

## Description

### DECK PLATE

#### Technical Field

[0001] The present invention relates to a deck plate used for constructing a floor structure or a ceiling structure.

#### Background Art

[0002] In constructing a floor structural body and a ceiling structural body of a building, deck plates are widely used. The deck plate is installed such that the deck plate is made to extend between beams, and both end portions of the deck plate are fixed to upper surfaces of the beams. After the deck plate is fixed, concrete is placed on the deck plate and, then, the concrete solidifies so that a floor structural body or a ceiling structural body is constructed.

The deck plate is formed such that roll-forming is performed on a thin plate material thus performing bending processing on a metal plate. Ribs which are formed of one sheet of thin plate material are formed on the deck plate so as to enhance rigidity (for example, see Patent Literature 1).

The deck plate has a flat upper surface so that there is no resistance force on a boundary surface (contact surface) with a lower surface of a floor structural body or a ceiling structural body. Accordingly, the deck plate is used as a formwork member having rigidity capable of withstanding a load to be applied to the deck plate until concrete solidifies. The deck plate cannot be removed after the concrete solidifies so that the deck plate is left.

[0003]

#### Document List

## Patent Literature

Patent Literature 1: Japanese Patent Application Laid-Open No. Hei7-238621

## Summary of Invention

### Technical Problem

[0004] A horizontal load such as a seismic load acts on a floor structural body or a ceiling structural body so that the floor structural body or the ceiling structural body may be required to have a structure capable of withstanding such a load. However, the deck plate has no resistance force on a boundary with the structural body and hence, even if the deck plate is left, the deck plate almost does not have a function of resisting against a horizontal load.

Further, the deck plate is formed by performing bending processing, by which a thin plate material is largely bent, on the thin plate material. To maintain rigidity of the deck plate and to increase efficiency in a roll-forming step, it is necessary to determine an optimum bend radius. For example, as shown in Fig. 4, when a bend radius  $R1$  of curved portions 102 of a rib 101 formed by the bending processing is increased, roll-forming is facilitated. Accordingly, efficiency in the roll-forming step can be increased, and maintenance of a roll forming machine is facilitated. Further, with the formation of the ribs, an effective width  $W$  from the rib which can be taken into account in evaluating rigidity of the deck plate is set to a range of  $50t/2$  (" $t$ " being a plate thickness) ( $W=50t/2$ ) from an end portion of the curved portion 102, that is, from a boundary portion 104 between the curved portion 102 and a flat portion 103. Accordingly, a large effective width can be ensured in evaluating rigidity of the deck plate.

[0005] However, when the bend radius  $R1$  of the curved portions 102 of the rib 101 formed by the bending processing is excessively increased, a recess 105

formed by the curved portions 102 formed in the bending processing is increased. Due to the increase in size of the recess 105, an amount of concrete filled in the recess 105 is increased thus leading to an increase in weight of a floor structural body (ceiling structural body) and an increase in amount of a concrete material.

On the other hand, as shown in Fig. 5, when a bend radius R2 of a curved portion 202 of a rib 201 formed by the bending processing is reduced, bending processing in a roll-forming step becomes difficult. Accordingly, efficiency in the roll-forming step cannot be increased and, further, maintenance of a roll forming machine becomes complicated.

[0006] The present invention has been made in view of the above-mentioned problems, and it is an object of the present invention to provide a deck plate which has a function capable of resisting against a horizontal load acting on a floor structural body or a ceiling structural body, and has ribs formed with an optimum bend radius.

#### Solution to Problem

[0007] To solve the above-mentioned problems, the present invention is directed to a deck plate formed of a metal plate and made to extend between beams, the deck plate including: a flat portion; ribs continuously formed with the flat portion, and extending from one end to another end of the deck plate along an extension direction of the deck plate with a distance between the ribs on one surface of the flat portion; and end closed portions formed such that both end portions of the ribs are compressed in a direction perpendicular to the one surface, wherein the ribs include a curved portion formed into a curved shape on a boundary with the flat portion.

[0008] Further, it is preferable that a bend radius R of the curved portion fall within a range of from 6 mm to 10 mm.

[0009] Further, it is preferable that the ribs include a straight line portion which is continuously formed with the curved portion, and extends along a direction intersecting with a surface direction of the flat portion, a constraint portion for constraining a pair of metal plates which are folded back is formed on the straight line portion, and the constraint portion is formed at a position separated from a boundary between the curved portion and the straight line portion by a distance of at least 5 mm or more.

[0010] Further, it is preferable that the constraint portion is caulked.

#### Effects of Invention

[0011] According to the present invention, it is possible to manufacture a deck plate which has a function capable of resisting against a horizontal load acting on a floor structural body or a ceiling structural body, and has ribs formed with an optimum bend radius.

#### Brief Description of Drawings

[0012]

[Fig. 1] A view showing a deck plate installed between beams.

[Fig. 2] A perspective view of the deck plate.

[Fig. 3] A cross-sectional view of a rib where concrete is placed on an upper surface of the rib.

[Fig. 4] A cross-sectional view of a rib for describing a problem caused when a bend radius of a curved portion of the rib is increased.

[Fig. 5] A cross-sectional view of a rib for describing a problem caused when a bend radius of a curved portion of the rib is reduced.

## Description of Embodiments

[0013] A preferred embodiment of the present invention is described with reference to drawings. The embodiment described hereinafter is merely for the sake of example, and various embodiments may be conceivable within the scope of the present invention.

[0014] Fig. 1 is a view showing a deck plate installed between beams. Fig. 2 is a perspective view of the deck plate. Fig. 3 is a cross-sectional view of a rib where concrete is placed on an upper surface of the rib.

As shown in Fig. 1 to Fig. 3, a deck plate 10 forms a formwork for concrete to be placed in constructing a floor structure 30 (or ceiling structure) of a building, and is left even after the concrete solidifies.

[0015]

### <Configuration of deck plate>

As shown in Fig. 1, the deck plate 10 extends between beams 20 which are disposed on opposite sides. One end of the deck plate 10 is placed on one beam 20, and is fixed to the beam 20 by welding or the like. Another end of the deck plate 10 is placed on another beam 20, and is fixed to the beam 20 by welding or the like. To be more specific, each beam 20 is formed of an H-shaped steel, for example. Respective end portions of the deck plate 10 are placed on and fixed to flange portions of the H-shaped steel each forming the beam 20.

[0016] As shown in Fig. 2 and Fig. 3, the deck plate 10 is formed of a thin-plate-like steel plate on which plating treatment such as galvanizing treatment is performed. The deck plate 10 is manufactured such that a flat-plate-like steel plate is roll-formed by a roll forming machine. Bending processing is

performed on the deck plate 10 at a plurality of places by the roll forming machine.

The deck plate 10 includes ribs 1, flat portions 2, end closed portions 3, and projecting ridge portions 4.

[0017] The ribs 1 are formed by performing bending processing on a steel plate. As shown in Fig. 3, each rib 1 includes: a curved portion 11 which is bent on one surface side of the steel plate; a straight line portion 12 which is continuously formed with the curved portion 11, the surface direction of the straight line portion 12 extending in the direction orthogonal to the flat portion 2; a folded-back portion 13 which is continuously formed with the straight line portion 12, and is bent twice thus being folded back; a straight line portion 14 which is continuously formed with the folded-back portion 13, the surface direction of the straight line portion 14 extending along the straight line portion 12; and a curved portion 15 which is continuously formed with the straight line portion 14, and is bent toward the flat portion 2.

[0018] Each of the curved portion 11 and the curved portion 15 is formed such that a bend radius  $R$  thereof falls within a range of from 6 mm to 10 mm. This is because such a bend radius  $R$  allows the formation of a space (recess) between the curved portions 11, 15, and allows the space to have a depth required to engage a lower surface of the floor structure 30 (ceiling structure) and the deck plate 10 with each other. Such a bend radius  $R$  also allows bending processing by roll-forming to be performed relatively easily. Concrete placed on an upper surface of the deck plate 10 flows into the recess formed between the curved portion 11 and the curved portion 15, and solidifies thus forming a projection which projects from a lower surface of the floor structure 30. The projection forms an engaging portion E with the deck plate 10.

[0019] The straight line portion 12 and the straight line portion 14 are formed such that a surface of the straight line portion 12 and a surface of the straight line portion 14 come into contact with each other. The straight line portion 12 and the straight line portion 14 are connected with each other by caulking processing or the like thus forming a constraint portion 18. With such a configuration, the straight line portion 12 and the straight line portion 14 are constrained so as not to be separated from each other. Accordingly, the deck plate 10 can maintain a cross-sectional shape thereof so that the deck plate 10 can withstand a predetermined load. In this embodiment, the constraint portion 18 is formed at the position separated from a boundary A between the curved portions 11, 15 and the straight line portions 12, 14 by a distance of at least 5 mm or more. That is, the straight line portion 12 and the straight line portion 14 are caulked and connected with each other such that a distance L from the boundary A to an upper end portion B of the constraint portion 18 (caulked portion) assumes 5 mm or more.

The folded-back portion 13 is folded back such that a starting point and an end point of the folded-back portion 13 are disposed adjacently to each other so as to cause the straight line portion 12 and the straight line portion 14 to come into contact with each other. Accordingly, the folded-back portion 13 forms a space S having a substantially triangular shape in cross section.

[0020] The plurality of ribs 1 are formed at predetermined intervals along the width direction (short-length direction) of the deck plate 10. The ribs 1 are formed so as to extend along the length direction (long-length direction) of the deck plate 10. That is, the ribs 1 are continuously formed from one end to another end of the deck plate 10 along the extension direction which the deck plate 10 extends between the beams 20.

[0021] The flat portions 2 are portions of the deck plate 10 on which bending processing is not performed. That is, the flat portion 2 is a portion sandwiched between the ribs 1 disposed adjacently to each other. In the deck plate 10, the respective flat portions 2 are formed on the same plane.

[0022] The end closed portions 3 are formed on both end portions of the deck plate 10 in the length direction (long-length direction). The end closed portions 3 are formed such that both end portions of the ribs 1 are compressed in the direction perpendicular to a surface of the deck plate 10. With the formation of the end closed portions 3, the rib 1 is formed to have a cross section where the end closed portions 3 at both end portions of the rib 1 are compressed, and other portions of the rib 1 sandwiched between the end closed portions 3 are formed into a substantially triangular shape in cross section. As a result, both end portions of the rib 1 have a height lower than other portions of the rib 1 so that the deck plate 10 can be placed on upper surfaces of the flange portions of the beams 20. The end closed portion 3 is formed such that a length of the end closed portion 3 along the extending direction of the rib 1 is longer than a length of a portion of the end closed portion 3 placed on the upper surface of the flange portion of the beam 20.

[0023] The projecting ridge portions 4 are formed on each flat portion 2. The projecting ridge portions 4 are formed by emboss processing, for example. The projecting ridge portions 4 are formed so as to project to the side opposite to the ribs 1 in the deck plate 10. The projecting ridge portions 4 extend in the direction orthogonal to the extending direction of the ribs 1, that is, extend along the width direction (short-length direction) of the deck plate 10. The plurality of projecting ridge portions 4 are formed at predetermined intervals along the extending direction of the ribs 1, that is, along the length direction (long-length direction) of the deck plate 10.

[0024] As described above, the deck plate 10 is formed of a metal plate and hence, it is unnecessary to support the deck plate 10 from below whereby a space formed below the deck plate 10 can be effectively utilized. Further, the deck plate 10 includes the end closed portions 3 at both end portions thereof so that the deck plate 10 can be placed on the upper surfaces of the beams 20. Moreover, it becomes unnecessary to dispose a member for preventing leakage of concrete between the deck plate 10 and the beams 20 forming a formwork. In the case of an RC structure, it is possible to make a portion of the end closed portions 3 bite into the beam 20 and hence, an effect of preventing the deck plate 10 from being removed can be enhanced.

Further, the rib 1 of the deck plate 10 includes, on the boundaries with the flat portion 2, the curved portions 11, 15 each having a bend radius  $R$  falling within a range of from 6 mm to 10 mm. The bend radius of the curved portions 11, 15 is not extremely small so that roll-forming is facilitated. Accordingly, efficiency in a roll-forming step can be increased, and maintenance of a roll forming machine is also facilitated.

[0025] Further, when concrete is placed on the deck plate 10, concrete enters a recess formed between the curved portion 11 and the curved portion 15 and solidifies so that the concrete forms the engaging portion E which projects from the lower surface of the floor structure 30 thus engaging with the deck plate 10. Accordingly, even when horizontal forces caused by earthquakes or the like act on the floor structure 30, the engaging portions E disposed at a lower portion of the floor structure 30 are engaged with the deck plate 10 thus enhancing rigidity of the floor structure 30. In this embodiment, the curved portions 11, 15 are formed with the bend radius  $R$  falling within a range of from 6 mm to 10 mm. Accordingly, it is possible to form a space having a depth required to engage the engaging portion E and the deck plate 10 with each other.

Further, the plurality of projecting ridge portions 4 are formed at predetermined intervals along the direction orthogonal to the extending direction of the engaging portion E. Accordingly, in addition to the length direction of the deck plate 10, also in the width direction, concrete disposed at the lower portion of the floor structure 30 is engaged with the projecting ridge portions 4 of the deck plate 10 so that rigidity of the floor structure 30 can be enhanced.

[0026] Further, with the formation of the ribs 1, an effective width W from the center of the rib 1 (that is, a contact portion between the straight line portion 12 and the straight line portion 14) which can be taken into account in evaluating rigidity of the deck plate 10 is set to a range of  $50t/2$  ("t" being a plate thickness) ( $W=50t/2$ ) from an end portion of the curved portions 11, 15, that is, the boundary portion 16 between the curved portions 11, 15 and the flat portion 2. Accordingly, a large effective width can be ensured in evaluating rigidity of the deck plate 10.

Further, when a size of the engaging portion E formed by the curved portions 11, 15 is extremely increased, an amount of concrete for forming the engaging portion E is largely increased at the time of placing concrete thus leading to a large increase in weight of the floor structure 30 (or ceiling structure) and a large increase in amount of a concrete material. On the other hand, when the engaging portion E is formed by the curved portions 11, 15 with the bend radius R falling within a range of from 6 mm to 10 mm, such an effect can be reduced.

[0027] Further, when the bend radius R increases, the distance L from the boundary A between the curved portions 11, 15 and the straight line portions 12, 14 to the upper end portion B of the constraint portion 18 (caulked portion) shortens. Accordingly, moisture contained in concrete may leak to the

constraint portion 18 between the straight line portion 12 and the straight line portion 14 so that rust may be formed on the constraint portion 18, or rust may be formed on the rib 1 due to intrusion of water into the rib 1. On the other hand, by setting the distance L from the boundary A to the upper end portion B of the constraint portion 18 (caulked portion) to 5 mm or more, leakage of water can be also prevented so that the formation of rust can be suppressed.

[0028]

<Others>

The present invention is not limited to the above-mentioned embodiment. For example, the folded-back portion 13 is not limited to a triangular shape. Provided that the folded-back portion 13 is folded back such that the straight line portion 12 and the straight line portion 14 come into contact with each other, a folded shape of the folded-back portion 13 can be freely changed.

Further, the projecting ridge portions 4 are not limited to the case where the projecting ridge portions 4 project on a surface of the deck plate 10 on a side opposite to the ribs 1. The projecting ridge portions 4 may be formed so as to project in the same direction as the ribs 1. In this case, when the deck plate 10 is viewed from a surface thereof on a side opposite to the ribs 1, grooves are formed on the flat portions 2.

#### List of Reference Signs

[0029]

- 1 rib,
- 2 flat portion,
- 3 end closed portion,
- 4 projecting ridge portion,

- 10 deck plate,
- 11 curved portion,
- 12 straight line portion,
- 13 folded-back portion,
- 14 straight line portion,
- 15 curved portion,
- 18 constraint portion (caulked portion),
- 20 beam,
- 30 floor structure (ceiling structure),
- R bend radius,
- E engaging portion

## Claims

1. A deck plate formed of a metal plate and made to extend between beams, the deck plate comprising:

a flat portion;

ribs continuously formed with the flat portion, and extending from one end to another end of the deck plate along an extension direction of the deck plate with a distance between the ribs on one surface of the flat portion; and

end closed portions formed such that both end portions of the ribs are compressed in a direction perpendicular to the one surface, wherein

the ribs include a curved portion formed into a curved shape on a boundary with the flat portion.

2. The deck plate according to claim 1, wherein a bend radius  $R$  of the curved portion falls within a range of from 6 mm to 10 mm.

3. The deck plate according to claim 2, wherein the ribs include a straight line portion which is continuously formed with the curved portion, and extends along a direction intersecting with a surface direction of the flat portion,

a constraint portion for constraining a pair of metal plates which are folded back is formed on the straight line portion, and

the constraint portion is formed at a position separated from a boundary between the curved portion and the straight line portion by a distance of at least 5 mm or more.

4. The deck plate according to claim 3, wherein the constraint portion is caulked.