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(54) Method for reinforcing a steel beam and steel beam obtained via this method

(57) The invention relates to a method for reinforcing a steel beam (1). For that purpose, a number of prestress wires (8) or strands of prestress wires is stretched parallel to a bottom plate (4) of the beam (1), after which the bottom plate (4) is covered with liquid concrete (9) or epoxybound concrete, in such a way that the prestress wires (8) or strands of prestress wires are completely embedded. Subsequently the concrete (9) or epoxy-bound concrete is cured, after which the prestress wires (8) are cut off near the ends of the steel beam (1).

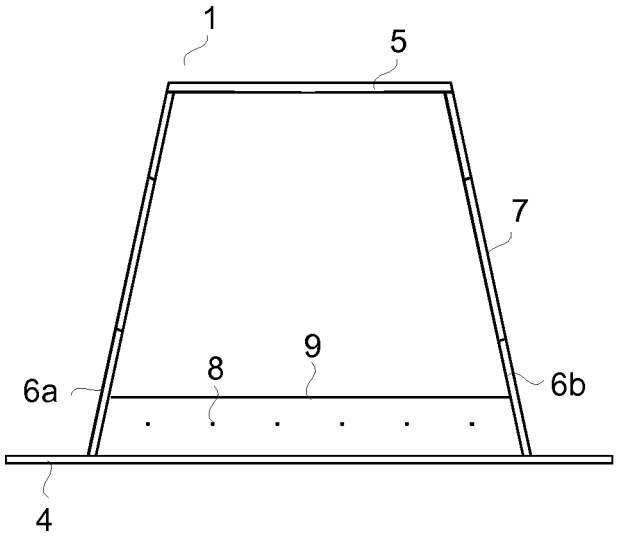

Fig. 2A

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Description

[0001] The invention relates to a method for reinforcing a steel beam provided with a bottom plate.

[0002] The inventive method is characterised in that parallel to the bottom plate a number of prestress wires or strands of prestress wires is put under tension, that subsequently the bottom plate is covered with a pourable and curable material, in such a way that the prestress wires or strands of prestress wires are completely embedded and that subsequently the pourable material is given the opportunity to cure, after which the prestress wires are cut off near the ends of the steel beam.

[0003] Prestress wires are known as such, as well as their application for reinforcing support structures. In combination with steel beams they are rarely used in the art, as the fastening of the prestress wires to the steel beam is considered to be problematic. Welding is not an option, as steel prestress wires have been submitted to a heat treatment which considerably increases the tensile strength and this heat treatment is annulled in the welding process, while prestress wires or strands of prestress wires made of aramide fibres are also not heat resistant and cannot be welded. In the literature a method is known in which a steel beam is provided with end plates, with openings in which prestress wires may be clamped with the aid of conically shaped clamping means, but this method is considered to be laborious, while the conically shaped clamping means seriously increase the costs. With the method according to the invention the steel beam is partly filled with for example concrete or epoxy-bound concrete or another mixture that may cure and that provides a good connection between the prestress wires and the beam, which is relatively simple and cost effective. Moreover, beams are often embedded in concrete, for example if they form part of a system floor with floor plates or precast reinforced concrete plates. In that case, partly filling the beams beforehand is practically for free.

[0004] A favourable realisation in which the method may easily be applied and for which a significant material saving may be realised is characterised in that the steel beam comprises a bottom plate, two side plates and a top plate and that the steel beam is partly filled with the pourable material.

A steel beam thus obtained is visually hardly to distinguish from a classical steel beam, while the amount of steel may substantially be reduced. Moreover, the prestress wires are safely put away inside the beam, which means that there is no possibility that the prestress wires will be damaged or unintentionally heated during transportation or installation.

[0005] A further favourable embodiment is characterised in that the bottom plate projects outside the side plates and is provided with raised edges, where the spaces between the side plates and the raised edges are also filled with the pourable material. A beam obtained in this manner is higher than a classical beam, which means that the desired bearing power may be obtained with less steel, and it still offers enough bearing surface for supporting floor plates that rest on its edges.

[0006] A favourable embodiment is according to a further aspect of the invention characterised in that a steel beam is manufactured in a rolling process starting from a single steel strip. For a classical beam this is impossible or at least practically impossible, as the material thickness would not allow this. When prestress wires are used, the material thickness may be chosen three times or even four times smaller, which brings a directly rolled beam within reach.

[0007] A further favourable embodiment is characterised in that during the rolling process a traction rope is fed into the steel beam and that after the rolling process a number prestress wires or strands of prestress wires is pulled in a longitudinal direction into the steel beam with the aid of the traction rope. One may roll a beam up to an arbitrary length in a single process, subsequently stretch the prestress wires, next fill the steel beam partly with a pourable material that may cure and finally cut the reinforced steel beam to lengths once the material has cured.

[0008] A further favourable embodiment of the inventive method is characterised in that simultaneously with the prestress wires or strands of prestress wires a hose is pulled in a longitudinal direction into the steel beam and that after the prestress wires or strands of prestress wires have been stretched the hose, together with a distributing body is pulled out of the steel beam, in the process of which pourable material is fed into the steel beam via the hose.

[0009] The invention also relates to a steel beam, for supporting floor plates, consisting of a bottom plate, a top plate and two side plates. The inventive beam is characterised in that the beam is provided with a number of prestress wires or strands of prestress wires, extending mutually parallel and parallel to the bottom plate and that the beam is at least partly filled with a cured material that completely encloses the prestress wires or strands of prestress wires.

[0010] A favourable embodiment is characterised in that the beam comprises a bottom plate and two identical combined plates, which combined plates each have been folded in a longitudinal direction, in such a way that they comprise a side plate and half a top plate, as well as connecting means for connecting the combined plates to the bottom plate. The advantage is that the bottom plate as well as the combined plates may be manufactured substantially lighter. Moreover, the cured material provides for an unbreakable connection of the combined plates and the bottom plate.

[0011] A further favourable embodiment is characterised in that the beam consists of a single part, which part is rolled in a rolling process starting from a single steel band, which is possible because the material thickness of the beam may be chosen three times or even four times smaller because of the application of prestress

wires.

[0012] A further favourable embodiment is characterised in that the bottom plate is designed such that it projects outside the side plates and is provided with raised edges, and that the spaces between the side plates and the raised edges are also filled with a cured material. The raised edges may be filled with a curable material simultaneously with the beam. On that moment the prestress wires are already put under stress, but the beam itself is not yet put under stress, which means that it will be straight and in a horizontal plane, while afterwards it will be arch-shaped due to the prestressed wires.

[0013] A further favourable embodiment is characterised in that the side plates are provided with body holes and/or holes for letting pass support rods. Via the body holes an inside of the beam can be reached and pipes and reinforcing steel may pass the beam. Moreover, concrete may flow into the beam for example while the floor is poured. The support rods may support reinforcing steel extending in a longitudinal direction, so that a beam may be strengthened if circumstances demand so.

[0014] The invention will now be further explained with a reference to the following figures, in which:

Fig. 1 represents a beam according to the state of the art;
Fig. 2A represents a beam according to the invention in cross section;
Fig. 2B represents an alternative beam according to the invention in cross section;
Fig. 2C represents another alternative beam according to the invention in cross section;
Fig. 3 schematically represents a beam in side view during filling;
Fig. 4A represents a rolled beam in cross section after it has been rolled;
Fig. 4B represents this beam in cross section while the prestress wires are pulled in;
Fig. 4C represents this beam in cross section during filling;
Fig. 5A represents in cross section a beam provided with support rods;
Fig. 5B represents in cross section a beam provided with a bottom plate with raised edges;
Fig. 5C represents in cross section an alternative beam provided with a bottom plate having raised edges.

[0015] Fig. 1 represents a steel beam 1 according to the state of the art in side view, where beam 1 forms part of a floor to be poured and on which floor plates 2a,2b are placed, as well as concrete columns 3 onto which beam 1 rests. In the embodiment shown here, beam 1 has an at least substantially trapezial cross section and consists of a ground plate 4, a top plate 5 and side plates 6a,6b which have been welded together. Usually, side plates 6a,6b are provided with a number of body holes 7, such that beam 1 if desired can be filled up with concrete, together with the space between the floor plates 2a,2b. Beam 1 is available in a number of different sizes, usually with the same ground plate 4 but with heights that can be selected in dependence of the thickness of floor plates 2a,2b.

[0016] Fig. 2A represents a beam 1 according to the invention in cross section, where a number of prestress wires 8 made of steel or aramide fibres is stretched inside beam 1 and cast in a layer 9 consisting of concrete or epoxybound concrete or another mixture that after curing will realise a good connection between the prestress wires and the beam. Steel prestress wires have gone through a combined stretch and heat treatment which increases the tensile strength about a factor four, as a result of which the thickness of wall of beam 1 may be reduced. When enough prestress wires or strands of prestress wires made of steel or of aramide fibres are added, the thickness of wall may even substantially be reduced as compared with a situation without prestress wires.

[0017] Fig. 2B represents an alternative beam in cross section, consisting of a ground plate 10 with two folded edges 11 a, 11 b and two identical combined plates 12a, 12b of which the lower edges are slid into folded edges 11a,11b of ground plate 10. The upper edges of combined plates 12a,12b are bent at right angles 13a,13b which may rest one against the other. The folding of the various parts is relatively easy, as their thickness of wall is relatively small, for example 2.5 millimetres. Also in this alternative beam 1 a number of prestress wires 8 made of steel or aramide fibres is stretched and cast in a layer 9 consisting of concrete or epoxybound concrete or another mixture that after curing will realise a good connection between the prestress wires and the beam. An important additional advantage is that layer 9 now moreover forms an immovable connection between ground plate 10 and combined plates 12a,12b. A further important advantage of this alternative beam is that no welding is necessary any more, which means that the manufacturing process is compatible with the application of prestress wires which cannot endure heat.

[0018] Fig. 2C represents another alternative beam 1 in cross section 1, consisting of only one steel strip 14 which has been rolled in such a way that a beam is obtained, the rolling process itself being obvious for the skilled man. Also in this alternative beam 1 a number of prestress wires 8 made of steel or aramide fibres is stretched and cast in a layer 9 consisting of concrete or epoxybound concrete or another mixture that after curing will realise a good connection between the prestress wires and the beam. The rolling of the steel strip is relatively easy, as the thickness of the strip is small, for example 2.5 millimetres. In the milling process, lengths of for example 100 metres are produced, after which prestress wires 8 and layer 9 are inserted. Subsequently, the final product may be sawed to lengths that can be sold.

[0019] Fig. 3 schematically represents a beam 1 in side view during filling. Beam 1 is temporarily provided with

cast stops 15a,15b, provided with holes having seal rings where prestress wires or strands of prestress wires 8 run through which are put under tension or kept under tension with the aid of a hydraulic cylinder 16, after which a concrete mixture or an epoxyconcrete mixture is poured into beam 1 via body holes 7, until prestress wires 8 are sufficiently covered. After curing, the cast stops 15a,15b are removed. In order to simplify this removal, cast stops 15a,15b may previously be covered with retarding paper. In beam 1, two rows of relatively small holes 17 are visible. Via these holes steel support rods may be passed if desired, which may support additional reinforcement rods.

[0020] Fig. 4A represents a rolled beam 1 in cross section after it has been rolled, completely similar to the beam shown in Fig. 2B. During rolling, a rope 18 is fed into beam 1, with which afterwards the prestress wires may be pulled in.

[0021] Fig. 4B shows in cross section this beam while the prestress wires 8 are pulled in. For that purpose a spreader 19 is fixed to rope 18, onto which the necessary number of prestress wires 8 attached. Moreover a hose 20 is attached to spreader 19, which may be used for pouring the concrete.

[0022] Fig. 4C represents this beam in cross section during filling, where concrete is supplied via hose 20 and evenly distributed by a distributor 21 which is supported by guide blocks 22a,22b, while hose 20 is pulled through beam 1 with a constant speed.

[0023] Fig. 5A represents in cross section a beam provided with support rods 23,24 which are put through holes 17 as shown in Fig. 3 and on which additional support rods 25 can be placed if the circumstances demand so, for example for mutually fixing the reinforcement of floor plates, placed on both sides of the beam.

[0024] Fig. 5B represents in cross section a beam provided with a bottom plate 4 with raised edges 26a,26b. The advantage is here that the height of beam 1 can be chosen larger than the thickness of a floor of which beam 1 forms part, which means that beam 1 can be constructed lighter. The spaces between raised edges 26a,26b and side plates 6a,6b are filled with for example concrete or epoxybound concrete, so that wide supporting surfaces are formed for floor plates of which the ends rest on bottom plate 4.

[0025] Fig. 5C represents in cross section an alternative beam provided with a bottom plate 4 having raised edges 26a,26b. Also in this case the spaces between raised edges 26a,26b and side plates 6a,6b are filled with for example concrete or epoxybound concrete, so that wide supporting surfaces are formed for floor plates of which the ends rest on bottom plate 4.

Claims

1. Method for reinforcing a steel beam provided with a bottom plate, **characterised in that** parallel to the bottom plate a number of prestress wires or strands of prestress wires is put under tension, that subsequently the bottom plate is covered with a pourable and curable material, in such a way that the prestress wires or strands of prestress wires are completely embedded and that subsequently the pourable material is given the opportunity to cure, after which the prestress wires are cut off near the ends of the steel beam.

2. Method according to claim 1, **characterised in that** the steel beam comprises a bottom plate, two side plates and a top plate and that the steel beam is partly filled with the pourable material.

3. Method according to claim 2, **characterised in that** the bottom plate projects outside the side plates and is provided with raised edges, where the spaces between the side plates and the raised edges are also filled with the pourable material.

4. Method according to claim 1, **characterised in that** a steel beam is manufactured in a rolling process starting from a single steel strip.

5. Method according to claim 4, **characterised in that** during the rolling process a traction rope is fed into the steel beam and that after the rolling process a number prestress wires or strands of prestress wires is pulled in a longitudinal direction into the steel beam with the aid of the traction rope.

6. Method according to claim 5, **characterised in that** simultaneously with the prestress wires or strands of prestress wires a hose is pulled in a longitudinal direction into the steel beam and that after the prestress wires or strands of prestress wires have been stretched the hose, together with a distributing body is pulled out of the steel beam, in the process of which pourable material is fed into the steel beam via the hose.

7. Steel beam for supporting floor plates, consisting of a bottom plate, a top plate and two side plates, **characterised in that** the beam is provided with a number of prestress wires or strands of prestress wires, extending mutually parallel and parallel to the bottom plate and that the beam is at least partly filled with a cured material that completely encloses the prestress wires or strands of prestress wires.

8. Beam according to claim 7, **characterised in that** the beam comprises a bottom plate and two identical combined plates, which combined plates each have been folded in a longitudinal direction, in such a way that they comprise a side plate and half a top plate, as well as connecting means for connecting the combined plates to the bottom plate.

9. Beam according to claim 7, **characterised in that** the beam consists of a single part, which part is rolled in a rolling process starting from a single steel band.

10. Beam according to claim 7, **characterised in that** the bottom plate is designed such that it projects outside the side plates and is provided with raised edges, and that the spaces between the side plates and the raised edges are also filled with a cured material.

11. Beam according to one of the claims 8 to 10, **characterised in that** the side plates are provided with body holes and/or holes for letting pass support rods.

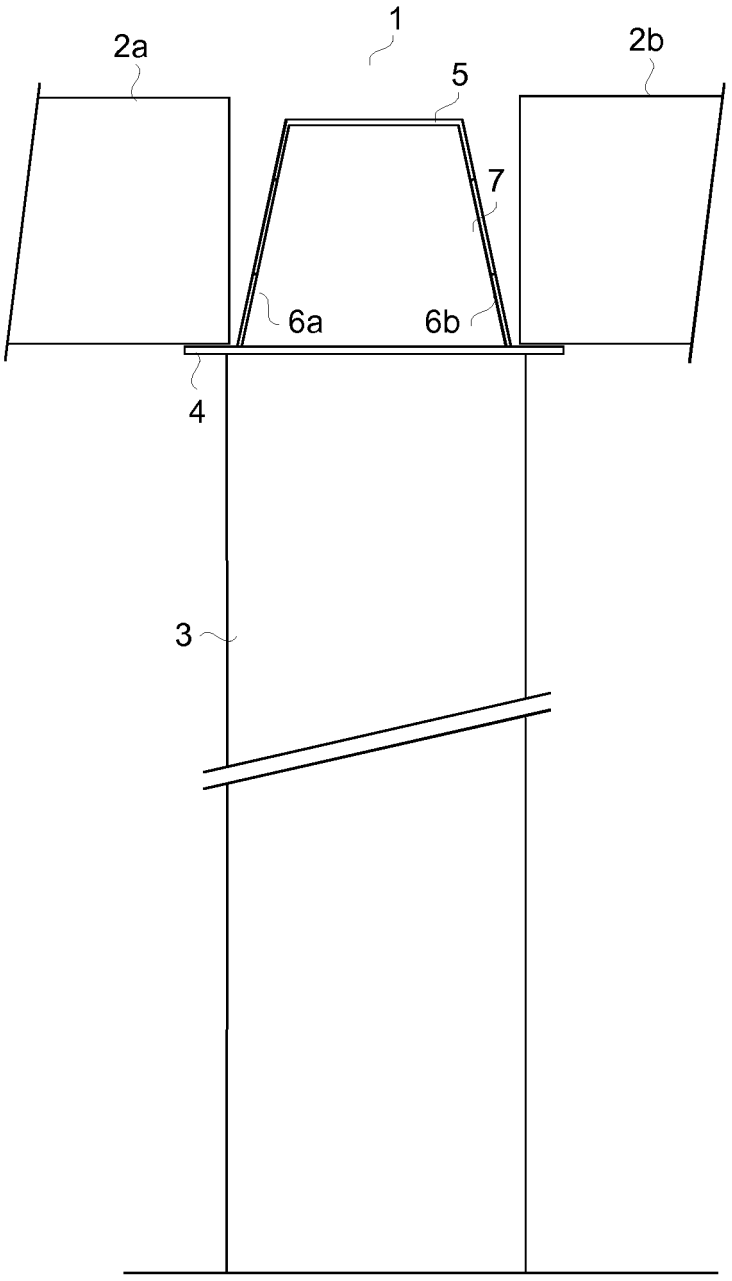

Fig. 1

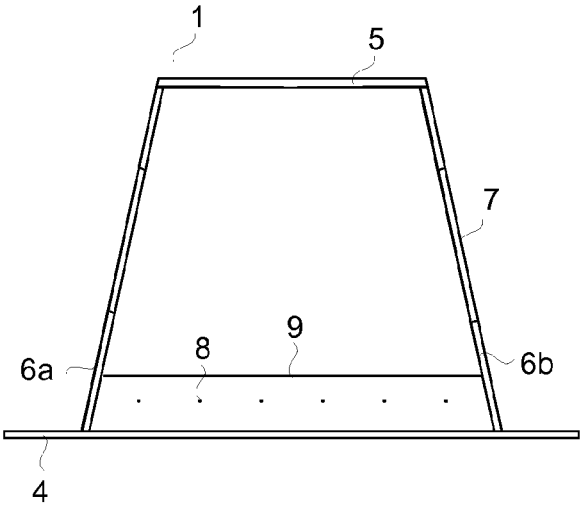

Fig. 2A

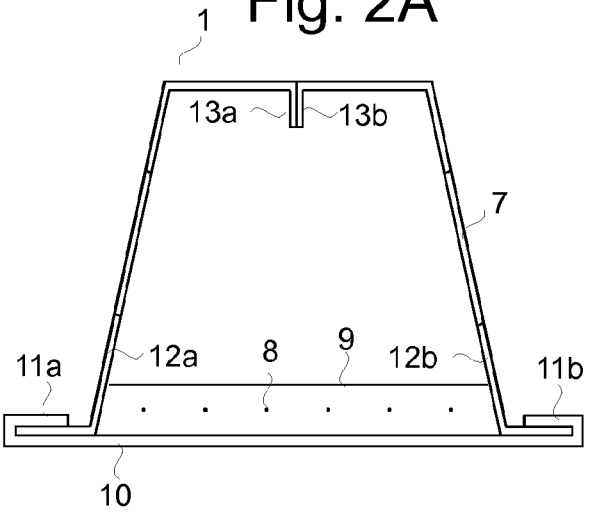

Fig. 2B

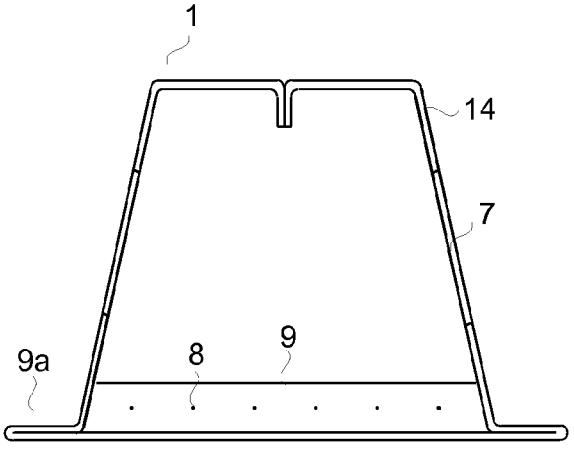

Fig. 2C

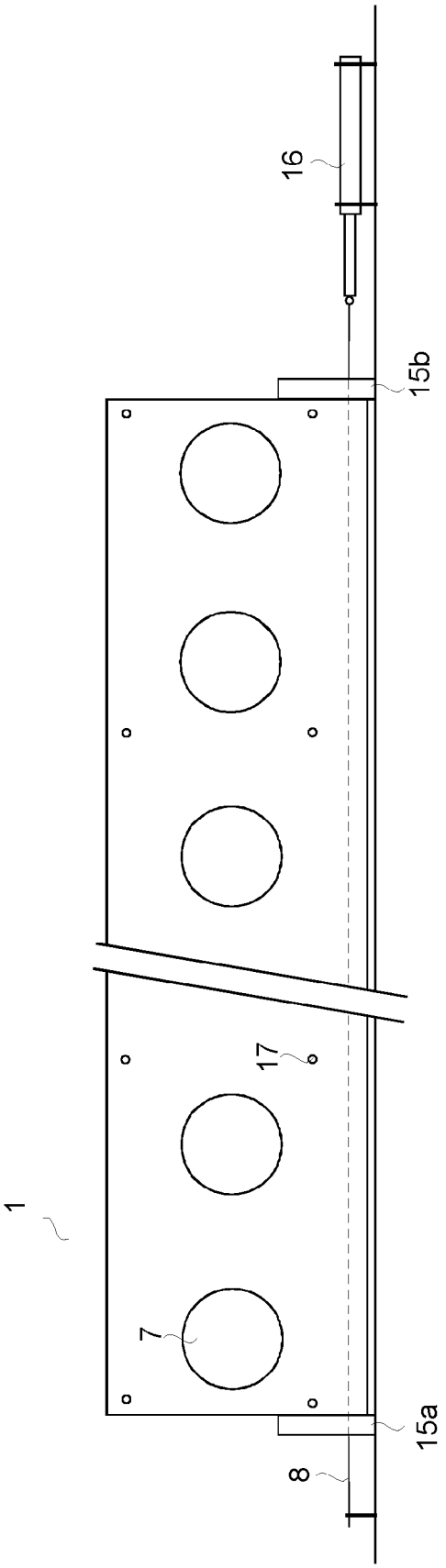

Fig. 3

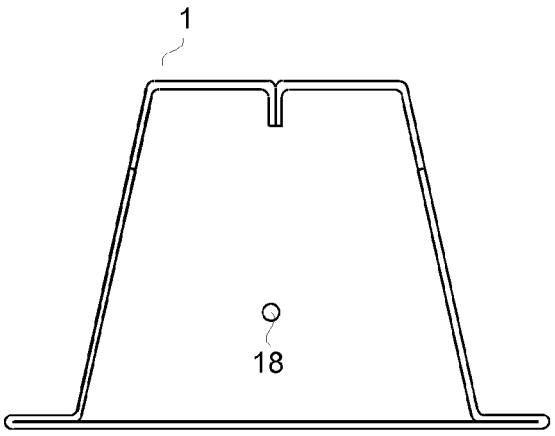

Fig. 4A

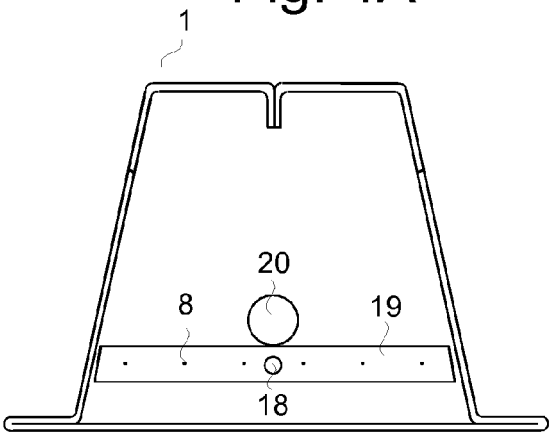

Fig. 4B

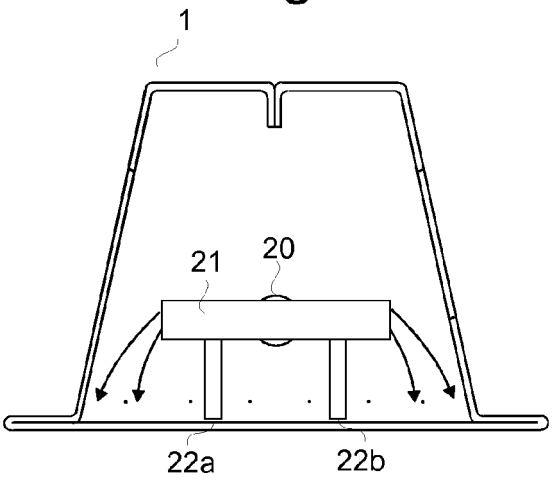

Fig. 4C

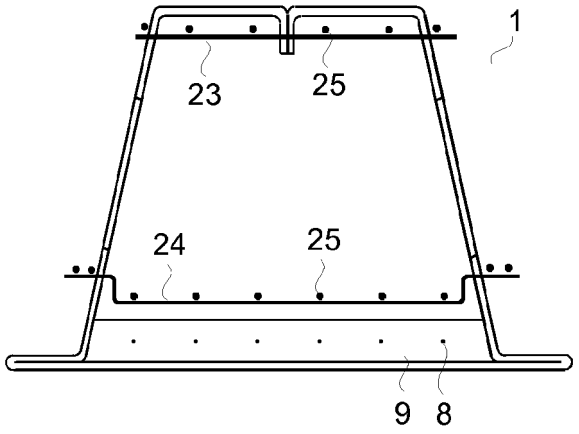

Fig. 5A

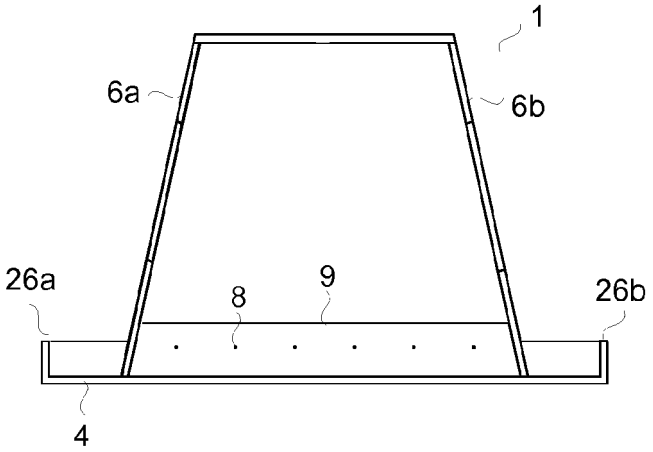

Fig. 5B

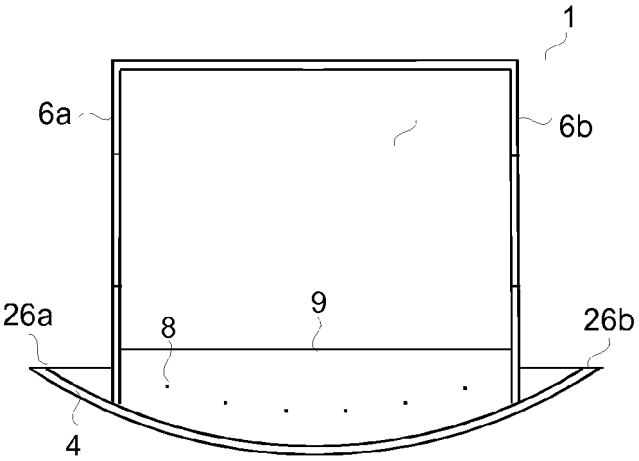

Fig. 5C