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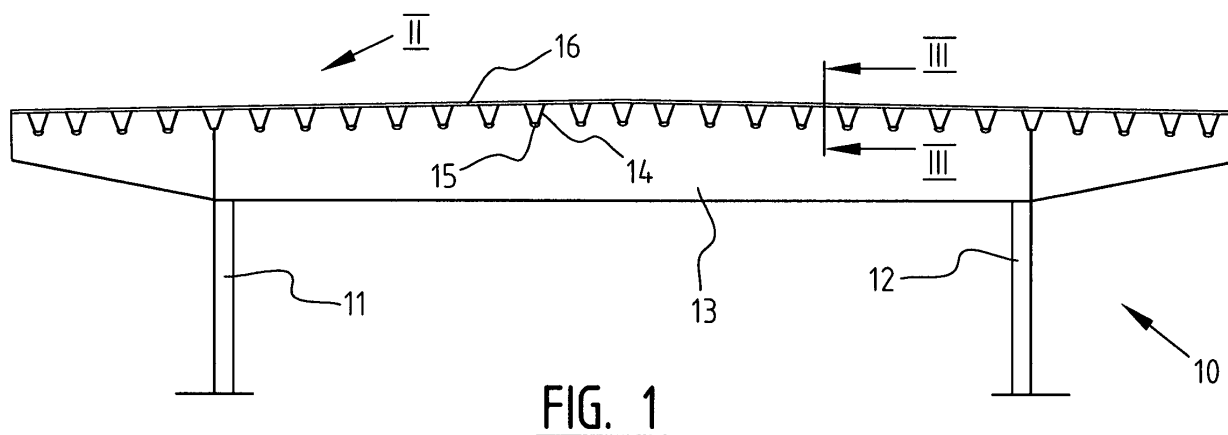
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(54) **Reinforced steel bridge**

(57) The present invention relates to a method for arranging a layer on a thin steel floor of a relatively heavily travelled bridge, wherein a glass fibre-reinforced resin

layer of epoxy or a similar material is applied to the steel plate and wherein the glass fibre is attached to the steel plate using an adhesive layer.



Description

Introduction

[0001] In order to cope with increasingly large flows of traffic bridges of steel or concrete, or hybrids thereof, are being placed at many locations in Europe and elsewhere.

[0002] In the Netherlands and in the rest of the world modern steel bridges are provided with a relatively thin steel deck, i.e. about 10-14 mm for fixed bridges and 14-18 mm on movable bridges. The steel decks are so-called orthotropic plate floors, of which the cover plate, the upper flange of the longitudinal girders, without cover plate also referred to as trough section, the cross girders and the main girders are integrated into one plate. The welded connection between trough and plate cover and the connection to the cross girders has been found in practice to be fatigue-susceptible. A possible explanation for this is the insufficient co-action between the cover plate and the asphalt layer of for instance 50 mm applied to the steel cover plate, particularly at higher outside temperatures, wherein the asphalt becomes softer than at lower temperatures. The asphalt layer is also intended for skid resistance necessary for braking, and for preservation, i.e. protection of the steel plate cover from corrosion.

[0003] Recent tests have shown that replacing asphalt with so-called high-strength concrete results is not a sufficient solution to the above problems and is not sufficiently durable. The upper side of the layer of high-strength concrete became very bumpy, evidently because of unevenness in the poured high-strength concrete.

[0004] The (Dutch) State Water Management Agency is for the moment being hesitant about replacing asphalt layers on other bridges with high-strength concrete.

[0005] The present invention relates to a method for arranging a layer on a thin steel floor of a relatively heavily travelled bridge, wherein a glass fibre-reinforced resin layer of epoxy or a similar material is applied to the steel plate and wherein the glass fibre is attached to the steel plate using an adhesive layer. The (synthetic) fibre and the epoxy or the similar material provide a good strength, so that the steel plate, in addition to being preserved, will also be stronger and therefore have fewer problems with fatigue and the pressure on the welded connections is relieved. The epoxy or the similar material and the steel plate co-act as a composite, and provide an increased strength. This increased strength results in lower stresses, whereby fatigue occurs less.

[0006] According to a preferred embodiment of the method, the similar material for the resin layer comprises vinyl ester resin and/or polyester resin.

[0007] According to a further preferred embodiment of the method, asphalt is applied over the epoxy layer, vinyl ester layer or polyester layer.

[0008] According to yet another preferred embodiment of the method, the epoxy layer comprises a high-strength

plastic comprising a first component of bisphenol A resin with one or more additives and a second component based on aliphatic amine. These components provide high strength as well as good lamination properties.

[0009] According to yet another preferred embodiment of the method, the steel plate has a thickness of 10-18 mm, in the case of fixed bridges preferably 10-14 mm.

[0010] According to yet another preferred embodiment of the method, the thickness of the wearing course comprising epoxy or the similar material, (synthetic) fibre and/or asphalt amounts on average to about 20-50 mm. First tests with a thickness of 20 mm have given a promising indication of the applicability of this wearing course. In order to further increase durability however, it is recommended to apply a somewhat thicker layer, preferably in the range of 20-50 mm.

[0011] According to yet another preferred embodiment of the method, an additional intermediate layer of fibres is added to the layer of epoxy, vinyl ester resin or polyester resin. The laminate is hereby strengthened, which further improves the bending stiffness.

[0012] According to yet another preferred embodiment of the method, the additional fibres comprise carbon fibres, glass fibres and/or aramid fibres.

[0013] According to yet another preferred embodiment of the method, the fibres are arranged by means of a vacuum technique. The binder is drawn by means of the vacuum technique through the reinforcing material, this making possible material properties not achievable with manual arrangement of the different layers.

[0014] According to yet another preferred embodiment of the method, the intermediate layer comprises a honeycomb structure, preferably comprising Kevlar, steel, aluminium, stainless steel and/or (glass) fibre. The honeycomb structure improves the 3-D matrix structure, this enhancing the bending stiffness.

[0015] According to yet another preferred embodiment of the method, the intermediate layer comprises a 3WEAVE[®] structure. This 3WEAVE[®] structure is commercially available from the company 3TEX Inc.

[0016] The invention further relates to a bridge provided with a carriageway arranged according to the above described method, and to a fibre-reinforced epoxy for the purpose of reinforcing an orthotropic bridge deck floor.

[0017] Further advantages, features and details of the present invention will be elucidated on the basis of the following description of a preferred embodiment thereof with reference to the accompanying drawings, in which:

Figure 1 shows a cross-sectional view of a preferred embodiment of a typical orthotropic deck configuration of a bridge wherein the method according to the present invention is applied;

Figure 2 is a perspective view of detail II of Figure 1; and

Figure 3 shows a section along main girders III-III in Figure 1.

[0018] A bridge 10 comprises two uprights 11 and 12 provided with a number of transverse cross girders 13, wherein longitudinal stiffening members in the form of trough-like sections 14, or troughs, are welded fixedly to a steel plate 16 of for instance 12-18 mm thickness. These troughs 14 are also welded to the cross girders 13 or placed therethrough. For a better fatigue behaviour the cross girders are provided with a recess 15. Because of the heavy traffic load, and/or more intensive use, the asphalt layers provide too little resistance, particularly in the summer, whereby fatigue occurs, particularly in the welded connection between the plate and the trough sections and at the connection to the cross girder. Inspection of the cover plate and replacing the defective welded connections is a time-consuming and costly affair, while during these lengthy operations the bridge must be fully or half-closed for the duration thereof.

[0019] Tests with arranging high-strength concrete have not brought about satisfactory results.

[0020] Arranged according to the present invention on steel plate 16 (Figure 3) is an epoxy layer 17 of plastic such as polyamide and the like, preferably reinforced with (glass) fibre, carbon fibre and/or aramid fibre, on which can be arranged a wearing course 18, for instance of asphalt.

[0021] The layers must fulfil a number of functions:

- reinforcing the steel plate cover, this resulting in an increased fatigue lifespan;
- giving skid resistance during braking;
- filling in, wherein a deformable transition is formed between the steel deck and the final wearing course; and
- providing for preservation, i.e. protecting the steel deck from corrosion.

[0022] These functions can be realized by a number of different materials, wherein the wearing course must be sufficiently rough, while the layers of plastic thereunder can compensate in sufficient measure for the unevenness of the steel plates, which can result in height differences of as much as about 70 mm, while the sealing, adhesion and deformation remains ensured. Further tests will determine the optimum combination of layers and thicknesses for this purpose.

[0023] The present invention is not limited to the above described preferred embodiment thereof, the rights sought being defined by the following claims, within the scope of which many modifications can be envisaged.

Claims

1. Method for arranging a layer on a thin steel floor of a relatively heavily travelled bridge, wherein a glass fibre-reinforced resin layer of epoxy or a similar material is applied to the steel plate and wherein the glass fibre is attached to the steel plate using an

adhesive layer.

2. Method as claimed in claim 1, wherein the similar material for the resin layer comprises vinyl ester resin and/or polyester resin.
3. Method as claimed in claim 1 or 2, wherein asphalt is applied over the epoxy layer, vinyl ester layer or polyester layer.
4. Method as claimed in claim 2, wherein the epoxy layer comprises a high-strength plastic having a first component of bisphenol A resin with one or more additives and a second component based on aliphatic amine.
5. Method as claimed in any of the foregoing claims, wherein the steel plate has a thickness of 10-18 mm, in the case of fixed bridges preferably 10-14 mm.
6. Method as claimed in any of the foregoing claims, wherein the thickness of the wearing course comprising epoxy or a similar material, (synthetic) fibre and/or asphalt amounts on average to about 20-50 mm.
7. Method as claimed in any of the foregoing claims, wherein an additional intermediate layer of fibres is added to the layer of epoxy, vinyl ester resin or polyester resin.
8. Method as claimed in claim 7, wherein the additional fibres comprise carbon fibres, glass fibres and/or aramid fibres.
9. Method as claimed in any of the foregoing claims, wherein the fibres are arranged by means of a vacuum technique.
10. Method as claimed in any of the foregoing claims, wherein the intermediate layer comprises a honeycomb structure.
11. Method as claimed in claim 10, wherein the honeycomb structure comprises Kevlar, steel, aluminium, stainless steel and/or (glass) fibre.
12. Method as claimed in any of the foregoing claims, wherein the intermediate layer comprises a 3WEAVE® structure.
13. Bridge provided with a carriageway arranged according to the method as claimed in one or more of the claims 1-12.
14. A fibre-reinforced epoxy for the purpose of reinforcing an orthotropic bridge deck floor.

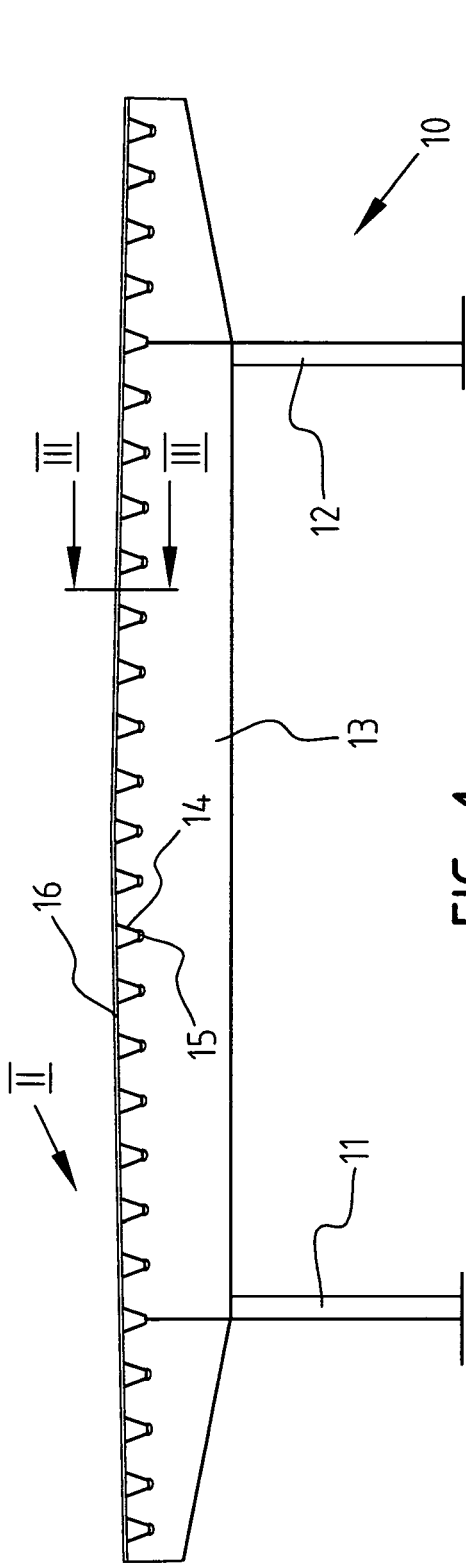


FIG. 1

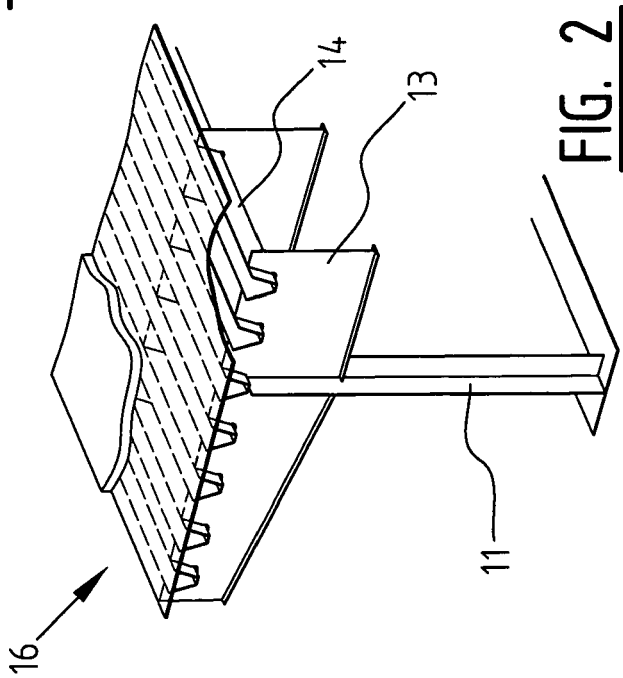


FIG. 2

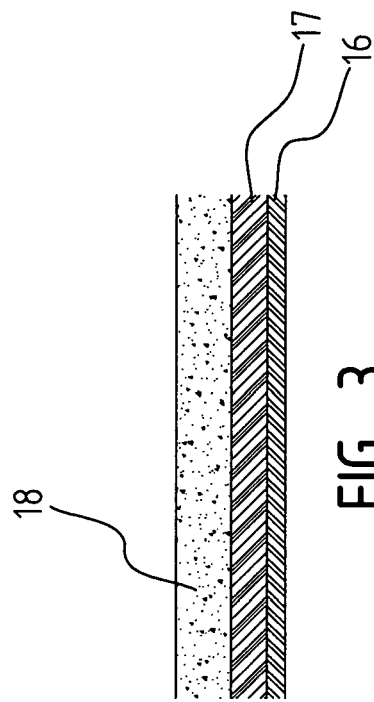


FIG. 3