

Description

Title of Invention :

DECK PLATE AND COMPOSITE DECK SLAB

Technical Field

[0001] The present invention relates to a deck plate and a composite deck slab.

Background Art

[0002] Floors of medium- to high-rise buildings and the like are often constructed by composite deck slabs formed by integrating deck plates with concrete. In a composite deck slab, the deck plate bears tensile force, whereas the concrete bears compression force, thereby forming a composite structure that supports a load acting on the floor (refer to Patent Literature 1, for example).

The deck plate is located on the side of the floor below, and thus, if load-bearing capacity is lost by heat during a fire, the deck plate no longer functions as a material forming the composite deck slab structure. It is required that the upper surface of the composite deck slab does not reach a predetermined temperature so that combustible materials on the floor above do not burn during a fire.

Document List

Patent Literature

[0003]

Patent Literature 1: Japanese Patent Application Publication No. 2020-41348

Summary of Invention

Technical Problem

[0004] As countermeasures for the above-described problem, it is known to apply fire-resistant coating by spraying a material with high heat-shielding properties to the deck plate, or to use the deck plate without fire-resistant coating within a limited performance range. Furthermore, since leaving the lower surface of the deck plate exposed to the floor below leads to poor appearance, finishing treatment is often applied to the lower surface of the deck plate. As such, since a deck plate for a composite deck slab is subjected to performance limitation during a fire, improvement of fire-resistant performance is required, whereas improvement of appearance is required under regular conditions, which results in increase in the number of treatments applied to the deck plate.

[0005] Thus, the present invention is made in view of the above-described problem and intended to provide a technology that can simplify treatment applied to a deck plate while achieving improvement of a plurality of functions and performance, such as improvement of fire-resistant performance of the deck plate and a composite deck slab, and appearance.

Solution to Problem

[0006] To solve the above-described problem, an aspect according to the present invention is a deck plate used for a composite deck slab, the deck plate being characterized by including a wooden part provided on a lower surface side of the deck plate, and the wooden part has a thickness calculated as a product of a fire-resistant time to be added to the composite deck slab and a carbonization rate of the wooden part.

[0007] It is preferable that the wooden part be subjected to fire-resistant treatment that provides fire-resistant performance for a predetermined time, and the wooden part have a thickness calculated as a product of a time obtained by subtracting the predetermined time from the fire-resistant time and the carbonization rate of the wooden part.

[0008] It is preferable that a deck plate body part have fire-resistant performance for a predetermined time.

[0009] It is preferable that the wooden part be formed of a design-purpose finishing material or the like.

[0010] It is preferable that a deck plate body part be formed with a plurality of ridge parts and valley parts alternately, the wooden part be attached to the valley parts, and a space be formed between the wooden part and the ridge parts.

[0011] To solve the above-described problem, an aspect according to the present invention is a composite deck slab characterized by including the above-described deck plate and a concrete part placed on an upper surface of the deck plate.

[0012] It is preferable that the composite deck slab include a reinforcement member that reinforces the concrete part.

[0013] It is preferable that the composite deck slab have fire-resistant performance for a predetermined time.

Effects of Invention

[0014] According to an aspect of the present invention, it is possible to simplify treatment applied to a deck plate, while achieving improvement of a plurality of functions and performance, such as improvement of fire-resistant performance of the deck plate and a composite deck slab and appearance.

Brief Description of Drawings

[0015]

[Fig. 1] Fig. 1 is a perspective view illustrating part of a composite deck slab.

[Fig. 2] Fig. 2 is a perspective view of a deck plate.

[Fig. 3] Fig. 3 is a diagram of the composite deck slab when viewed in a transverse direction.

[Fig. 4] Fig. 4 is a diagram of the composite deck slab when viewed in a longitudinal direction.

[Fig. 5] Fig. 5 is a table for description of the relation between the thickness of a wooden part and a fire-resistant time.

[Fig. 6] Fig. 6 is a table for description of the relation between a reinforced region of the composite deck slab and a range that is not covered with the wooden part.

[Fig. 7] Fig. 7 is a table for description of an example of the relation between the reinforced region of the composite deck slab and the range that is not covered with the wooden part.

[Fig. 8] Fig. 8 is a graph comparing the amount of deflection of a composite deck slab between a composite deck slab including no wooden part and a composite deck slab including the wooden part when heated.

[Fig. 9] Fig. 9 is a graph comparing the maximum temperature of the upper surface of a composite deck slab between a composite deck slab including no wooden part and a composite deck slab including the wooden part when heated.

Description of Embodiments

[0016] An embodiment of the present invention will be described below with reference to the accompanying drawings. Note that, in the following description,

drawings are schematic, and for example, dimensional relations and proportions of elements may be different from those in reality. Among the drawings, there may be portions in which, for example, dimensional relations and proportions differ from one another.

[0017] <Composite deck slab>

Fig. 1 is a perspective view illustrating part of a composite deck slab. Fig. 3 is a diagram of the composite deck slab when viewed in a transverse direction. Fig. 4 is a diagram of the composite deck slab when viewed in a longitudinal direction.

As illustrated in Figs. 1, 3, and 4, a composite deck slab 1 is, for example, a composite structure including a deck plate 10 made of steel and a concrete part 60, and is used in the roof, rooftop, or floor of a building made of steel, reinforce concrete, wood, or the like. In the composite deck slab 1, the deck plate 10 resists tensile force, and the concrete part 60 resists compression force. Accordingly, the composite deck slab 1 can withstand large loads and can be bridged between support beams B made of a steel material such as H-shaped steel for a long span. In the composite deck slab 1, the deck plate 10 is provided on the lower surface side, and concrete is placed on the upper surface of the deck plate 10 and integrally solidified, thereby forming the concrete part 60. Accordingly, when the composite deck slab 1 is bridged between the support beams B, the lower surface of the deck plate 10 is exposed to the floor below. Note that the support beams B are not limited to a steel material, but may be reinforced concrete, lumber, or a wood-based material.

[0018] In the following description, a direction in which the deck plate 10 is bridged across the support beams B of a building is referred to as a longitudinal direction (length direction) L of the deck plate 10, a direction in which the deck plate 10 extends intersecting the longitudinal direction L is referred to as a

transverse direction (width direction) W, and a direction in which the deck plate 10 is placed on the support beams B is referred to as a height direction H of the deck plate 10.

[0019] (Deck plate)

Fig. 2 is a perspective view of the deck plate.

As illustrated in Fig. 2, the deck plate 10 includes a deck plate body part 10a and a wooden part 20.

The deck plate body part 10a is a corrugated steel plate formed by roll forming or the like of a thin steel plate subjected to surface treatment such as zinc plating. Note that the deck plate body part 10a does not necessarily need to be subjected to surface treatment such as plating. The deck plate body part 10a includes a ridge part 11, a valley part 13, and an inclined part 15. The deck plate body part 10a is formed with a plurality of ridge parts 11 and valley parts 13 alternately, with each pair of adjacent ridge part 11 and valley part 13 being connected by an inclined part 15. The deck plate body part 10a has a corrugated shape in which the ridge parts 11 and the valley parts 13 extending in the longitudinal direction L are continuous with each other in the transverse direction W through the inclined parts 15.

[0020] The deck plate body part 10a includes, for example, two ridge parts 11, one valley part 13, and two pairs of inclined parts 15, and is formed in a corrugated shape at a section in the transverse direction W. Note that only one ridge part 11 may be provided at one deck plate body part 10a, depending on the dimension of the deck plate 10 in the transverse direction W. When one deck plate 10 is coupled to another deck plate 10 in the transverse direction W, a coupling part between the deck plates 10 functions as a valley part 13. The deck plate 10 may be subjected to end-closing fabrication at both end portions in the longitudinal direction L.

[0021] The ridge parts 11 are parts formed flat and positioned on the upper side with respect to the support beams B in a state (hereinafter also referred to as a "bridged state") in which the deck plate 10 is bridged across the support beams B, and are plate-shaped parts extending in the longitudinal direction L.

Each ridge part 11 includes a groove 12. The groove 12 is formed so as to be recessed toward the lower surface side of the deck plate 10. The groove 12 extends in the longitudinal direction L, and when there is only one groove 12, the groove 12 is provided near the center in the transverse direction W.

The groove 12 of each ridge part 11 improves the strength of the ridge part 11. The groove 12 is not limited to being formed only once in each ridge part 11, and a plurality of grooves 12 may be formed. The grooves 12 may be intermittently formed in the longitudinal direction L. Note that the grooves 12 do not necessarily need to be formed.

[0022] The valley parts 13 are parts that are parallel or substantially parallel to the ridge parts 11 and are formed flat and placed on the support beams B in the bridged state. The valley parts 13 are plate-shaped parts extending in the longitudinal direction L. The valley parts 13 do not overlap the ridge parts 11 in the transverse direction W. Note that the grooves 12 formed in the ridge parts 11 may be formed in the valley parts 13.

Each valley part 13 includes a protruding part 14. The protruding part 14 is formed so as to protrude toward the upper surface side of the deck plate 10. The protruding part 14 extends in the longitudinal direction L, and when there is only one protruding part 14, the protruding part 14 is provided near the center in the transverse direction W.

The protruding part 14 of each valley part 13 improves the strength of the valley part 13. The protruding part 14 is not limited to being formed once in each valley part 13, and a plurality of protruding parts 14 may be formed. The

protruding parts 14 may be intermittently formed in the longitudinal direction L. Note that the protruding parts 14 do not necessarily need to be formed.

[0023] Each inclined part 15 is a part connecting a ridge part 11 and a valley part 13 and is a plate-shaped part extending in the longitudinal direction L. The inclined part 15 extends obliquely from a side edge of the ridge part 11 in the transverse direction W toward a side edge of the valley part 13. The inclined part 15 is inclined so as to form at a predetermined angle relative to the ridge part 11 and the valley part 13, for example, an obtuse angle. Note that the grooves 12 formed in the ridge parts 11 may be formed in the inclined parts 15.

[0024] Each inclined part 15 includes an engagement portion 16. The engagement portion 16 is a protruding part formed so as to protrude from the surface of the inclined part 15 toward the upper surface side of the deck plate 10. The engagement portion 16 is formed by, for example, embossing, and a plurality of engagement portions 16 are provided at predetermined intervals in the extending direction (longitudinal direction L) of the inclined part 15. The engagement portion 16 increases the strength of the inclined part 15 and promotes engagement between the concrete part 60 and the deck plate 10, thereby increasing the composite effect of the composite deck slab 1. The engagement portion 16 may extend in the longitudinal direction L.

[0025] A bulging part 17 is formed at each transition part between a valley part 13 and an inclined part 15. Each bulging part 17 is one of parts protruding toward mutually opposite sides at a pair of inclined parts 15 at one ridge part 11. Specifically, bulging parts 17 at a pair of inclined parts 15 facing each other with a valley part 13 interposed therebetween are formed so as to face each other and bulge in directions approaching each other. Each bulging part 17 is positioned on the valley part 13 side of the corresponding engagement portion 16. The bulging parts 17 may be intermittently formed in the longitudinal direction L.

[0026] A groove 18 is formed at each transition part between a bulging part 17 and a valley part 13. The groove 18 is formed as an engaging groove (dovetail groove) extending in the longitudinal direction L. A section of the groove 18 in the transverse direction W is formed so as to be curved. The grooves 18 are formed in directions approaching each other at a pair of inclined parts 15 at one ridge part 11. Specifically, the grooves 18 are formed so as to face each other at a pair of inclined parts 15 continuous with valley parts 13 of the deck plate 10 and are curved in directions departing from each other. The grooves 18 may be intermittently formed in the longitudinal direction L. The groove 18 promotes engagement between the concrete part 60 and the deck plate 10, thereby increasing the composite effect of the composite deck slab 1.

[0027] The wooden part 20 is provided on the lower surface side of the deck plate 10 (lower surface side of the deck plate body part 10a). The wooden part 20 is, for example, a wooden board formed in a plate shape and is fixed to the lower surface side of the valley parts 13 by using screws or the like. The wooden part 20 may not be only lumber but may be also a wood-based material, such as what is called engineered wood, including laminated wood or LVL, in which strength or fire resistance and flame-retardancy, or both are improved by, for example, chemical treatment or resin addition, or may be a material with improved resistance to mold or wood-decay fungi. In addition, attachment of the wooden part 20 to the deck plate body part 10a is not limited to screws, but the attachment may be performed by adhesive or other means, and the attachment method is not limited. The wooden part 20 is not limited to being attached so as to directly contact the lower surfaces of the valley parts 13 of the deck plate body part 10a, but the wooden part 20 may be attached in a state of being spaced apart from the lower surfaces of the valley parts 13 of the deck plate body part 10a through a member such as a pipe member or a steel

material. In other words, in the deck plate 10, the wooden part 20 may be directly or indirectly attached to the lower surface side of the deck plate body part 10a by any means.

The wooden part 20 is a design-purpose finishing material that covers the lower surface of the deck plate 10, which is exposed to the floor below between the support beams B in a state in which the deck plate 10 is placed on the support beams B, and improves appearance.

The wooden part 20 is formed so as to have a thickness calculated as a product of a fire-resistant time (fire-resistant performance) to be added to the composite deck slab 1 and the carbonization rate of the wooden part 20.

[0028] Fig. 5 is a table for description of the relation between the thickness of the wooden part 20 and the fire-resistant time.

Specifically, as illustrated in Fig. 5, when the carbonization rate of a wood material forming the wooden part 20 is 0.65 mm/min and it is desired to impart 30 minutes of fire-resistant time to the composite deck slab 1, the thickness of the wooden part 20 may be set to $0.65 \text{ mm/min} \times 30 \text{ min} = 19.5 \text{ mm}$.

Similarly, as illustrated in Fig. 5, the thickness of the wooden part 20 may be set to 19.5 to 39.0 mm when it is desired to impart 30 to 60 minutes of fire-resistant time to the composite deck slab 1, the thickness of the wooden part 20 may be set to 39.0 to 78.0 mm when it is desired to impart 60 to 120 minutes of fire-resistant time to the composite deck slab 1, and the thickness of the wooden part 20 may be set to 78.0 to 117.0 mm when it is desired to impart 120 to 180 minutes of fire-resistant time to the composite deck slab 1. Note that the carbonization rate of the wood material does not necessarily need to be 0.65 mm, and the thickness of the wooden part 20 varies in accordance with the carbonization rate.

[0029] The composite deck slab 1 may have fire-resistant performance for a predetermined time in an uncoated state in which no coating treatment is applied to the deck plate 10 and no wooden part 20 is provided. For example, when the composite deck slab 1 has a fire-resistant time (fire-resistant performance) of 120 minutes in the uncoated state, the fire-resistant performance of the composite deck slab 1 can be for ensured for a fire-resistant time of 180 minutes, which is the sum of 120 minutes of fire-resistant time of the composite deck slab 1 and 60 minutes of fire-resistant time of the wooden part 20, by providing the wooden part 20 with a thickness of 39 mm on the lower surface of the deck plate 10. When the composite deck slab 1 including the deck plate 10 is desired to have a fire-resistant time of 180 minutes, the wooden part 20 may be formed to have a thickness of 39 mm, which is necessary for the remaining 60 minutes of fire-resistant performance after subtracting 120 minutes of fire-resistant time of the composite deck slab 1.

[0030] The wooden part 20 may be subjected to flame-retardant treatment that provides fireproof performance for a predetermined time. For example, when a wooden board forming the wooden part 20 is subjected to treatment (such as chemical solution treatment) to impart incombustibility (for ensuring 20 minutes of flame-retardant time), quasi-incombustibility (for ensuring 10 minutes of flame-retardant time), and flame-retardancy (for ensuring 5 minutes of flame-retardant time), the wooden part 20 can be thinned by thicknesses corresponding to products of these flame-retardant times with the carbonization rate.

Specifically, when it is desired to impart fire-resistant performance of 120 minutes of fire-resistant time to the composite deck slab 1 and the wooden part 20 is subjected to treatment for incombustibility (for ensuring 20 minutes of flame-retardant time), the wooden part 20 may have a thickness for 100 minutes of fire-resistant time, in other words, $0.65 \text{ mm/min} \times 100 \text{ min} = 65.0 \text{ mm}$, which

is obtained by subtracting 20 minutes of flame-retardant time of the treatment for incombustibility from 120 minutes of fire-resistant time.

[0031] Since the wooden part 20 is provided on the lower surface of the deck plate 10 as described above, the wooden part 20 is first heated in a case of fire. Thus, by forming the wooden part 20 to a thickness corresponding to a fire-resistant time to be imparted to the composite deck slab 1 with consideration of the carbonization rate of the wooden part 20, the deck plate body part 10a is hardly affected by heat until the wooden part 20 burns out.

The wooden part 20 is provided in the longitudinal direction L and the transverse direction W so as to cover the lower surface of the deck plate body part 10a exposed to the floor below, and is fixed to the deck plate body part 10a in a state of being in contact with the valley parts 13 of the deck plate body part 10a. Accordingly, as illustrated in Fig. 4, a gap is formed between the ridge parts 11 of the deck plate body part 10a and the wooden part 20, and a space S surrounded by a ridge part 11, inclined parts 15, and the upper surface of the wooden part 20 is formed. Due to the space S, a space layer is formed in the composite deck slab 1, which further enhances heat-shielding properties.

Note that the wooden part 20 may be any wood material with any quality, but the thickness of the wooden part 20 needs to be adjusted in accordance with the kind of the wood material since the carbonization rate differs in accordance with the kind of the wood material or the like.

In this manner, by utilizing a property that a wooden board exhibits a covering effect until it is lost due to carbonization under heating during a fire, fire-resistant performance (non-damage and heat-shielding properties) of the deck plate 10 and composite deck slab 1 can be improved by providing the wooden part 20 on the lower surface of the deck plate 10. Moreover, since the thickness of the wooden part 20 can be determined in accordance with a

carbonization rate based on the quality of the wood material forming the wooden part 20 and a fire-resistant time to be imparted to the composite deck slab 1, the wooden part 20 can be formed to an optimal thickness, and optimal selection of functionality and cost is possible without any excess or deficiency in fire-resistant performance. In other words, by forming the wooden part 20 to an optimal thickness, the wooden part 20 can be completely burned by heat of a fire, heating of the wooden part 20 does not end before the wooden part 20 burns out, and the wooden part 20 does not continue to burn as smoldering material after the fire is extinguished. Moreover, the fire-resistant performance (fire-resistant time) of the composite deck slab 1 can be easily adjusted only by adjusting the thickness of the wooden part 20.

[0032] On the lower surface of the deck plate body part 10a exposed to the floor below, the wooden part 20 may be provided on the deck plate body part 10a such that the lower surface of the deck plate body part 10a is exposed in a partial region of the composite deck slab, or may be provided so as to cover the entire lower surface of the deck plate body part 10a.

Specifically, the composite deck slab 1 is typically reinforced in the vicinity of the support beams B on which the deck plate 10 is placed, and the deck plate body part 10a may not be covered with the wooden part 20 to expose the lower surface of the deck plate body part 10a in an area (reinforced region) in which the reinforcement is effective. For example, as illustrated in Figs. 1 and 3, end portions of the wooden part 20 in the longitudinal direction of the deck plate 10 are positioned at places separated from the support beams B by a predetermined distance. In other words, near the end portions in the longitudinal direction of the deck plate 10, the wooden part 20 is not provided in partial regions other than regions in which the deck plate 10 is placed on the support beams B, and the end portions of the wooden part 20 in the

longitudinal direction of the deck plate 10 face flanges of the support beams B with gaps therefrom. Accordingly, the wooden part 20 is formed such that its length in the longitudinal direction of the deck plate 10 is shorter than the distance between the support beams B across which the deck plate 10 is bridged. In this configuration, between the end portions of the wooden part 20 in the longitudinal direction of the deck plate 10 and the flanges of the support beams B, the deck plate body part 10a is not covered with the wooden part 20, and the lower surface of the deck plate body part 10a may be exposed to the floor below.

For example, on the lower surface of the composite deck slab 1 forming a floor (on a side where the wooden part 20 is provided), when there is decorative finish for partition walls (wall materials) or beams, a region of the composite deck slab 1 where other finishing members are attached may be reinforced, the wooden part 20 may not be provided in the region whereas the other region may be covered with the wooden part 20, and the entire region may be covered with the wooden part 20 when there are no interfering objects such as finishes.

[0033] (Concrete part)

The concrete part 60 is formed through solidification of concrete placed on the deck plate 10. Reinforcement members 61 for reinforcing the composite deck slab 1 may be provided inside the concrete part 60.

As illustrated in Figs. 1, 3, and 4, the reinforcement members 61 are, for example, studs 62 joined to the flanges of the support beams B so as to be erected in the height direction H, a welded wire mesh 63 that prevents cracking of the concrete part 60, reinforcement bars (not illustrated), or reinforcement steel plates (not illustrated).

The studs 62 are arranged in the transverse direction W on the flanges of the support beams B. The welded wire mesh 63 is provided in the plane

direction of the ridge parts 11 with an interval in the height direction (up-down direction) from the upper surface of the deck plate 10 (deck plate body part 10a).

By providing the studs 62 to the support beams B, it is possible to enhance integration of the studs 62 and the concrete part 60 in addition to the deck plate 10, thereby reinforcing the composite deck slab 1 around the support beams B.

Note that, the plurality of studs 62 are provided on the flanges of the support beams B in the extending direction of the flanges, but instead of the studs 62, stud welding or the like may be applied.

[0034] With such reinforcement members 61, pull-out strength and the like at end portions of the composite deck slab 1 are improved, fixation to the support beams B is improved, the occurrence and propagation of cracking at the end portions of the composite deck slab 1 can be suppressed, and allowable performance of load capacity, span, and the like can be enhanced. In other words, the end portions of the composite deck slab 1 can be reinforced by dispersing stress generated around the studs 62, and thus fire-resistant performance can be improved.

Note that, in the above-described reinforcement members 61, the studs 62 and reinforcement bars, reinforcement steel plates and the like disposed around the support beams B can reinforce the end portions of the composite deck slab 1 (in the vicinity of the support beams B), whereas the welded wire mesh 63 disposed in the entire range inside the concrete part 60 and reinforcement bars and reinforcement steel plates provided at optional places can reinforce other places (such as a central part of the composite deck slab 1) than the end portions of the composite deck slab 1. In the reinforced region that is reinforced by the reinforcement members 61, a fire-resistant weak

point can be compensated by the reinforcement even without the wooden part 20.

In accordance with, for example, the size and load capacity of the composite deck slab 1, the composite deck slab 1 may be reinforced by using any one of the reinforcement members 61 or by combining a plurality of reinforcement members 61.

[0035] An area in which the lower surface of the deck plate body part 10a is not covered with the wooden part 20 for the reinforced region of the composite deck slab 1 will be described below. Fig. 6 is a table for description of the relation between the reinforced region of the composite deck slab 1 and the area not covered with the wooden part 20. Fig. 7 is a table for description of the relation between the reinforced region of the composite deck slab 1 and the area not covered with the wooden part 20 when a length L_x of the composite deck slab 1 in the transverse direction is a typical length of 3600 mm.

A range in which negative bending acts in the vicinity of the support beams B is $1/4$ of the length L_x of the composite deck slab 1 in the transverse direction. In this case, the range in which negative bending acts is $3600 \text{ mm}/4 = 900 \text{ mm}$, and structural reinforcement for negative bending is often applied in the range of 900 mm (approximately 1000 mm for simplicity) from the support beams B in the vicinity of the support beams B. In a case of reinforcement intended only for prevention of cracking propagation, reinforcement is often provided in the range of approximately $1/2$ of the above-described value, that is, $(L_x/4)/2 = 3600 \text{ mm}/4/2 = 450 \text{ mm}$ (approximately 500 mm for simplicity) from the support beams B.

[0036] Thus, as illustrated in Figs. 6 and 7, the distance from the flanges of the support beams B to end portions of the wooden part 20 (exposure length of

the deck plate body part 10a) is 0 to 150 mm in a case where no reinforcement is applied in the vicinity of the support beams B of the composite deck slab 1.

In a case where reinforcement for preventing cracking propagation of the concrete part 60 is applied in the vicinity of the support beams B of the composite deck slab 1, the distance from the flanges of the support beams B to the end portions of the wooden part 20 (the exposure length of the deck plate body part 10a) is 150 to $(L_x/4)/2$ mm, where L_x represents the length of the composite deck slab 1 in the transverse direction. As illustrated in Fig. 7, in a case where the length L_x of the composite deck slab 1 in the transverse direction is 3600 mm, the distance from the flanges of the support beams B to the end portions of the wooden part 20 (the exposure length of the deck plate body part 10a) is 150 to 450 mm (approximately 150 to 500 mm for simplicity).

In a case where structural reinforcement for negative bending is applied in the vicinity of the support beams B of the composite deck slab 1, the distance from the flanges of the support beams B to the end portions of the wooden part 20 (the exposure length of the deck plate body part 10a) is 450 to $(L_x/4)$ mm, where L_x represents the length of the composite deck slab 1 in the transverse direction. As illustrated in Fig. 7, in a case where the length L_x of the composite deck slab 1 in the transverse direction is 3600 mm, the distance from the flanges of the support beams B to the end portions of the wooden part 20 (the exposure length of the deck plate body part 10a) is 450 to 900 mm (approximately 500 to 1000 mm for simplicity).

[0037] According to the deck plate 10 and the composite deck slab 1 as described above, by utilizing a property that a wood material exhibits a covering effect until it is lost through carbonization under heating during a fire, fire-resistant performance (non-damage and heat-shielding properties) of the deck plate 10 and the composite deck slab 1 can be improved by providing the wooden

part 20 on the lower surface of the deck plate 10. Moreover, since the thickness of the wooden part 20 can be determined in accordance with a carbonization rate based on the quality of the wood material forming the wooden part 20 and a fire-resistant time desired to be imparted to the composite deck slab 1, the wooden part 20 can be formed to an optimal thickness, and optimal selection of functionality and cost is possible without any excess or deficiency in fire-resistant performance. In other words, by forming the wooden part 20 to an optimal thickness, the wooden part 20 can be completely burned by heat of a fire, heating of the wooden part 20 does not end before the wooden part 20 burns out, and the wooden part 20 does not continue to burn as smoldering material after the fire is extinguished. Moreover, the fire-resistant performance (the fire-resistant time) of the composite deck slab 1 can be easily adjusted only by adjusting the thickness of the wooden part 20.

[0038] Typically, in the composite deck slab 1, reinforcement in the vicinity of the support beams B is easily and more common than at the center, and thus the unreinforced center of the composite deck slab 1 is a weak point. When fire-resistant covering (the wooden part 20) is provided on the entire lower surface of the deck plate 10, the weak point remains at the center of the composite deck slab 1, but when covering is deliberately omitted only in the vicinity of the support beams B where reinforcement is performed, the weak point in terms of fire resistance is the vicinity of the support beams B.

Thus, in accordance with specifications of reinforcement applied to the composite deck slab 1, the lower surface of the deck plate body part 10a is exposed by not providing the wooden part 20 for a predetermined length from the flange of each support beam B. Accordingly, during a fire, if a finishing member (decorative material) is burned away, the deck plate body part 10a is intensively heated in the vicinity of the support beams B, where the wooden

part 20 is not present, and accordingly, buckling occurs and the deck plate 10 separates from the concrete part 60. Note that, in the composite deck slab 1 where the deck plate 10 and the concrete part 60 are not separated and the composite effect is maintained, decrease in the structural strength of the composite deck slab 1 can be minimized even if the deck plate 10 is separated from the concrete part 60 in a narrow part of a region in which reinforcement is applied.

After the wooden part 20 is lost, thermal expansion concentrates at the buckled place, and this expansion can be absorbed. Specifically, at a place where the deck plate 10 separates and buckles from the concrete part 60, thermal expansion of the deck plate 10, which is unnecessary additional force, can be absorbed without causing damage to the composite deck slab 1, thermal expansion does not occur in a region of the deck plate 10 where the wooden part 20 was provided, and the broad area of this region is not damaged by thermal expansion.

[0039] In this manner, even if the vicinity of the support beams B is deliberately made a weak point of the composite deck slab 1, it will not become a weak point that directly leads to collapse of the composite deck slab 1 since reinforcement is provided in the vicinity of the support beams B. Furthermore, depending on design conditions, the vicinity of the support beams B does not immediately collapse even without reinforcement. Thus, by deliberately not covering the deck plate body part 10a in the vicinity of the support beams B, thermal expansion of the deck plate 10 can be concentrated in the vicinity of the support beams B to prompt separation of the deck plate 10. Then, as a fire progresses and all of the wooden part 20 are burned away, the entire surface of the deck plate 10 is heated in the same manner as in a normal composite deck slab, but by that time, the deck plate 10 is already separated from the concrete

part 60 in the vicinity of the support beams B and absorbs thermal expansion, thereby providing damage on a broad area of the composite deck slab 1.

Thus, with the composite deck slab 1, damage due to thermal expansion of the deck plate 10, which would be otherwise accumulated in the vicinity of the center of a normal composite deck slab, can be prevented by thermal expansion in the vicinity of the support beams B with high strength, and the fire-resistant performance of the composite deck slab 1 can be significantly improved. Moreover, increase in cost of various reinforcement applied to a normal composite deck slab can be compensated and reduced by minimizing a covered area.

[0040] The wooden part 20 also functions a design-purpose finishing material that hides the lower surface of the deck plate body part 10a, and thus, by only providing the wooden part 20 on the deck plate 10, the composite deck slab 1 can have both a fire-resistant coating function to block heat input to the deck plate 10 and the function of a decorative finish, and while simplifying treatment applied to the deck plate 10, it is possible to achieve improvement of a plurality of functions and performance, such as improvement of the fire-resistant performance of the deck plate 10 and the composite deck slab 1, for example, omission of fire-resistant reinforcement bars if they would otherwise be necessary, and appearance.

The plurality of functions are, for example, improvement of in-plane shear force, the deck plate and the composite deck slab have a function to bear in-plane shear force due to earthquake or wind, and the presence of the wooden part 20 can improve the function, and as a result, the load-bearing capacity can be improved without changing the configurations of the deck plate and the composite deck slab. If performance equivalent to that of the deck plate or the composite deck slab without the wooden part 20 is necessary, the presence of

the wooden part 20 makes it possible to simplify the configurations of the deck plate and the composite deck slab, such as the height or thickness of the deck plate and the volume or strength of the concrete, or to increase the span or load of the slab.

Other functions are, for example, improvement of structural performance, and the presence of the wooden part 20 can improve the function to support vertical loads during construction of the deck plate or upon completion of the composite deck slab or structural deck slab. If performance equivalent to that of a deck plate or composite deck slab without the wooden part 20 is necessary, the presence of the wooden part 20 makes it possible to simplify the configurations of the deck plate and the composite deck slab, such as the height or thickness of the deck plate and the volume or strength of concrete, and allows increase in the span or load of the slab.

By only precasting the wooden part 20 into the valley parts 13 of the deck plate body part 10a, decorative finishing of the deck plate 10 and fire-resistant performance of the composite deck slab 1 can be imparted, and thus floor slab and ceiling finishing can be collectively performed by only placing concrete on the upper surface of the deck plate 10 at the site.

By subjecting the wooden part 20 to fire-resistant treatment that provides fire-resistant performance for a predetermined time, it is possible to reduce a necessary thickness of the wooden part 20 for required fire-resistant performance.

By applying fire-resistant performance for a predetermined time to the composite deck slab 1, it is possible to reduce a necessary thickness of the wooden part 20 for required fire-resistant performance.

Since the space S is formed between the lower surface of the deck plate body part 10a and the wooden part 20, a space layer can be formed in the

composite deck slab 1 to increase heat-shielding properties so that heat transfer to the upper surface side (floor above side) of the composite deck slab 1 can be suppressed. Accordingly, a time required to reach ignition temperature of combustible materials on the floor above can be extended.

Note that the wooden part 20 is not limited to wood but may be a member that improves a plurality of functions and performance such as fire-resistant performance and appearance, for example, a board, panel, or sheet such as wood wool cement board or gypsum board. Furthermore, when the wooden part 20 is formed as a unit in the width direction, its width may be the same as the width of the deck plate 10 or may be larger or smaller than the width of the deck plate 10. Furthermore, joints between the wooden parts 20 may or may not coincide with fitting parts between the deck plates 10.

[0041] <Evaluation of non-damage properties>

Fig. 8 is a graph comparing the amount of deflection of a composite deck slab between a composite deck slab including no wooden part 20 and the composite deck slab 1 including the wooden part 20 when heated, with the horizontal axis representing heating time, and the vertical axis representing displacement of the composite deck slab. In other words, Fig. 8 is evaluation of the non-damage properties of each composite deck slab. In the graph of Fig. 8, the dashed line corresponds to the composite deck slab including no wooden part 20, and the solid line corresponds to the composite deck slab 1 including the wooden part 20.

As illustrated in Fig. 8, it can be understood that, until 60 minutes when heating ends, the displacement gradually increases for both composite deck slabs, but the displacement is less likely to occur for the composite deck slab 1 including the wooden part 20. It can also be understood that, at any point during heating or after heating, the displacement of the composite deck

slab is more suppressed for the composite deck slab 1 including the wooden part 20. This indicates that the composite deck slab 1 including the wooden part 20 is less prone to deflection and damage due to heat during a fire.

[0042] <Evaluation of heat-shielding properties>

Fig. 9 is a graph comparing the temperature of the upper surface of a composite deck slab between a composite deck slab including no wooden part 20 and the composite deck slab 1 including the wooden part 20 when heated, with the horizontal axis representing heating time, and the vertical axis representing the temperature of the upper surface of the composite deck slab. In other words, Fig. 9 is evaluation of heat-shielding properties of each composite deck slab. In the graph of Fig. 9, the dashed line corresponds the composite deck slab including no wooden part 20, and the solid line corresponds to the composite deck slab 1 including the wooden part 20.

As illustrated in Fig. 9, it can be understood that the temperature of the upper surface increases for both composite deck slabs as the heating time increases, but the temperature of the upper surface is less likely to increase for the composite deck slab 1 including the wooden part 20. It can also be understood that, at any time, the temperature of the upper surface of the composite deck slab is more suppressed for the composite deck slab including the wooden part 20. This indicates that the composite deck slab 1 including the wooden part 20 exhibits lower increase in the temperature of the upper surface of the composite deck slab during a fire and has higher heat-shielding properties. In other words, it is indicated that the presence of the wooden part 20 reduces influence on the floor above during a fire.

[0043] <Other>

Although the preferable embodiments of the present invention are described above, the present invention is not limited to the above-described

embodiment but includes any aspect included in the concept and claims of the present invention. Configurations may be selectively combined as appropriate so as to achieve at least part of the above-described problem and effects. For example, the shape, material, disposition, and size of each constituent component in the above-described embodiment may be changed as appropriate depending on a specific use aspect of the present invention.

For example, when the vicinity of the center of the composite deck slab 1 is already reinforced, the vicinity of the center may not be covered with the wooden part 20. In other words, in the composite deck slab 1, a reinforced region or a region with higher strength than others may not be covered with the wooden part 20 by a predetermined range in accordance with specifications of reinforcement, thereby forming the region with higher strength as a weak point in terms of fire resistance.

The specifications of reinforcement are not limited to the above-described specifications, but an area where the lower surface of the deck plate body part 10a is not covered with the wooden part 20 can be set in accordance with each specification.

List of Reference Signs

[0044]

1 composite deck slab

10 deck plate

10a deck plate body part

11 ridge part

12 groove

13 valley part

14 protruding part

- 15 inclined part
- 16 engagement portion
- 17 bulging part
- 18 groove
- 20 wooden part
- 60 concrete part
- 61 reinforcement member
- 62 stud
- 63 welded wire mesh
- S space

Claims

1. A deck plate used for a composite deck slab, the deck plate being characterized by comprising a wooden part provided on a lower surface side of the deck plate, wherein the wooden part has a thickness calculated as a product of a fire-resistant time to be added to the composite deck slab and a carbonization rate of the wooden part.

2. The deck plate according to claim 1, characterized in that the wooden part is subjected to fire-resistant treatment that provides fire-resistant performance for a predetermined time, and the wooden part has a thickness calculated as a product of a time obtained by subtracting the predetermined time from the fire-resistant time and the carbonization rate of the wooden part.

3. The deck plate according to claim 1 or 2, characterized in that a deck plate body part has fire-resistant performance for a predetermined time.

4. The deck plate according to claim 1 or 2, characterized in that the wooden part is formed of a design-purpose finishing material or the like.

5. The deck plate according to claim 1 or 2, characterized in that a deck plate body part is formed with a plurality of ridge parts and valley parts alternately, the wooden part is attached to the valley parts, and a space is formed between the wooden part and the ridge parts.

6. A composite deck slab characterized by comprising:
the deck plate according to claim 1; and
a concrete part placed on an upper surface of the deck plate.

7. The composite deck slab according to claim 6, characterized by
comprising a reinforcement member that reinforces the concrete part.

8. The composite deck slab according to claim 6 or 7, characterized
by having fire-resistant performance for a predetermined time.