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(54) METHOD FOR MANUFACTURING A COMPOSITE BEAM OF STEEL AND CONCRETE, AND STEEL BEAM FILLED WITH CONCRETE

(57) A method for manufacturing a composite beam (1) of steel and concrete, which comprises two web plates (4), a lower flange plate (3) and an upper flange plate (2) made of steel and connected so as to define within the beam (1) a casting space (11) for concrete. Openings (8) are formed in only one or each web plate (4), while concrete feeding openings (18) are formed in the upper flange plate (2). Removable casting moulds (9) are temporarily fitted in the openings (8) of the web plate(s) (4), closing the openings (8) and comprising projections (10) extending into the casting space (11). Concrete is cast into the casting space (11) via the concrete feeding openings (18) of the upper flange plate (2). After the concrete in the casting space (11) has hardened, the casting moulds (9) are removed, whereby recesses (14) are formed, extending into the casting space (11), the sides of the recesses (14) being formed of the concrete present in the casting space (11).

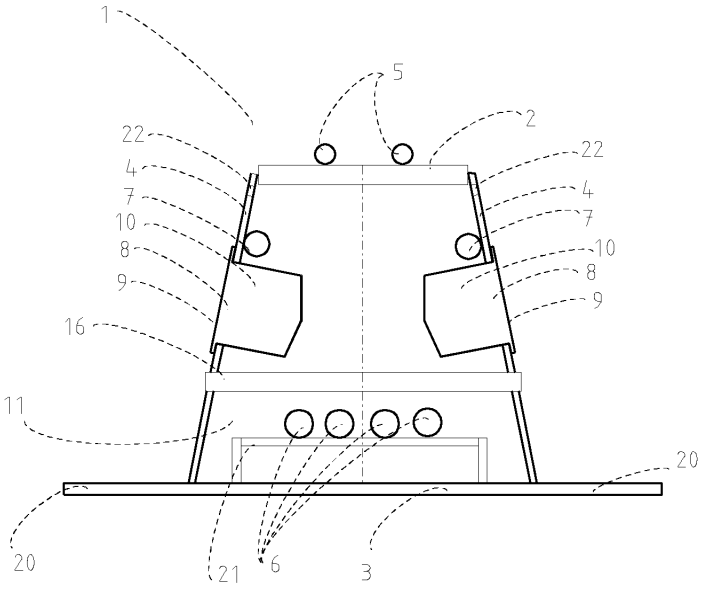

Figure 1

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Description

[0001] This invention relates to a method for manufacturing a steel beam according to claim 1. Further, the invention relates to a steel beam.

[0002] The invention relates to a steel beam in the form of a housing structure, which steel beam is installed onto columns of a building frame. Concrete slabs, for example hollow core slabs, thin shell slabs, composite slabs and cast-in-place concrete slabs, are installed and supported onto projections of a lower flange plate of the steel beam. Once the concrete slabs are installed, the space between the outer surface of the steel beam and ends of the concrete slabs as well as the space within the housing structure of the steel beam are filled by concrete casting. After hardening of the joint and the housing concrete the steel beam functions together with the concrete slabs as a load-bearing composite structure. Usually, all concrete casting for the steel beam is performed on site after installation of the beam often in weather conditions susceptible to snowfall and frost. In winter, the snow and ice collected within the housing structure of the steel beam often has to be removed by steam melting before the concrete casting, which requires much time and increases the costs. As the concrete casting forms a load-bearing concrete structure of the building frame, concrete casting in winter conditions is also a high-risk operation due to the risk of freezing of the concrete. Elimination of the risk of freezing always requires additional operations and thus additional costs. If the cast fresh concrete freezes, the structure will have to be taken down, because a frozen concrete casting structure cannot be used.

[0003] It is an object of this invention to provide a method for manufacturing a steel beam and a steel beam by means of which the problems described above may be alleviated.

[0004] The object according to the invention is achieved by a method according to claim 1 and a steel beam according to claim 10.

[0005] In the method according to the invention, bottom edges of web plates are connected to a lower flange plate at a distance from each other and an upper flange plate is connected to top edges of the web plates, whereby the web plates, the lower flange plate and the upper flange plate define within the beam a casting space for concrete, and openings are formed in only one or in each web plate. Further, concrete feeding openings are formed in the upper flange plate, casting moulds are fitted in the openings of the web plate or the web plates, which casting moulds close the openings and comprise projections extending into the casting space, and concrete is cast into the casting space via the concrete feeding openings of the upper flange plate.

[0006] The steel beam according to the invention comprises two web plates, at least one of which has openings, a lower flange plate and an upper flange plate, which web plates are fastened from bottom edges thereof to the lower flange plate at a distance from each other, and which upper flange plate is fastened to top edges of the web plates. The web plates, the lower flange plate and the upper flange plate define a casting space which is filled with concrete. The upper flange plate has concrete feeding openings, and in the concrete there are recesses at the openings of the web plates, which recesses extend into the casting space.

[0007] The invention provides significant advantages.

[0008] Contrary to the traditional methods, in the solution according to the invention the casting space of the steel beam is cast with concrete already before transportation to an installation site and installation, for example at a workshop in warm factory-like conditions, whereby the high-risk concrete casting at the installation site is avoided. In addition, filling of the casting space of the beam before installing the beam into place increases the load-bearing capacity of the beam for loads in the installation situation before joint casting compared to the traditional beam. The structure of a steel composite beam is traditionally formed of a housing structure defining a casting space, in both diagonal webs of which there are concrete feeding openings at intervals of about 400 mm for feeding concrete into the casting space of the beam. Due to these concrete feeding openings of the web, the traditional steel beam cannot be cast before transportation to the installation site for example at the workshop, because the concrete casting does not stay within the beam, but it has to be done at the installation site after all structures surrounding the beam and the necessary moulds have been installed. In the method according to the invention the concrete casting into the casting space of the beam may be done for example at the workshop before installation of the beam and transportation to the installation site.

[0009] The invention provides a highly cost-efficient method for manufacturing a steel beam and for raising the load-bearing capacity of the steel beam. In the invention, casting moulds are placed in the openings of the diagonal web plate, by which casting moulds the casting openings are temporarily closed for the time of concrete casting into the casting space. Concrete is fed into the casting space from the concrete feeding openings of the upper flange and the casting moulds prevent the concrete from flowing out from the casting space via the openings of the web plate. After the concrete in the casting space has hardened, the casting moulds are removed and the steel beam may be transported to the site, installed into place, and the necessary joint casting may be performed.

[0010] The openings in the diagonal web plate of the steel beam are traditionally round in shape, but the shape of a rectangle is also possible. The openings may also be oval shaped or some other shape fulfilling other functional and strength requirements of the opening. The casting mould to be placed into the opening is manufactured from plastic casting or easily mouldable composite material. The casting mould covers the opening of the

web plate and thereby prevents the concrete from flowing out from the casting space. The casting mould comprises a projection extending into the casting space. The length of the projection extending into the casting space may vary from 10 mm to the full width of the beam. In terms of strength, it is advantageous that the projection of the casting mould extends to a depth of 40-100 mm into the casting space from the inner surface of the web plate. Projections on opposite sides of the beam may extend halfway through the width of the beam and meet each other, thus forming a recess extending through the beam when the casting moulds are removed. In this case, technology as desired may be passed through the beam. Alternatively, the projections of the casting moulds on opposite sides of the beam do not meet each other, i.e. concrete is present between the projections.

[0011] The projection of the casting mould may extend into the casting space perpendicularly to the web plate or horizontally. The projection of the casting mould may be shaped as an inward-tapering cone, so it can be easily removed from the opening when the concrete casting of the casting space begins to harden or has hardened. The removal of the casting mould may be facilitated by treating the outer surface of the projection with mould oil or with a retardant chemical slowing down the hardening of the concrete casting. When the casting mould is removed, a recess is formed in the concrete in the casting space, which recess is filled with concrete in connection with joint casting of the beam at the installation site. The joint concrete cast into the recesses of the concrete of the casting space provides a composite effect connection with the concrete of the casting space and the joint concrete outside of the beam, which are cast at different times.

[0012] This invention solves the following problems or shortcomings relating to the manufacturing technique and strength-related load-bearing capacity of the traditional steel beams:

- By means of the method according to the invention, the concrete casting into the casting space of the beam may be performed in factory-like and warm conditions. This significantly reduces the total costs of the manufacture and installation of the beam and removes the risk of failure of winter-time casting.
- By means of the method, the installation-time load-bearing capacity of the beam may be significantly raised, because the concrete casting in the casting space of the beam already functions in composite effect with the steel housing defining the casting space and reinforcing bars present in the casting space at the time of installation of the beam. The beam according to the invention has a significantly greater bending strength to bear loads in the installation situation compared to the traditional steel beam.
- By means of the method, the composite effect structures of the web and the concrete feeding openings of the beam and their strength behaviour as in the simultaneous joint and filling casting of the traditional steel beam may be maintained, despite different times of the concrete casting.

[0013] In one embodiment of the invention, after the concrete in the casting space has hardened, the casting moulds are removed from the openings of the web plate or the web plates, whereby recesses are formed, which recesses extend into the concrete in the casting space.

[0014] In one embodiment of the invention, concrete is cast into the casting space before the steel beam is transported to an installation site and/or installed into place at the installation site.

[0015] In one embodiment of the invention, a reinforcing bar is fastened to an inner surface of one or each web plate above the openings, for example at a corner between the web plate and the upper flange plate, and/or one or more second reinforcing bars are fastened to a top surface of the upper flange plate.

[0016] In one embodiment of the invention, supports are fastened at a regular spacing to a top surface of the lower flange plate, third reinforcing bars are placed onto the supports and are fastened to the supports.

[0017] In one embodiment of the invention, air removal holes are formed in upper parts of the web plates and/or in the upper flange plate.

[0018] In one embodiment of the invention, the projections of the casting moulds extend to a depth of 10-200 mm, typically to a depth of 40-100 mm, into the casting space from the inner surface of the web plate.

[0019] In one embodiment of the invention, only one web plate or each web plate lies in a diagonal position relative to the lower flange plate, and the projection of the casting mould extends into the casting space perpendicularly to the inner surface of the diagonal web plate or extends horizontally into the casting space.

[0020] In one embodiment of the invention, the steel beam is installed into place, concrete slabs are supported onto the steel beam, and joint concrete is cast into a joint space between the steel beam and ends of the concrete slabs and into the recesses extending into the casting space of the steel beam.

[0021] In one embodiment of the invention, the recesses in the concrete of the casting space extend to a depth of 10-200 mm, typically to a depth of 40-100 mm, into the casting space from the inner surface of the web plate.

[0022] In one embodiment of the invention, the recesses have a diameter of 50-300 mm, typically 80-200 mm.

[0023] In one embodiment of the invention, the steel beam comprises reinforcing bars which are fastened to the inner surface of the web plates above the openings, for example at corners between the web plates and the upper flange plate.

[0024] In one embodiment of the invention, the steel beam comprises second reinforcing bars which are fas-

tened to the top surface of the upper flange.

[0025] In one embodiment of the invention, the steel beam comprises third reinforcing bars which are placed onto supports fastened to the lower flange plate in the casting space, and which are fastened to the supports.

[0026] The invention will now be described in more detail by way of examples with reference to the accompanying drawings, in which

Figure 1 illustrates, as a cross-section, a steel beam according to one embodiment of the invention after concrete has been cast into a casting space of the beam and before removal of casting moulds from web plate openings,

Figure 2 illustrates the steel beam of Figure 1 at an installation site after installation of concrete slabs and joint casting on the outside of the steel beam,

Figure 3 illustrates the steel beam of Figure 1 as seen from the top, and

Figure 4 illustrates the steel beam of Figure 1 as seen from the side.

[0027] The drawings illustrate a steel beam 1 filled with concrete according to one embodiment of the invention, onto which steel beam concrete slabs, such as for example hollow core slabs, thin shell slabs, composite slabs and cast-in-place concrete slabs, are supported. The steel beam 1 comprises two web plates 4, a lower flange plate 3 and an upper flange plate 2. The web plates 4 are fastened from bottom edges thereof for example by welding to the lower flange plate 3 at a distance from each other. The upper flange plate 2 is fastened to top edges of the web plates 4 for example by welding. The web plates 4, the lower flange plate 3 and the upper flange plate 2 define a casting space 11 which is filled with concrete before transportation to an installation site, for example at a site of manufacture of the steel beam 1. The steel beam 1 may comprise end plates 17 which are fastened for example by welding to the ends of the steel beam and which delimit the casting space 11.

[0028] In case the steel beam 1 is an intermediate beam, the lower flange plate 3 extends to both sides of the web plates 4, whereby the lower flange plate 3 forms, on the sides of the steel beam, support projections 20 onto which the ends of the concrete slabs may be supported. In case the steel beam 1 is an edge beam, the lower flange plate 3 extends to the side of only one web plate 4, whereby the support projection 20 is arranged on the side of only one web plate 4. The web plates 4 are diagonal relative to the lower flange plate 3 and are tilted towards each other in such a way that the top edges thereof are closer to each other than the bottom edges. In case the steel beam 1 is an intermediate beam, both web plates 4 are diagonal. In case the steel beam 1 is an edge beam, one web plate 4 may be perpendicular to the lower flange plate 2 and the other web plate 4 diagonal relative to the lower flange plate 4 and tilted towards the perpendicular web plate 4.

[0029] Only one web plate 4 or each web plate 4 comprises openings 8 which extend from an outer surface to an inner surface of the web plate 4. In case the steel beam 1 is an intermediate beam, each web plate 4 comprises openings 8. In case the steel beam 1 is an edge beam, only one web plate 4, i.e. the diagonal web plate 4, may comprise openings 8. The openings 8 typically have a diameter of 100-200 mm. A distance between the centres of adjacent openings 8 is typically 400 mm. The openings 8 may be round, or rectangle or oval shaped.

[0030] The upper flange plate 2 comprises concrete feeding openings 18 via which concrete is cast into the casting space 11 for example by die casting. Concrete is cast into the casting space 11 before the steel beam 1 is installed into place at the installation site and/or before transportation to the installation site. Concrete is cast into the casting space 11 typically at the site of manufacture of the steel beam 1, for example at a workshop. The concrete feeding openings 18 have a diameter of 50-300 mm, typically 80-200 mm. The upper flange plate 2 typically comprises two or more concrete feeding openings 18, for example one concrete feeding opening 18 in proximity to each end of the steel beam 1. The concrete feeding openings 18 are shaped and sized in accordance with a technique required by die casting of concrete. Further, the steel beam 1 comprises air removal holes 22 for removing air from the casting space 11 of the steel beam 1 when the beam is being filled with concrete. The air removal holes 22 may be located at the top edges of the web plates 4 and/or in the upper flange plate 2. The air removal holes 22 have a diameter of 16-20 mm, typically 18 mm.

[0031] The steel beam 1 comprises reinforcing bars 7 which are fastened to the inner surface of the web plates 4 above the openings 8, for example at corners between the web plates 4 and the upper flange plate 2. The reinforcing bars 7 extend in a longitudinal direction of the steel beam 1. Typically, one reinforcing bar 7 is fastened to each web plate 4. The reinforcing bars 7 provide a composite effect between the concrete in the casting space 11 of the steel beam and the steel structure defining the casting space 11. The composite effect is provided upon hardening of the concrete in the casting space 11 of the steel beam 1, already before the steel beam 1 is transported to the installation site and/or installed into place. This significantly increases the load-bearing capacity of the steel beam 1 at the time of installation.

[0032] The steel beam 1 may comprise second reinforcing bars 5 which are fastened for example by welding 1 to a top surface of the upper flange 2. There are typically 2-4 second reinforcing bars 5. The second reinforcing bars 5 provide a composite effect between the steel beam 1 and joint concrete 15 outside of the steel beam 1. The second reinforcing bars 5 extend in the longitudinal direction of the steel beam 1.

[0033] In addition, the steel beam 1 may comprise third reinforcing bars 6 which are placed onto supports 21 fastened to a top surface of the lower flange plate 3 in the casting space 11, and which are fastened to the supports 21. The third reinforcing bars 6 are unattached to the lower flange plate 3, to the web plates 4 and to the upper flange plate 2. The increase of the load-bearing capacity of the steel beam 1 at the time of installation is also based on a change in the strength behaviour of the third reinforcing bars 6, as the third reinforcing bars 6 begin to bear the load already before the beam 1 is installed into place, after the concrete in the casting space 11 has hardened. This considerably increases the load-bearing capacity of the beam 1 compared to the traditional concrete casting into the casting space of the beam, which is done at the installation site after installation.

[0034] Additionally, the steel beam may comprise pipes 16 which extend in a transverse direction through the steel beam 1 at the web plates 4. Pieces of torsional steel of the steel beam 1 may be fitted through the pipes 16. The pipes 16 are located below the openings 8.

[0035] In the concrete present in the casting space 11 there are recesses 14 at the openings 8 of the web plates 4, which recesses extend into the casting space 11. The recesses 14 extend to a depth of 10-200 mm, typically to a depth of 40-100 mm, into the casting space 11 from the inner surface of the web plate 4. The recesses 14 have a diameter of 50-300 mm, typically 80-200 mm. The diameter of the recesses 14 is at most equal to the diameter of the openings 8. The recesses 14 are in the form of a cone or a cylinder. Typically, the recesses 14 extend into the casting space 11 to a depth at which the recesses 14 located in alignment on the opposite sides of the steel beam 1 are not in communication with each other. In this case there is concrete between the recesses 14 located in alignment on the opposite sides of the steel beam 1. Alternatively, the recesses 14 located in alignment on the opposite sides of the steel beam 1 may meet each other in the casting space 11, whereby the recess extends through the casting space 11 in the transverse direction of the steel beam. In this case, technology as desired may be passed through the steel beam 1. Typically, there is a recess 14 at each opening 8. The recesses 14 extend into the casting space 11 perpendicularly to the inner surface of the web plate 4 or are horizontal. The concrete in the casting space 11 forms the bottom and/or the sides of the recesses 14.

[0036] The steel beam 1 may be manufactured as follows. The web plates 4, the lower flange plate 3 and the upper flange plate 2 are cut from a steel sheet to a desired size. The openings 8 are formed in the web plates 4. The air removal holes 22 are formed in the web plates 4 and/or in the upper flange plate 2. The reinforcing bars 7 are fastened by welding to the inner surfaces of the web plates 4 above the openings 8. The concrete feeding openings 18 are formed in the upper flange plate 2. The supports 21 are fastened at a regular spacing to the top surface of the lower flange plate 3 and the third reinforcing bars 6 are placed onto the supports 21 and are fastened to the supports 21. The web plates 4 are fastened from the bottom edges thereof by welding to the lower flange plate 3 at a distance from each other. The upper flange plate 2 is fastened to the top edges of the web plates 4 by welding. The web plates 4, the lower flange plate 3 and the upper flange plate 2 define within the beam a casting space 11 for concrete. The end plates 17 may be fastened by welding to the ends of the steel beam 1. The second reinforcing bars 5 are fastened by welding to the top surface of the upper flange plate 2.

[0037] Casting moulds 9 are fitted in the openings 8 of the web plates 4, which casting moulds comprise projections 10 extending via the openings 8 into the casting space 11. The projection 10 extends into the casting space 11 to a depth of 0-200 mm, typically to 40-100 mm, from the inner surface of the web plate 4. The projection 10 may be in the form of a cylinder or a cone. The outer diameter of the projection 10 is smaller than the diameter of the opening 8. The projection 10 has an outer diameter of 50-300 mm, typically 80-200 mm. The projection 10 extends into the casting space 11 perpendicularly to the inner surface of the web plate 4 or horizontally. The casting mould 9 covers the opening 8 of the web plate and prevents the concrete from flowing out from the casting space 11 via the opening 8. The outer surface of the projection 10 of the casting mould may be treated with mould oil or with a retardant chemical preventing the concrete from hardening before installation into the openings 8 to facilitate the removal of the casting mould 9 after concrete casting. The casting moulds 9 are manufactured from a durable and reusable material, for example plastic or a composite material. To prevent the casting moulds 9 from coming off by the action of casting pressure in the casting space 11, the casting moulds 9 are locked into the openings 8 for example by U-shaped stopper arms which extend over the steel beam 1.

[0038] Concrete is cast into the casting space 11 through the concrete feeding openings 18 for example by die casting. During concrete casting, air is removed from the casting space 11 via the air removal holes 22. The concrete feeding into the casting space 11 is stopped when concrete comes out from the air removal holes 22. Concrete is cast into the casting space 11 before the steel beam 1 is transported to the installation site and/or installed into place at the installation site. Concrete is cast into the casting space 11 for example at the site of manufacture of the steel beam 1, such as at a workshop.

[0039] Once the concrete has hardened in the casting space 11, the casting moulds 9 are removed from the openings 8. The casting moulds 9 form recesses 14 at the openings 8, which recesses extend into the concrete in the casting space 11. The casting moulds 9 may be used in the casting of the next steel beam 1.

[0040] After the concrete has been cast into the casting space 11, the steel beam 1 is transported to the installation site and installed into place, i.e. the steel beam is

fastened from the ends thereof for example to columns. Concrete slabs 12 are supported from the ends thereof onto both support projections 20 (intermediate beam) or onto only one support projection 20 (edge beam). Joint concrete is cast into a space 13 between the ends of the concrete slabs 12 and the outer surface of the steel beam 1 and over the steel beam 1.

[0041] The joint concrete 13 also fills the recesses 14 extending into the casting space 11. The concrete cast into the recesses 14 provides a composite effect with the concrete in the casting space 11 and the joint concrete outside of the steel beam 1. A composite effect connection of the steel beam 1 is thereby provided.

[0042] It will be obvious to a person skilled in the art that the invention is not limited exclusively to these solutions. The invention and its embodiments may thus vary within the scope of the claims.

Claims

1. A method for manufacturing a steel beam (1), which steel beam (1) comprises two web plates (4), a lower flange plate (3) and an upper flange plate (2), in which method

- openings (8) are formed in only one or each web plate (4), and
- bottom edges of the web plates (4) are connected to the lower flange plate (3) at a distance from each other and the upper flange plate (2) is connected to top edges of the web plates (4), whereby the web plates (4), the lower flange plate (3) and the upper flange plate (2) define within the beam (1) a casting space (11) for concrete,

characterized in that

- concrete feeding openings (18) are formed in the upper flange plate (2),
- casting moulds (9) are fitted in the openings (8) of the web plate (4) or the web plates (4), which casting moulds close the openings (8) and comprise projections (10) extending into the casting space (11), and
- concrete is cast into the casting space (11) via the concrete feeding openings (18) of the upper flange plate (2).

2. The method according to claim 1, **characterized in that** after the concrete in the casting space (11) has hardened, the casting moulds (9) are removed from the openings (8) of the web plate (4) or the web plates (4), whereby recesses (14) are formed, which recesses extend into the concrete in the casting space (11) .

3. The method according to claim 1 or 2, **characterized in that** concrete is cast into the casting space (11) before the steel beam (1) is transported to an installation site and/or installed into place at the installation site.

4. The method according to any one of the preceding claims, **characterized in that** a reinforcing bar (7) is fastened to an inner surface of one or each web plate (4) above the openings (8), for example at a corner between the web plate (4) and the upper flange plate (2), and/or one or more second reinforcing bars (5) are fastened to a top surface of the upper flange plate (2).

5. The method according to any one of the preceding claims, **characterized in that** supports (21) are fastened to a top surface of the lower flange plate (2), and third reinforcing bars (6) are placed onto the supports (21) and are fastened to the supports (21).

6. The method according to any one of the preceding claims, **characterized in that** air removal holes (22) are formed in upper parts of the web plates (4) and/or in the upper flange plate (2).

7. The method according to any one of the preceding claims, **characterized in that** the projections (10) of the casting moulds (9) extend to a depth of 10-200 mm, typically to a depth of 40-100 mm, into the casting space (11) from the inner surface of the web plate (4).

8. The method according to any one of the preceding claims, **characterized in that** only one web plate (4) or each web plate (4) lies in a diagonal position relative to the lower flange plate (2), and the projection (10) of the casting mould extends into the casting space (11) perpendicularly to the inner surface of the diagonal web plate (4) or extends horizontally into the casting space (11).

9. The method according to any one of the preceding claims, **characterized in that** the steel beam (1) is installed into place, concrete slabs are supported onto the steel beam (1), and joint concrete is cast into a joint space (13) between the steel beam (1) and ends of the concrete slabs and into the recesses (14) extending into the casting space (11) of the steel beam (1).

10. A steel beam (1), comprising two web plates (4), at least one of which has openings (8), a lower flange plate (3) and an upper flange plate (2), which web plates (4) are fastened from bottom edges thereof to the lower flange plate (3) at a distance from each other, and which upper flange plate (2) is fastened to top edges of the web plates (4), which web plates (4),

lower flange plate (3) and upper flange plate (2) define a casting space (11) which is filled with concrete, **characterized in that** the upper flange plate (2) has concrete feeding openings (18), and at the openings (8) of the web plates (4) there are recesses (14) in the concrete, which recesses extend into the casting space (11), and sides of the recesses (14) are formed of the concrete present in the casting space (11).

11. The steel beam (1) according to claim 10, **characterized in that** the recesses (14) extend to a depth of 10-200 mm, typically to a depth of 40-100 mm, into the casting space (11) from an inner surface of the web plate (4).

12. The steel beam (1) according to claim 10 or 11, **characterized in that** the recesses (14) have a diameter of 50-300 mm, typically 80-200 mm.

13. The steel beam (1) according to any one of the preceding claims 10-12, **characterized in that** the steel beam (1) comprises reinforcing bars (7) which are fastened to the inner surface of the web plates (4) above the openings (8), for example at corners between the web plates (4) and the upper flange plate (2).

14. The steel beam (1) according to any one of the preceding claims 10-13, **characterized in that** the steel beam (1) comprises second reinforcing bars (5) which are fastened to a top surface of the upper flange (2).

15. The steel beam (1) according to any one of the preceding claims 10-14, **characterized in that** the steel beam (1) comprises third reinforcing bars (6) which are placed onto supports (21) fastened to the lower flange plate (3) in the casting space (11), and which are fastened to the supports (21).

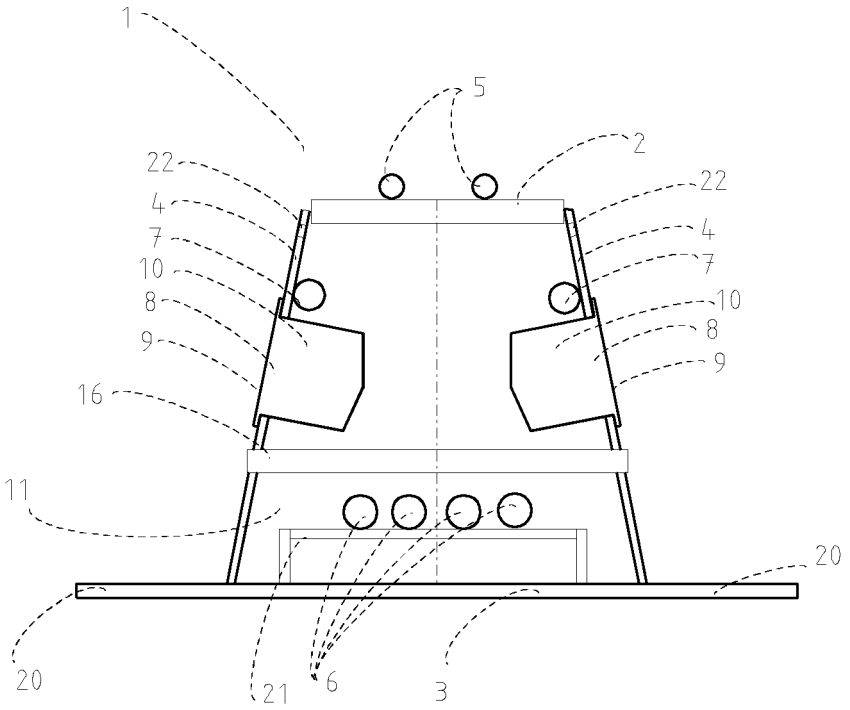

Figure 1

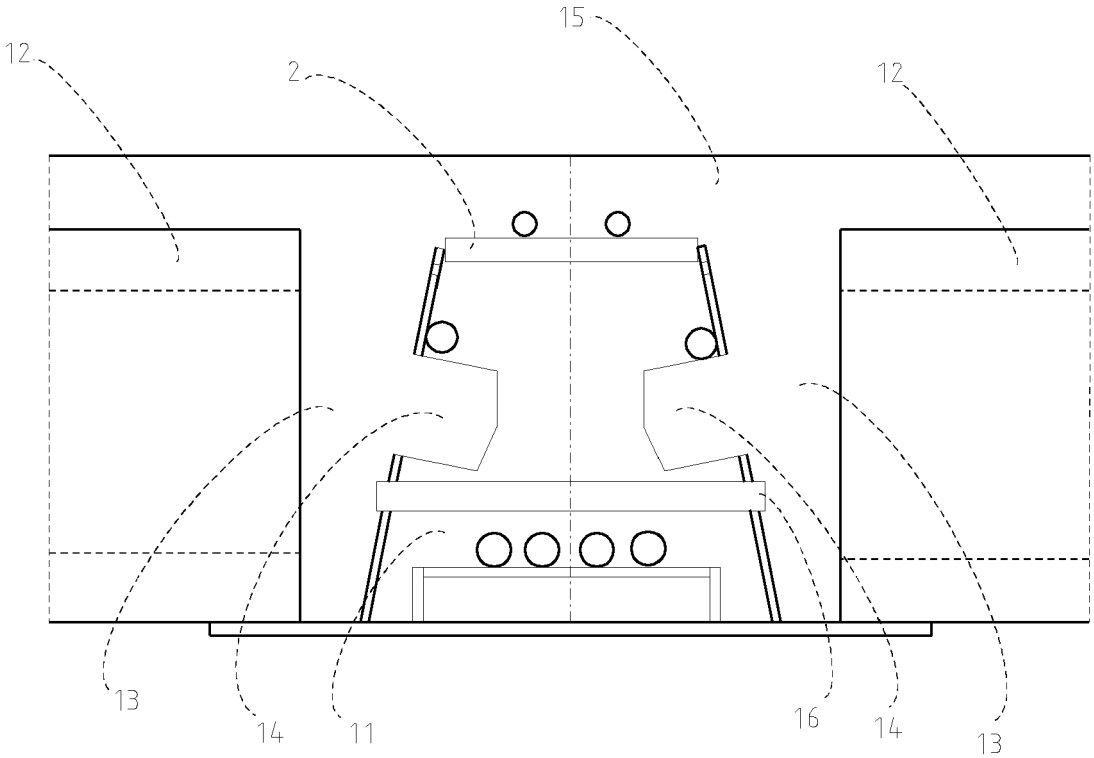

Figure 2

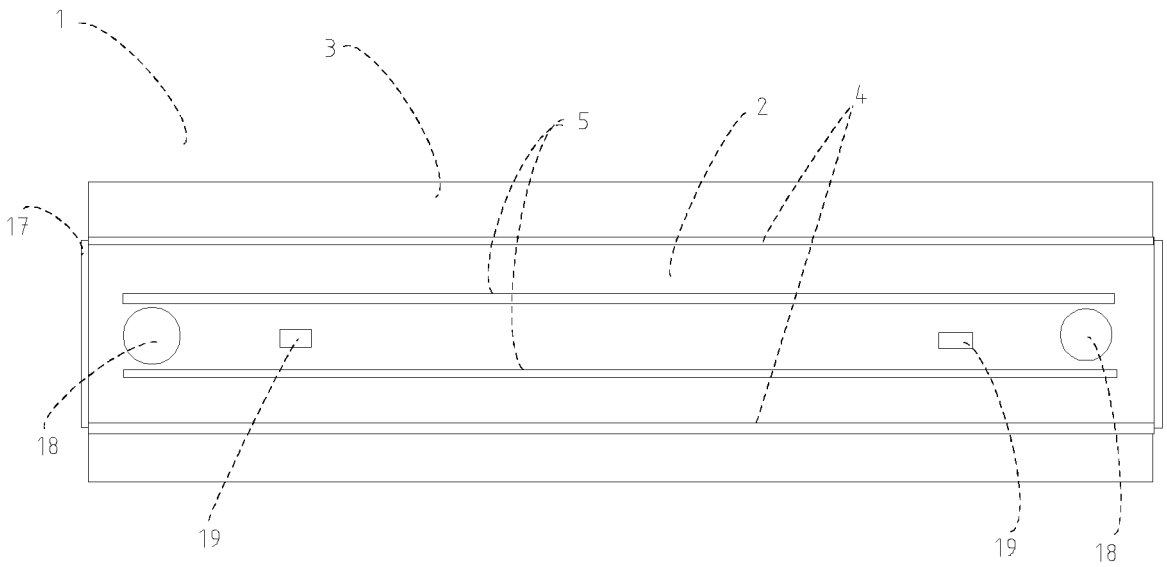

Figure 3

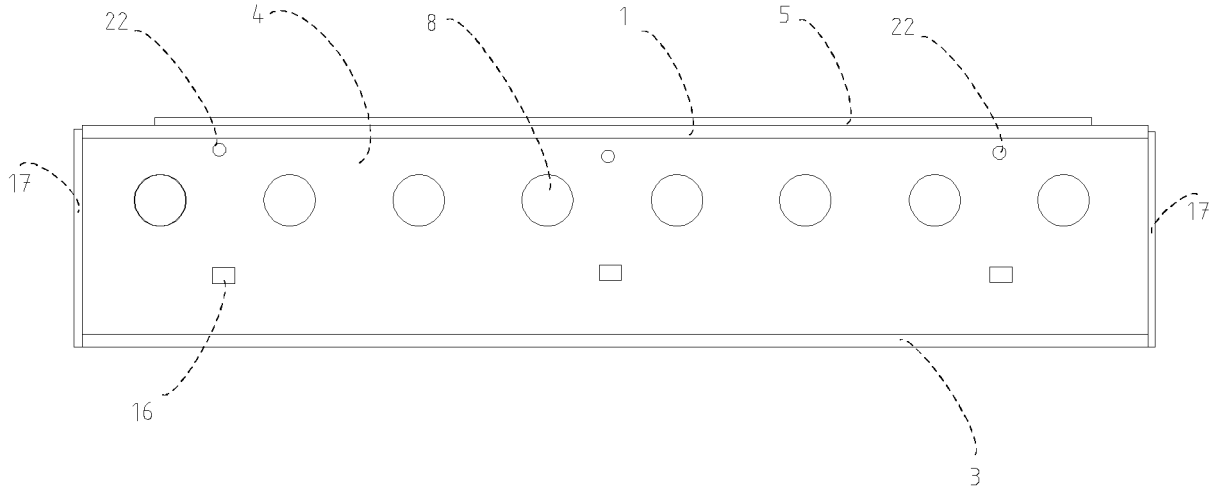

Figure 4

Europäisches Patentamt
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EUROPEAN SEARCH REPORT

Application Number
EP 24 21 0493

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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