinforcing bars are oriented along the longest side of the cage or box and the spacers are arranged perpendicular to the reinforcing bars. The reinforcing structure is preferably of similar size and shape as the body, however it may alternatively be embedded in a part of the body only, to reinforce that part of the body. The reinforcing structure preferably comprises at least four reinforcing bars. The reinforcing bars are preferably arranged substantially parallel to each other and are typically spaced apart 5 - 20 cm. The reinforcing bars are preferably made from iron or steel. The reinforcing bars typically have a diameter of 8-20 mm, but may be thinner or thicker.

[0022] The spacer may be made of aluminium, or other light metals, but is preferably made of plastics such as nylon, ABS, polycarbonate etc. A plastic is preferred as plastic is both cheap and light, thus decreasing the cost and weight of the spacer. Preferably the reinforcing structure comprises at least two spacers spaced apart by a distance such as at least one meter.

[0023] The spacer is preferably moulded. Alternatively the spacer can be machined from a sheet of the spacer material.

[0024] The retainment means are preferably formed integrally with the spacer.

[0025] The retainment means preferably comprises a resilient body having a recess into which the reinforcing bar can be forced during deformation of the retainment means, where after the retaining bar is kept in the recess and its removal is prevented by the resiliency of the retainment means. The retainment means may for example comprise a C-shaped clip or similar structure having two arms between which the reinforcing bar can be forced. Preferably the retainment means is configured such that the reinforcing bar can be attached to the retainment means using a single one-axial motion, such as is possible when for example the retainment means is a C-shaped clip. This is preferable because it allows easy automation of the process of connecting the reinforcing bars to the spacers for constructing the reinforcing structure.

[0026] The retaining or keeping of the reinforcing bar in the retainment means is preferably reversible, but may alternatively be irreversible by the provision of barbs or similar structures on or along the edges of the recess.

[0027] In any case the retainment means should preferably be configured so that the retaining or keeping of the reinforcing bar in the retainment means is strong enough that the reinforcing bars are not relinquished from the retainment means when the spacers and the reinforcing bars are covered with concrete. Preferably the retainment means are configured to be strong enough that the reinforcing structure in addition can be handled, such as by lifting by only one of the reinforcing bars of the reinforcing structure, without the reinforcing bars being relinquished from the retainment means.

[0028] The at least one spacer of the reinforcing structure is preferably a spacer according to the second aspect of the present invention, embodiments of which are defined in claims 4-9.

[0029] By the preferred embodiment of the first aspect of the present invention as defined in dependent claim 2 an especially strong and tough reinforced concrete element is provided with limited amount of reinforcing bars.

[0030] The steel fibres should have a length of at least 40, preferably 49 mm. Preferably the steel fibres should have hooks at their ends. The diameter of the steel fibres may be 1 mm.

[0031] The concrete should comprise 20 to 50 kg steel fibres per m3 of concrete, more preferably 30 to 50 kg steel fibres per m3 of concrete.

[0032] The properties of the reinforced concrete element according to dependent claim 3 make the reinforced concrete element especially suitable as a concrete pile.

[0033] In the context of the present invention the term elongated should be understood as comprising a situation where the element referred to has a length at least 2 times its width.

[0034] In the context of the present invention the term concrete pile is to be understood as comprising not only a single concrete pile, but also as comprising a concrete pile made from a plurality of segments joined by pile joints, and a single segment of a concrete pile made from a plurality of segments.

[0035] The concrete pile preferably has a square cross section. The four longitudinal edges are the edges extending along the concrete pile

[0036] The reinforcing structure is preferably configured such that each of the reinforcing bars is covered by a suitable layer of concrete. The suitable layer may be at least 2 cm, preferably at least 3 cm as measured from the outside of the concrete pile.

[0037] This is advantageous as the concrete protects the reinforcing bars from water and thereby from corrosion.

[0038] The spacer is preferably configured such that the four retainment means define the corners of a tetragon, preferably a rectangle, and more preferably a square.

[0039] Preferably the retainment means are positioned inwards from the outer contour of the spacer. Thus, when the reinforcing structure is placed in a mould the reinforcing structure is supported by the outer contour of the spacers and the reinforcing bars are thus distanced from the walls of the mould. This ensures that the suitable layer of concrete is formed to cover the reinforcing bars once the concrete is poured into the mould and cured.

[0040] The reinforcing structure thus preferably has a first and a second cross section, the first cross section, corresponding to the outer contour of the spacer, being larger than the second cross section, corresponding to the cross section formed by the reinforcing bars held in the retainment means.

[0041] As the spacers are made of a light weight material such as plastic, the spacers themselves offer only negligible reinforcing of the concrete pile, which concrete pile accordingly comprises substantially no laterally directed reinforcing bars.

[0042] At least one of the above mentioned and further objects are moreover achieved by a second aspect of the present invention pertaining to a spacer according to claim 4 for use in the reinforced concrete element according to the first aspect of the present invention.

[0043] As the retainment means keep the plurality of reinforcing bars in a reinforcing structure in place before and during curing, the commonly used secondary reinforcing is not needed for keeping the reinforcing bars in place. The retainment means decrease the time and skill needed for producing a reinforcing structure using the spacer and thereby also the time and skill needed for producing a reinforced concrete element.

[0044] The spacer is used for forming the reinforcing structure of the reinforced concrete element according to the first aspect of the present invention.

[0045] The spacer may be made of aluminium, or other light metals, but is preferably made of plastics such as nylon, ABS, polycarbonate etc. A plastic is preferred as plastic is both cheap and light, thus decreasing the cost and weight of the spacer and making it easy to handle.

[0046] The spacer is preferably moulded. Alternatively the spacer can be machined from a sheet of the spacer material.

[0047] The spacer preferably has a planar or flat shape. Typically the spacer is configured such that the reinforcing bars are retained perpendicular to the spacer. Preferably the retainment means are positioned spaced apart on the spacer so as to define the corners of a tetragon, preferably a rectangle, more preferably a square.

[0048] The retainment means are preferably formed integrally with the spacer.

[0049] The retainment means preferably comprises a resilient body having a recess into which the reinforcing bar can be forced during deformation of the retainment means, where after the reinforcing bar is kept in the recess and its removal is prevented by the resiliency of the retainment means. The retainment means may for example comprise a C-shaped clip or similar structure having two arms between which the reinforcing bar can be forced. Preferably the retainment means is configured such that the reinforcing bar can be attached to the retainment means using a single one-axial motion, such as is possible when for example the retainment means is a C-shaped clip. This is preferable because it allows easy automation of the process of connecting the reinforcing bars to the spacers for constructing the reinforcing structure.

[0050] The retaining or keeping of the reinforcing bar in the retainment means is preferably reversible, but may alternatively be irreversible by the provision of barbs or similar structures on or along the sides of the recess.

[0051] In any case the retainment means should preferably be configured so that the retaining or keeping of the reinforcing bar in the retainment means is strong enough that the reinforcing bars are not relinquished from the retainment means when the spacers and the reinforcing bars are covered with concrete. Preferably the retainment means are configured to be strong enough that the reinforcing structure in addition can be handled, such as by lifting by only one of the reinforcing bars of the reinforcing structure without the reinforcing bars being relinquished from the retainment means.

[0052] Preferably the spacer is configured, when retaining reinforcing bars in the retainment means, to form a cage or box -shaped reinforcing structure in which the reinforcing bars are oriented along the longest side of the cage or box and the spacers are arranged perpendicular to the reinforcing bars. Preferably the spacer comprises four retainment means for connection with four reinforcing bars.

[0053] Preferably the retainment means are positioned inwards from the outer contour of the spacer. Thus, when a reinforcing structure is made using the spacer and reinforcing bars and the reinforcing structure is placed in a mould, the reinforcing structure is supported by the outer contour of the spacers and the reinforcing bars are thus distanced from the walls of the mould. This ensures that the suitable layer of concrete is formed to cover the reinforcing bars once the concrete is poured into the mould and cured. This is advantageous as the concrete protects the reinforcing bars from water and thereby from corrosion.

[0054] The spacer according to the second aspect of the present invention as defined in claim 5 simplifies the connection of reinforcing bars to the spacers since the reinforcing bars can be connected to the spacer before the spacer is folded into the reinforcing structure configuration, thus there is no need to handle or move the unfinished reinforcing structure until all reinforcing bars have been connected to the spacers.

[0055] The hinges may be separate from the elongated members but are preferably integral with the elongated members. Preferably the hinges are configured to allow said elongated base member and said elongated side members to be folded from a plane linear configuration to the reinforcing structure configuration.

[0056] In the plane linear configuration the retainment means are preferably provided on one side of the elongated members such that the spacer can be placed on a surface and the reinforcing bars being lowered into the retainment means from above.

[0057] The retainment means may be connected to the elongated side and base members, or the elongated side members, via a distance element to position the retainment means suitably inwards from the outer contour of the spacer to ensure that the suitable layer of concrete is formed to cover the reinforcing bars when the reinforcing structure comprising the spacer and the reinforcing bars are placed in a mould and concrete is poured into the mould.

[0058] The reinforcing structure configuration should correspond to the cross section of the desired reinforcing structure to be embedded and used in the reinforced concrete element. In the reinforcing structure configuration the first and second elongated side members are preferably substantially perpendicular to the elongated base member to form a U-shape. Preferably the retainment means are provided on the elongated members in such a way that the retainment means are positioned on the inner sides of the elongated members when the spacer is in the reinforcing structure configuration.

[0059] A preferred embodiment of the spacer according to the second aspect of present invention is defined in dependent claim 6. This embodiment is advantageous as the elongated top member, once reinforcing bars have been positioned in the retainment means on the elongated base and side members, can be folded and connected, by means of the locking retainment means, with the reinforcing bar positioned in the retainment means situated farthest away along the spacer from the locking retainment means, thus locking the spacer in the reinforcing bar positioning configuration. This allows the spacer with reinforcing bars to be handled as a reinforcing structure without unfolding.

[0060] The elongated top member may be similar to the base elongated base member.

[0061] The locking retainment means may be identical to the retainment means. Alternatively the locking retainment means may be shaped as a hook. In any case the locking retainment means should preferably be configured to be strong enough for maintaining said reinforcing structure configuration even where the reinforcing structure is be handled, such as by lifting by only one of the reinforcing bars of the reinforcing structure.

[0062] An alternative embodiment of the spacer according to the second aspect of present invention is defined in dependent claim 7. This embodiment is advantageous as, by using only two hinges, and locking members comprised by the side members, the spacer is easier to fold into the reinforcing structure configuration, thus allowing easier automation of the folding.

[0063] The first and the second locking members are preferably perpendicular to the elongated side members. The first and second locking members should be configured such that the locking structures are brought in contact once the spacer has been folded into the reinforcing structure configuration. Preferably the first and second locking members, when connected via the first and second complimentary locking structures, together form a structure similar to the elongated base member.

[0064] The first and second locking structures should be configured such that they are brought into a locking engagement when they are pressed against each other during folding of the spacer. Suitable locking structures include a barbed spear and a hole, two tongues having opposing racks, a rack and a pawl, a snap fit connection comprising for example a beam having a hook and a recess having a wall for engaging the hook, etc. Further suitable locking structures include a hook and a ring.

[0065] It is further contemplated within the context of the present invention that the first and second locking structure may comprise pressure sensitive adhesive or a hook and loop fastener. Also contemplated within the context of the present invention is the use of a pin and a hole engaging each other by interference fit.

[0066] In the embodiments of the spacer according to the claims 5-7 the hinges are preferably living hinges. The living hinges may be formed by oblique partial cuts into a base material forming said elongated base member, said elongated side members, and for the spacer according to claim 6, the elongated top member.

[0067] The first and second hinges are preferably configured such that, in one extreme position correlated with the elongated base and side members being folded into the reinforcing structure configuration, the elongated base member and the elongated first side member, and the elongated base member and the elongated second side member, respectively, form 90° angles.

[0068] The first alternative embodiment of the spacer according to the second aspect of the present invention as defined in claim 8 is advantageous in that it does not require any folding to form the reinforcing structure.

[0069] Each corner of the frame includes an outer corner on the outer contour of the frame and an inner corner on the inner contour of the frame. Preferably the retainment means are positioned at the inner corners of the frame and the frame further comprises radial cut-outs, one at each corner of the frame and extending from the outer corner to the retainment means, the cut-outs being adapted for allowing a reinforcing bar to be passed radially from outside the spacer into the retainment means. More preferably the frame comprises four elongated members spaced apart at their edges to form the cut-outs, the retainment means joining the elongated members to each other. The retainment means may for example be C-shaped or semi circular structures connecting the elongated members and being open to the cut-outs.

[0070] The second alternative embodiment of the spacer according to the second aspect of the present invention as defined in claim 9 is advantageous in that it does not require any folding to form the reinforcing structure and requires a minimum of material.

[0071] Preferably the retainment means are positioned inwards of the tips and the body further comprises radial cut-outs, one at each tip of the body and extending from the tip to the retainment means, the cut-outs being adapted for allowing a reinforcing bar to be passed radially from outside the spacer into the retainment means.

[0072] In the spacer as defined in claim 8 and 9 the cut-outs allow the reinforcing bars to be connected to the retainment means from the exterior of the spacer, and ensure a suitable distance between the outer contour of the spacer and the retainment means such that when a reinforcing structure is made using the spacer and reinforcing bars and the reinforcing structure is placed in a mould, the reinforcing structure is supported by the outer contour of the spacers and the reinforcing bars are thus distanced from the walls of the mould. This ensures that the suitable layer of concrete is formed to cover the reinforcing bars once the concrete is poured into the mould and cured. This is advantageous as the concrete protects the reinforcing bars from water and thereby from corrosion

[0073] In the embodiments of the spacer according to the claims 5-9, the members, frame, and body preferably comprises trusses. This is advantageous as it increases the rigidity of the spacer which increases the rigidity of the reinforcing structure formed by the spacers and the reinforcing bars. In addition it may increase the strength of the reinforced concrete element in which the spacers are used because the voids in the trusses increase the amount of concrete which can be present in a cross section including a spacer, of the reinforced concrete element.

[0074] Further, in the embodiments of the spacer according to the claims 5-9, the spacer preferably comprises distance pins arranged on the spacers such that the distance pins project outwards from the outer contour of the spacer in the reinforcing structure configuration. This is advantageous as it ensures that the spacer, when placed in a mould, is distanced from the walls and bottom of the mould. This ensures that the spacer, when embedded in concrete, becomes covered with a layer of concrete, thus preventing any water from being led into the reinforced concrete structure via the spacer material. This further protects the reinforcing bars from water and corrosion. The distance pins should preferably be configured to be as thin as possible while still being capable of bearing the weight of the reinforcing structure with the reinforcing bars retained in the retainment means without failing and allowing any part of the spacers except the tip of the distance pin to contact the mould.

[0075] At least one of the above mentioned and further objects are moreover achieved by a third aspect of the present invention pertaining to a method according to claim 10 of producing a reinforcing structure.

[0076] By using at least two spacers according to the second aspect of the present invention a reinforcing structure can be produced easily, rapidly, and/or simply.

[0077] The reinforcing structure is suitable for use in the reinforced concrete element according to the first aspect of the present invention.

[0078] The at least two spacers are preferably positioned spaced apart and parallel to each other.

[0079] By the preferred embodiment of the method of producing a reinforcing structure according to the third aspect of the present invention as defined in claim 11, the folding of the spacers into the reinforcing structure configuration requires less effort by the workmen.

[0080] At least one of the above mentioned and further objects are moreover achieved by a the method according to claim 12 of producing a concrete pile.

[0081] By using a reinforcing structure obtained by the method according to the third aspect of the present invention and by using steel fibre reinforced concrete, a strong concrete pile can be produced rapidly and using less reinforcing.

[0082] The invention and its many advantages will be described in more detail below with reference to the accompanying schematic drawings, which for the purpose of illustration show some non-limiting embodiments, and in which

Fig. 1 shows, in side view, a concrete pile representing a reinforced concrete element according to the first aspect of the present invention,

Fig. 2 shows, in side view, a first embodiment of a spacer according to the second aspect of the present invention being used in the method according to the third aspect of the present invention,

Fig. 3 shows, in side view, a preferred embodiment of the method according to the third aspect of the present invention involving the use of an assembly table,

Fig. 4 shows, in side view, a second embodiment of a spacer according to the second aspect of the present invention, and

Fig. 5 shows, in side view, a third, a fourth, and a fifth embodiment of a spacer according to the present invention.

[0083] In the below description a superscript roman numeral added to a reference number indicates that the element referred to has the same or similar function as the element designated the un-superscripted reference number, however, differing in structure.

[0084] When further embodiments of the invention are shown in the figures, the elements which are new, in relation to earlier shown embodiments, have new reference numbers, while elements previously shown are referenced as stated above. Elements which are identical in the different embodiments have been given the same reference numerals and no further explanations of these elements will be given.

[0085] Fig. 1A shows a concrete pile 10 having an elongated shape with a top 12 and a bottom portion, generally designated the reference numeral 14. The top 12 may be provided with a crack ring for protecting the concrete pile 10 during driving into the ground. The bottom portion is provided with a rock point 16 for engaging subsurface rock formation to anchor the bottom portion 14. Further the rock point 16 protects the concrete pile 10 from breaking when driving the concrete pile 10 into soil containing boulders.

[0086] The concrete pile 10 further has a square cross section with four longitudinal sides, one of which is designated the reference numeral 18, and four longitudinal edges, one of which is designated the reference numeral 20.

[0087] Fig. 1 B shows an enlargement and partial cutaway of the concrete pile 10. The concrete pile 10 is reinforced by four longitudinally directed reinforcing bars, one of which is designated the reference numeral 22, which are embedded in the concrete 24. The concrete 24 is reinforced with steel fibres. Each of the reinforcing bars 22 is embedded along a corresponding edge 20 to reinforce the concrete pile 10. The concrete pile 10 is dimensioned based on the load bearing capacity of the concrete 24 present with the area bounded by the reinforcing bars 22, while the concrete 24 present between the reinforcing bars 22 and the longitudinal sides 18 primarily is dimensioned to provide adequate corrosion resistance for the reinforcing bars 22 by preventing water from contacting the reinforcing bars 22.

[0088] The reinforcing bars 22 are interconnected and positioned by a spacer, in its entirety designated the reference numeral 30, made of plastic. The concrete pile 10 comprises several spacers 30 spaced 1.2 m from each other along the concrete pile 10. The spacers 30 and the reinforcing bars 22 thus form a reinforcing structure.

[0089] The main components of the spacer 30 are an elongated base member 32, a first side member 34, a second side member 36, and four retainment means, one of which is designated the reference numeral 38. The elongated base and first and second side elements 32, 34 and 36 are joined to each other by living hinges as will be described in more detail with reference to fig. 2. The retainment means 38 are provided on the elongated first and second side members 34 and 36, and are shaped as a C-shaped clip so as to clip on to the reinforcing bars 22. Each retainment means 38 is joined to the side member 34 or 36 by a distance element 40 for positioning the reinforcing bars 22 suitably inwards of the elongated sides 18 of the concrete pile 10 to provide a corrosion protecting layer of concrete 24 between the reinforcing bars 22 and the exterior of the concrete pile 10.

[0090] In fig. 1 the elongated base and side members 32, 34 and 36 of the spacer 30 are folded into a reinforcing structure configuration for forming the reinforcing structure in which the reinforcing bars 22 are positioned in the positions needed for reinforcing the concrete pile 10.

[0091] To simplify the handling of the reinforcing structure comprising the spacer 30 and the reinforcing bars 22, the spacer 30 is further provided with an elongated top member 42 connected via a living hinge (not shown in fig 1) to the second elongated side member 36. The elongated top member 42 is similar to the elongated base member 32 but carries at its free end a locking retainment means 44 which is identical to the retainment means 38 with distance element 40. The elongated top member 42 is used to connect the elongated first and second sides by connecting the locking retainment means 44 to the corresponding one of the reinforcing bars 22, as will be described in more detail with reference to fig. 2, thus locking the elongated base and side elements 32, 34, and 36 in the reinforcing structure configuration

[0092] Although the concrete pile 10 in fig. 1 is shown having a rock point 16, the concrete pile 10 can also be used without the rock point 16 in soils containing no major boulders and where there is no subsurface rock formation to which the bottom portion 14 needs to be anchored. In this case the bottom portion 14 can be provided with a crack ring similar to that which can be provided at the top 12

[0093] Further, although the concrete pile 10 of fig. 1 is shown as a single body of concrete, the concrete pile 10 may be extended or divided into shorter, more easily transportable segments, using pile joints embedded in the concrete pile as is known in the art of concrete piles.

[0094] Further, although the locking retainment means 44 of fig 1 is shown as identical to the retainment means 38 and distance element 40, other shapes of locking retainment means are possible, for example to provide a higher or lower strength in the connection between the locking retainment means and the reinforcing bar.

[0095] Fig. 2 shows the spacer 30 being used in a method of producing the concrete pile 10. The spacer 30 is in fig 2A shown in an unfolded plane linear configuration. The base member 32 and the side members 34 and 36, and the second side member 36 and the top member 42, are foldably connected by living hinges, one of which is designated the reference numeral 46.

[0096] Fig. 2A shows the first step in which a plurality of spacers 30, only one being shown, are positioned parallel to each other and spaced apart by for example 1.2 m. reinforcing bars 22 are then laid perpendicularly to the spacers 30 and connected to the spacer 30 by the retainment means 38. The locking retainment means 44 does not yet connect to a reinforcing bar 22.

[0097] In fig. 2B the first and second side members 34 and 36 have been folded from the unfolded plane linear configuration shown in fig. 2A to the reinforcing structure configuration corresponding to the reinforcing structure formed by the spacer 30 and the reinforcing bars 22 in the concrete pile 10 of fig. 1. To lock the spacer 30 in the reinforcing structure configuration the elongated top member 42 is now folded to an orientation parallel to that of the base member 32 to bring the locking retainment means 44 towards the corresponding reinforcing bar 22 held by the first elongated side member 34.

[0098] In fig. 2C the elongated top member 42 has been folded so that it is fully parallel to the elongated base member 32 and the locking retainment means 44 has clipped onto the corresponding reinforcing bar 22. The spacer 30 is thus locked in the reinforcing structure configuration.

[0099] Thus, as shown in 2C the result of steps 2A to 2B is a reinforcing structure comprising a plurality of spaced apart spacers 30 interconnecting and positioning reinforcing bars 22 into a form of cage or box. As seen from figure the reinforcing structure has a first cross section, corresponding to the outer contour of the spacer 30, which is larger than the second cross section, corresponding to the retainment means 38 and the reinforcing bars 22.

[0100] In fig. 2D the reinforcing structure comprising the spacers 30 and the reinforcing bars 22 have been placed in an elongated mould, in its entirety designated the reference numeral 70. The mould 70 comprises a bottom 72 and two walls 74 and 76 and is shaped to fit the outer circumference of the spacer 30 in the reinforcing structure configuration. As is seen from fig. 2D the elongated top member 42, while providing the useful advantage of locking the spacer 30 in the reinforcing structure, is not essential as elongated base and side members 32, 24 and 36, with suitable living hinges 46 and in engagement with the bottom 72 and walls 74 76 of the mould 70, can maintain the reinforcing structure configuration during the casting of the concrete pile 10. As is seen from the figure the spacer 30, in addition to positioning the reinforcing bars 22 in relation to each other, further, by means of distance element 40, positions the reinforcing bars 22 a suitable distance inwards of the outer contour of the spacers, thus providing a separation between the reinforcing bars 22 and the walls and bottom 72, 74, and 76 of the mould 70, which separation can be filled with concrete 24 to provide a corrosion protecting layer of concrete 24 between the reinforcing bars 22 and the exterior of the concrete pile 10.

[0101] One or more crack rings, a rock point, or one or more pile joints or a loops, none of which are shown in fig. 2 , can be suitably positioned in the mould 70 and, as needed or desired, connected to the reinforcing bars 22 as is known in the art of concrete piles. Where pile joints are positioned in the mould, additional reinforcing bars connected to the pile joints can also be placed in the mould.

[0102] In fig. 2E concrete 24, reinforced with steel fibres, has been poured into the mould 70. Once the concrete 24 has set the mould 70 can be disassembled and the concrete pile 10 removed.

[0103] Fig. 3 shows a preferred embodiment of the method of producing a reinforcing structure according to the third aspect of the present invention involving the use of an assembly table, in it entirety designated the reference numeral 80. The assembly table includes an elongated centre panel 82, a first elongated side panel 84 and a second elongated side panel 86. Furthermore the assembly table 80 includes a hydraulic cylinder and piston unit 88, representing a height adjustment device, for lowering and raising the elongated centre panel 82.

[0104] The method starts as shown in fig. 3A by placing a plurality of spacers 30, only one being shown, parallel to each other and spaced apart by for example 1.2 m. along the assembly table 80, which thus must have a length substantially corresponding to the length of the desired reinforcing structure, and hence the length of the concrete pile 10 itself. Reinforcing bars 22 are then laid perpendicularly to the spacers 30 and connected to the spacer 30 by the retainment means 38. The locking retainment means 44 does not yet connect to a reinforcing bar 22. The assembly table 80 may additionally comprise 1.2 m spaced apart lateral grooves (not shown) provided on the panels 82, 84, and 86 into which the plurality of spacers 30 can be slid for positioning the spacers 30. The lateral grooves should have a depth allowing the retainment means 38 to project out of the grove sufficiently for connecting the retainment means 38 to the reinforcing bars 22.

[0105] Once all reinforcing bars 22 have been connected to the spacers 30, the hydraulic cylinder and piston unit 88 is actuated to lower the elongated centre panel 82 as seen in fig. 3B. At the same time the elongated side members 34 and 36 of the spacer 30 are folded so that the elongated base and side members 32, 34, and 36 assume the reinforcing structure configuration. The folding of the elongated side members 34 and 36 may be performed manually, or automatically. For an automatic folding the elongated side panels 84 and 86 may be provided with actuators (not shown) for engaging the elongated side members 34 and 36 for folding the spacer 30 into the reinforcing structure configuration.

[0106] The elongated top member 42 is now folded to an orientation parallel to that of the base member 32 to bring the locking retainment means 44 towards the corresponding reinforcing bar 22 held by the first elongated side member 34. The folding of the elongated top member 42 may be manual or automatic. For an automatic folding the second elongated side panel 86 may be provided with a suitable actuator (not shown) for engaging the elongated top member 42.

[0107] The finished reinforcing structure is shown in fig. 3C. The hydraulic cylinder and piston unit 88 is now once more activated but this time to raise the elongated centre panel 82 to allow the reinforcing structure to be lifted off the assembly table 80 as shown in fig 3D. The reinforcing structure can now be placed, for example, in the mould 70 for producing the concrete pile 10.

[0108] In an alternative embodiment of the assembly table (not shown) the elongated centre panel 82 is fixed while two hydraulic cylinder and piston units, or other suitable actuators, are connected to the elongated side panels 84 and 86 for pivoting the elongated side panels along the respective joint of the side panels and the centre panel, for folding the elongated side members 34 and 36 of the spacer 30 into the reinforcing structure configuration.

[0109] In fig. 3 the spacer 30 includes the distance element 40, however, due to the scale of the figure, the distance element 40 has not been indicated in the figure.

[0110] Fig. 4A shows a second embodiment of a spacer in its entirety designated the reference numeral 30^{I}, in an unfolded configuration. Spacer 30^{I} comprises modified elongated base and side members 32^{I}, 34^{I} and 36^{I} which differ from the corresponding members of spacer 30 in that the elongated members 32^{I}, 34^{I} and 36^{I} are thicker and formed with trusses for increased rigidity. The voids in the trusses further increase the amount of concrete 24 which can be present in the concrete pile 10 where the spacer 30^{I} is located. This increases the strength of the concrete pile since the material of the spacer 30^{I}, typically plastic, is less strong than the concrete 24. Accordingly modified retainment means 38^{I} are used since there is no longer a need for the distance member 40 used in spacer 30. The members 32^{I}, 34^{I} and 36^{I} are connected to each other by living hinges 46 similar as in the spacer 30. The elongated members 32’, 34^{I} and 36^{I} further comprises distance pins, one of which is designated the reference numeral 48, for ensuring a suitable distance between the surface 18 of the concrete pile and the elongated members. The distance pins 48 ensure that a layer of concrete is formed on the spacer 30^{I} so that water is not drawn into the concrete pile 10 via the spacer 30^{I}.

[0111] Instead of elongated top member 42, spacer 30^{I} comprises first and second locking members 50 and 52 attached to the first and second elongated side members 34^{I} and 36^{I}. The locking members 50 and 52 comprise a hole 54 and a barbed spear 56 representing first and second complementary locking structures configured to engage each other to retain the first and second locking members in contact for maintaining the reinforcing structure configuration, as shown in fig. 4B.

[0112] The spacer 30^{I} is advantageous as is easier to automatically fold into the reinforcing structure configuration since the folding of the elongated side members 34^{I} and 36^{I} leads to the engagement of the hole 54 and barbed spear 56 and the eventual locking of the spacer 30^{I} in the reinforcing structure configuration. Thus, in an automatic process, only two folding movements, effected for example by two hydraulic cylinder and piston units or other actuators, are needed for folding the spacer 30^{I}.

[0113] Fig. 5A shows a third embodiment of a spacer in its entirety designated the reference numeral 30". Spacer 30" resembles spacer 30^{I} in the latter’s reinforcing structure configuration, however spacer 30" is not foldable but provided as a ready to use spacer. Spacer 30" comprises four modified base members 32", which are similar to base member 32^{I} in spacer 30^{I}, joined at their respective ends by modified retainment means 38". Radially directed cut-outs, one of which is generally designated the reference numeral 58, allow access to the retainment means 38". Reinforcing bars 22 may be passed radially into the retainment means 38" through the cut-outs 58 for connection with the spacer 30".

[0114] Spacer 30" is advantageous as it does not require folding into a reinforcing structure configuration.

[0115] Fig. 5B shows a fourth embodiment of a spacer in its entirety designated the reference numeral 30^{III}. Spacer 30^{III} is similarly to spacer 30" not foldable, and is provided as a ready to use spacer. Spacer 30^{III} comprises a modified cross shaped base member 32^{III} forming four tips, one of which is generally designated the reference numeral 60. Each of the four tips 60 is provided with a retainment means 38^{III} and radially directed cut-out 58 similar to those of spacer 30". Reinforcing bars 22 may be passed radially into the retainment means 38^{III} through the cut-outs 58 for connection with the spacer 30^{III}.

[0116] Spacer 30^{III} is advantageous as the cross shaped base member 32^{III} uses less material than the members of the spacers 30, 30^{I}, and 30".

[0117] Fig. 5C shows a fifth embodiment of a spacer in its entirety designated the reference numeral 30^{IV}. Spacer 30^{IV} comprises a single elongated base member 32^{IV}, corresponding to the elongated side member 34^{I} of spacer 30^{I}, having two retainment means 38^{I}. Spacer 30^{IV} is contemplated to be used for keeping two reinforcing bars 22 at a time in place, a plurality of spacers 30^{IV} in sequence thus creating a reinforcing structure together with a plurality of reinforcing bars 22.

[0118] Spacer 30^{IV} is advantageous as it allows reinforcing structures of various cross sections, such a triangular, square, etc., to be formed as desired, using a single type of spacer.

[0119] In addition to increasing the rigidity of the spacers shown in figs. 4-5, the trusses, more particularly the voids in the trusses further increase the amount of concrete 24 which can be present in the concrete pile 10 where the spacer is located. This increases the strength of the concrete pile since the material of the spacer, typically plastic, is less strong than the concrete 24.

[0120] The spacer 30 shown in figs. 1-3 is shown as made of a solid material, however, it may alternatively be made of members comprising trusses.

EXAMPLE

[0121] A prototype implementation of the presently preferred embodiment of a reinforced concrete element in the shape of a concrete pile as shown and described with reference to fig. 1, hereinafter designated fp230, was made with the following specification: The diameter of the concrete pile was 230 x 230 mm. Concrete of strength class C50/60 was used. The concrete was reinforced with 30kg/m3 of steel fibres having the dimensions 49 x 1 mm and being provided with hooks in the ends. Four reinforcing bars with a diameter of 12 mm and reinforcing quality Ks60 were used. The reinforcing bars were placed such that the thickness of the concrete layer between the reinforcing bars and the outside of the concrete pile was 30 mm.

[0122] The reinforcing structure, in addition to the four reinforcing bars, comprised spacers as shown in figs. 1-3. The spacers were placed 1.2 m apart along the length of the concrete pile. The spacers were made from 8 mm thick nylon and the elongated members of the spacers were each approximately 230 mm long.

[0123] The fp230 concrete pile was tested in the field, by being driven into the ground, and computer simulated. The results of the tests were evaluated in comparison with the common standard piles SP1, SP2 and SP3, details of which are given in table 1 below, with the following results:

Table 1: Details of common standard piles SP1, SP2 and SP3, and fp230 concrete pile

Type	Cross sectional dimension (mm)	No. / dia. of reinforcing bars and lateral reinforcing	Concrete type	Max number of hits before cracking at 0.4 m ram height	Max load (kN) when driven into soft clay (6kPa shear strength)	Max length (m)
SP1	235 x 235	4 / Ø16 mm Ks60 + spiral reinforcing 05 mm 10 turns per m	K50	2500	749	11
SP2	270 x 270 275 x 275	4*2 / Ø12 mm Ks60 + spiral reinforcing 05 mm 10 turns per m	K50	3500	1023	11
SP3	270 x 270 275 x 275	4*2 / Ø16 mm Ks60 + spiral reinforcing 05 mm 10 turns per m	K50	3500	1223	11
fp230	230 x 230	4 / Ø12mm Ks60	K60 + 30 kg/m^3 steel fibre (49 x 1 mm, with end hooks)	+ 70%	1376	15

[0124] Load bearing capacity: The fp230 pile, despite its smaller or similar dimensions, and despite significantly less reinforcing, has the highest load capacity and can therefore replace all the common standard piles SP1, SP2 and SP3.

[0125] Using a steel density of 7850 kg/m^3 the total amount of steel (steel fibres + reinforcing bars) in a 10 m long fp230 pile was about 51 kg.

[0126] In comparison a 10 m long SP1 pile, where it is assumed that the distance between the reinforcing structure (spiral reinforcement and reinforcing bars) and the outside of the pile is 20 mm, contains about 63 kg steel for the four reinforcing bars (16 mm thick) + 12 kg steel for the spiral reinforcing, in total about 75 kg.

[0127] Thus the fp230 pile uses about 68% of the amount of steel of the SP1 pile, yet achieves a load capacity which is about 80% higher.

[0128] For a 10 m long SP3 pile with the dimensions 270 x 270 mm and 20 mm concrete between the reinforcing bars and the outside of the pile, the amount of steel is 126 kg for the 8 (4*2) reinforcing bars + 14 kg for the spiral reinforcing, in total about 140 kg.

[0129] Thus, when compared to the SP3 pile, the fp230 pile comprises about 36% of the amount of steel of the SP3 pile, yet achieves a load capacity which is about 13% higher.

[0130] The fp230 pile, since it uses less steel, is therefore lighter and cheaper to make. Since it is also smaller it is easier to transport than a common standard pile.

[0131] Driving properties: In driving test using a pile driver the fp230 pile could receive about 70% more driving impacts than the common standard piles without cracking and becoming unusable. The integrity of the fp230 pile was measured during driving with a PDA meter. The PDA meter measures the impact wave through the concrete pile and reveals any breaks or failures of the pile by detecting the partial reflection of the impact wave at the break or failure.

[0132] Strength, stress and handling: The fp230 pile is tough and thus does not exhibit sudden failures due to shear. It also has a higher strength when being lifted and handled. Therefore the fp230 pile may be produced in longer lengths of up to 15 m as opposed to 11 m for the common standard piles. Thus there is less need for expensive pile joints.

[0133] Further, the fp230 pile exhibited less fracturing and fissuring during handling and driving, limiting the risk of water reaching the reinforcing bars causing corrosion and loss of load capacity. Less fracturing and fissuring during handling and driving further prevents damage to the concrete during driving where the sudden compression of cracks from the driving impact increased the hydraulic pressure of water within the cracks, which water causes further damage to the concrete pile.

[0134] Production: The time and effort involved in producing the fp230 pile using the spacers was roughly half that of a common standard pole. As an illustration a SP1 pile having a reinforcing spiral with 10 turns per meter has 40 points per m where the reinforcing bars are tied to the spiral reinforcing, thus requiring a significant amount of work. In comparison the fp230 pile comprises a spacer only every 1.2 m, and each spacer has only 4 retainment means or clips where the reinforcing bars are easily attached and retained.

[0135]

List of parts with reference to the figures:

10.	Concrete pile
12.	Top
14.	Bottom portion
16.	Rock point
18.	Longitudinal side
20.	Longitudinal edge
22.	Reinforcing bar
24.	Concrete
30.	Spacer
32.	Elongated base member
34.	First elongated side member
36.	Second elongated side member
38.	Retainment means
40.	Distance element
42.	Elongated top member
44.	Locking retainment means
46.	Living hinge
48.	Distance pin
50.	First locking member

(continued)

52.	Second locking member
54.	Hole
56.	Barbed spear
58.	Cut-out
60.	Tip
70.	Mould
72.	Bottom
74.	First wall
76.	Second wall
80.	Assembly table
82.	Elongated centre panel
84.	First elongated side panel
86.	Second elongated side panel
88.	Hydraulic cylinder and piston unit

Claims

1. A reinforced concrete element (10) comprising a body of concrete (24) and a reinforcing structure embedded in the body, said reinforcing structure comprising a plurality of spaced apart reinforcing bars (22), said reinforcing structure further comprises at least one spacer (30) made of a light weight material such as plastic, said spacer comprising retainment means (38) for keeping said plurality of reinforcing bars (22) in said reinforcing structure in place before and during curing of said concrete (24), **characterized in that** said concrete (24) is reinforced with steel fibres.

2. The reinforced concrete element (10) according to claim 1, said reinforced concrete element (10) being an elongated concrete pile (10) with a substantially rectangular cross section and four longitudinal edges (20), wherein said reinforcing structure comprises at least four reinforcing bars (22), and wherein said reinforcing structure further is configured such that each of said at least four reinforcing bars (22) are directed along the body and embedded along a corresponding one of said longitudinal edges (20), said spacer (30) comprising at least four retainment means (38), each retainment means (38) being adapted to receive and retain a reinforcing bar (22).

3. The concrete pile according to claim 2, said concrete pile comprising substantially no laterally directed reinforcing bars.

4. The reinforced concrete element according to any preceding claim, said concrete comprising 20 to 50 kg, more preferably 30 to 50 kg, steel fibres per m3 of concrete.

4. The reinforced concrete element according to any preceding claim, said steel fibres having a length of at least 40 mm, or preferably 49 mm.

5. The reinforced concrete element according to any preceding claim, said steel fibres having a diameter of 1 mm.

6. The reinforced concrete element according to any preceding claim, said steel fibres having hooks at their ends.

8. The reinforced concrete element of any of the claims 1-6, said spacer (30^{II}) comprising a rectangular planar frame defining a reinforcing structure configuration, said frame having four corners, each of said retainment means (38") being provided at a corresponding one of said corners.

9. The reinforced concrete element of any of the claims 1-6, said spacer (30^{III}) comprising an X shaped or cross shaped body (32^{III}) defining a reinforcing structure configuration, said body having four tips (60), each of said retainment means (38^{III}) being provided at a corresponding one of said tips (60).

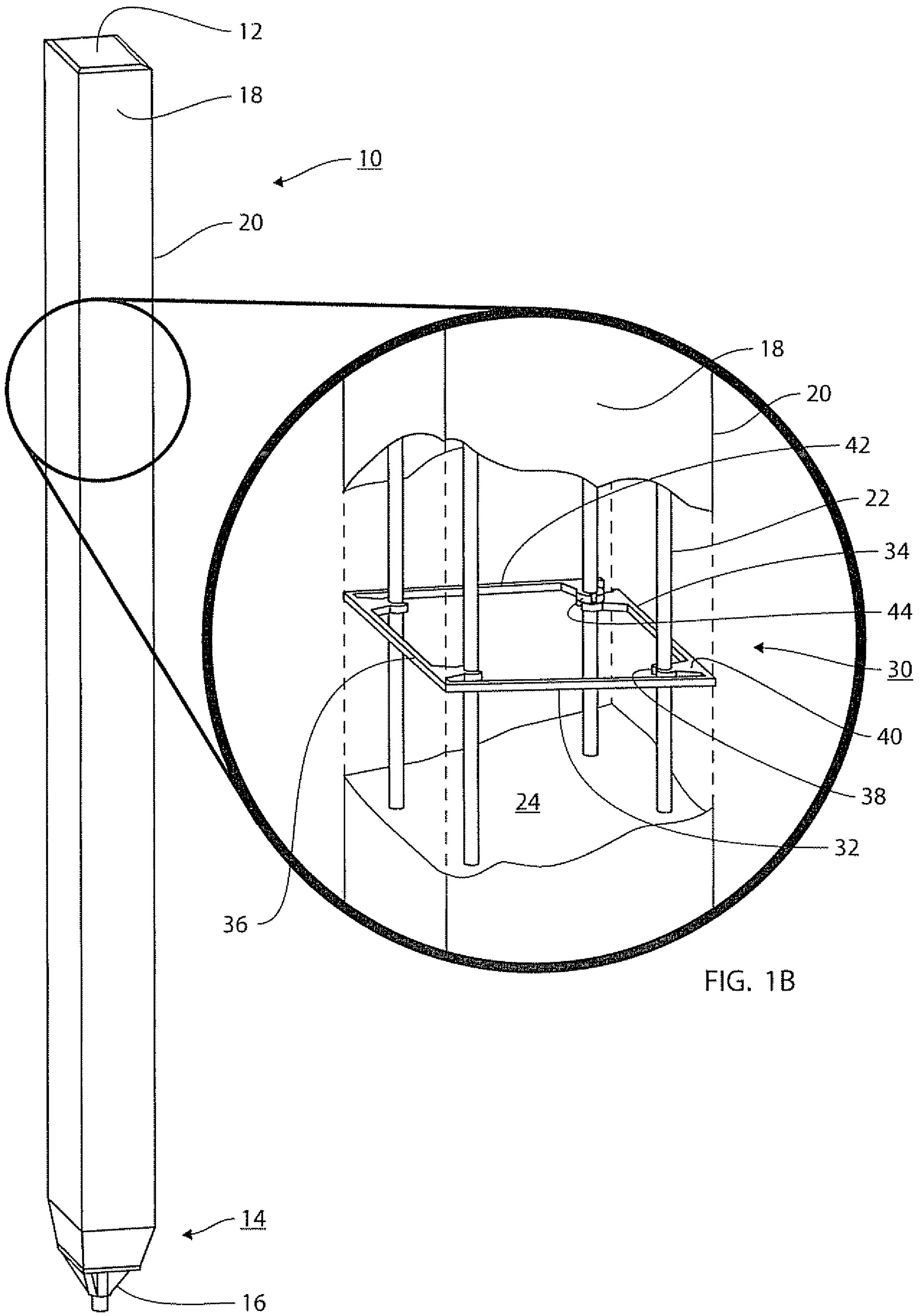

FIG. 1B

FIG. 1A

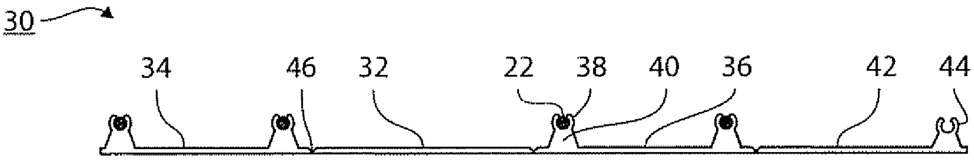

FIG. 2A

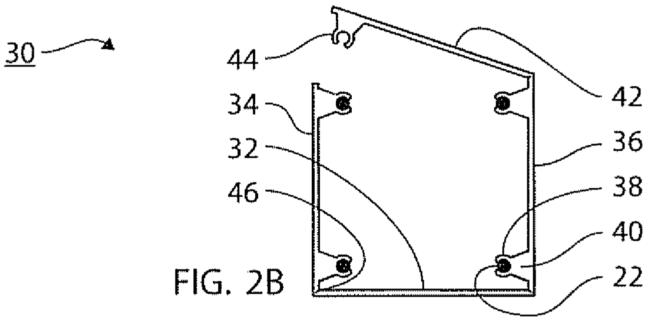

FIG. 2B

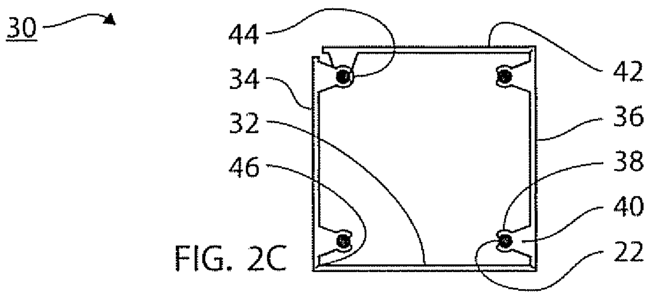

FIG. 2C

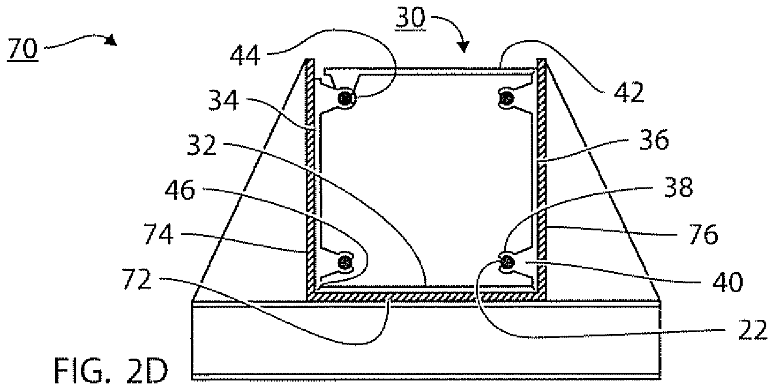

FIG. 2D

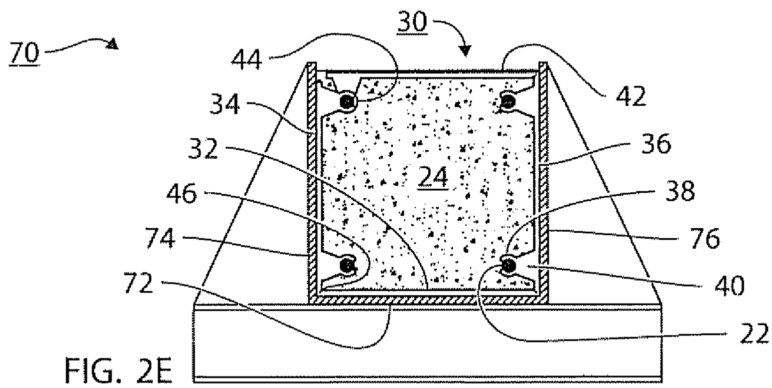

FIG. 2E

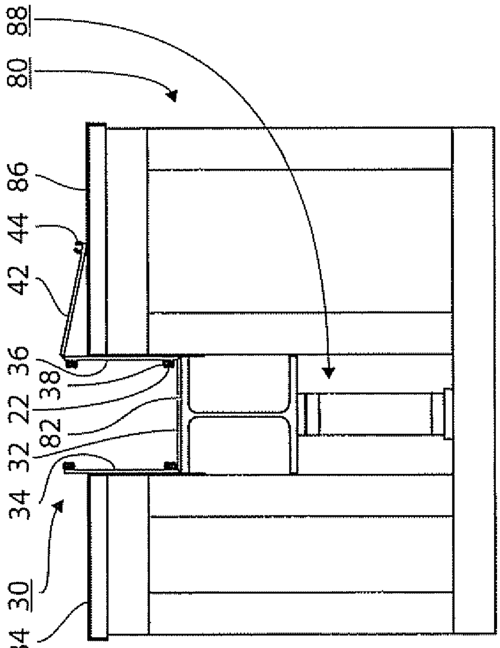

FIG. 3B

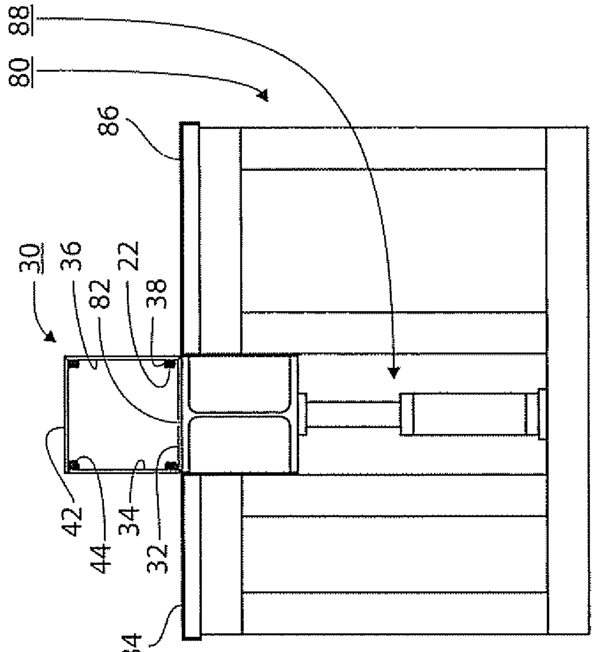

FIG. 3D

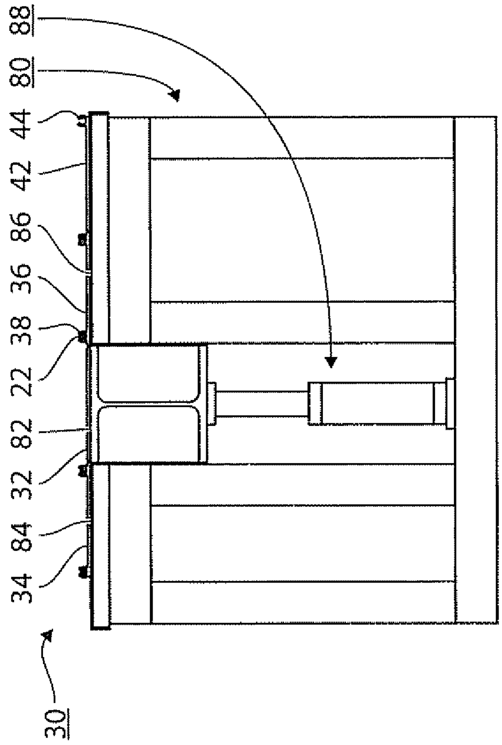

FIG. 3A

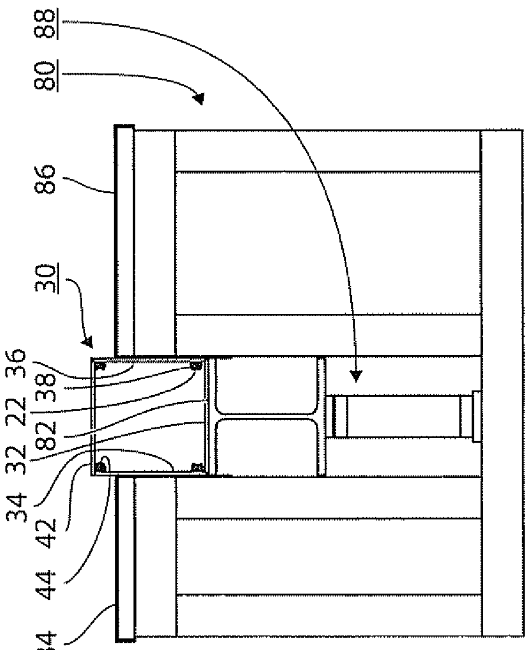

FIG. 3C

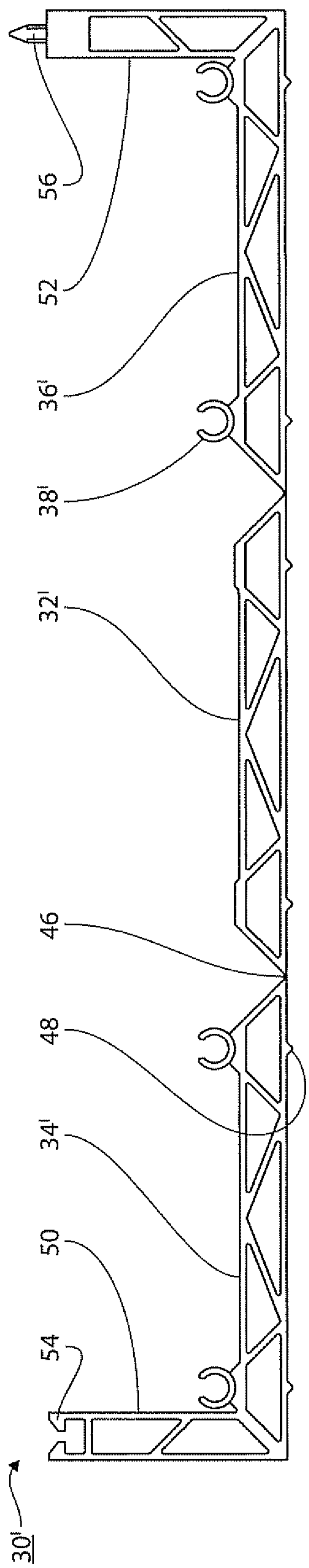

FIG. 4A

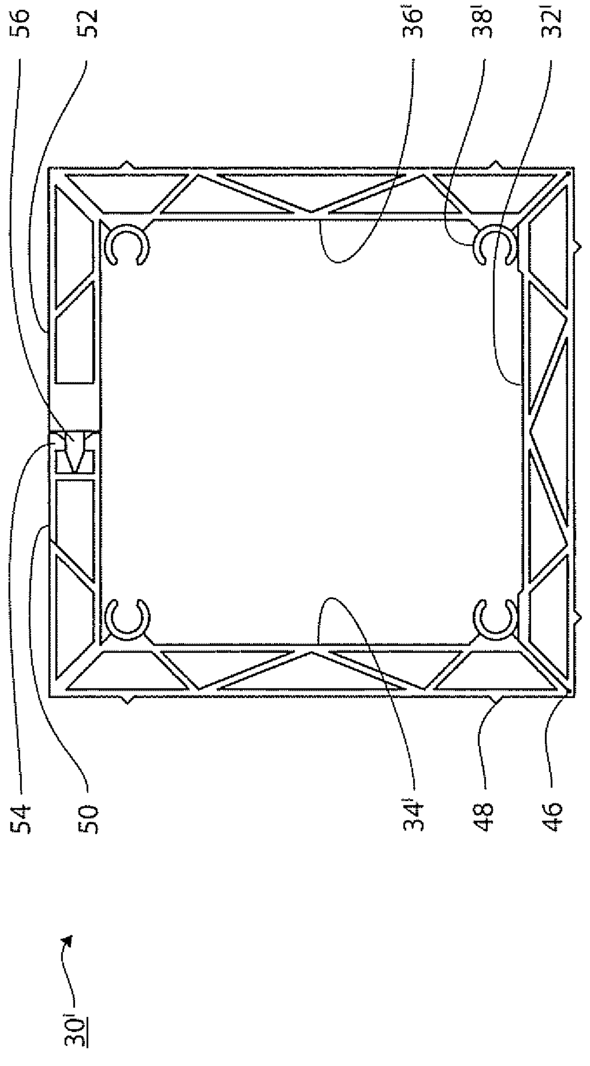

FIG. 4B

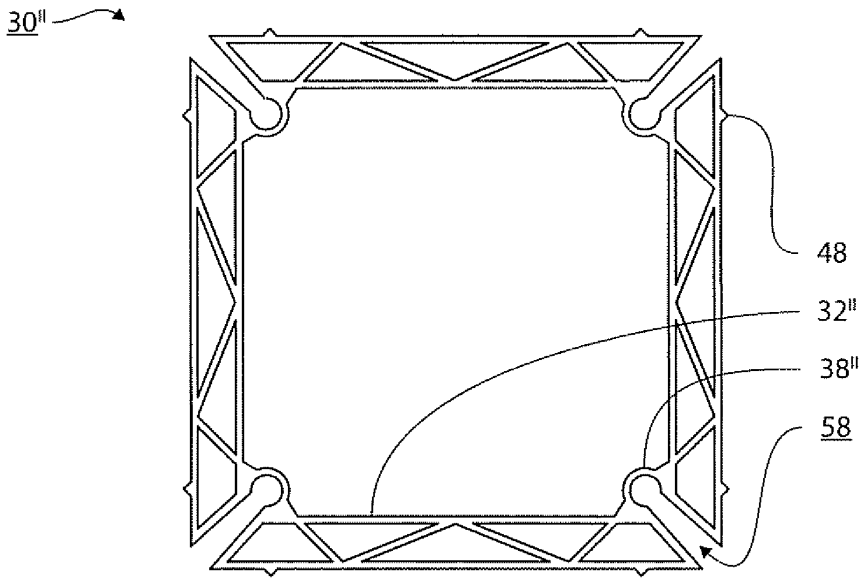

FIG. 5A

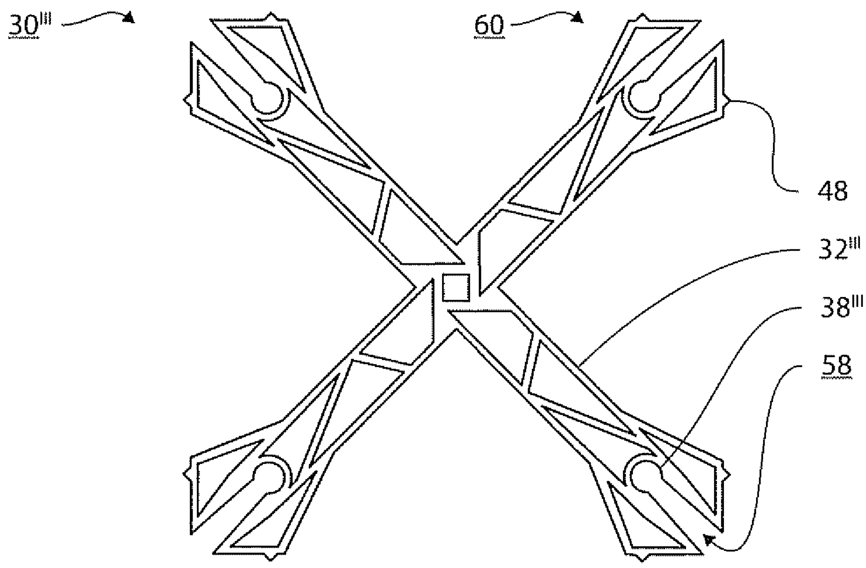

FIG. 5B

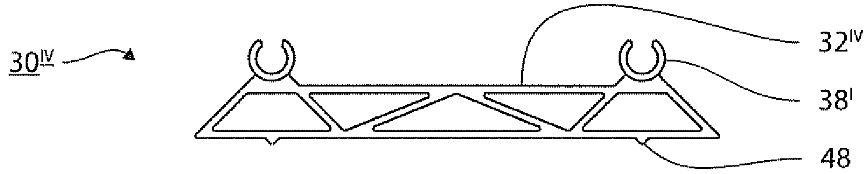

FIG. 5C

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EUROPEAN SEARCH REPORT

Application Number
EP 13 15 9517

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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Y	EP 0 794 296 A1 (GRAY ENG LTD [GB]) 10 September 1997 (1997-09-10) * column 2, line 48 - column 3, line 23; figures 1,2 * -----	1-6	
Y	AU 725 449 B2 (ROBERT JOHN BAIRD; RODNEY LEE FLOYD) 12 October 2000 (2000-10-12) * page 3, line 20 - page 4, line 15; figures 1-2 * -----	1-6,8	
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			E04C

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	31 July 2013	Valenta, Ivar

CATEGORY OF CITED DOCUMENTS

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