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(54) **WOODEN BRIDGE DECK WITH
FIBER-REINFORCED PLASTIC COATING**

Related U.S. Application Data

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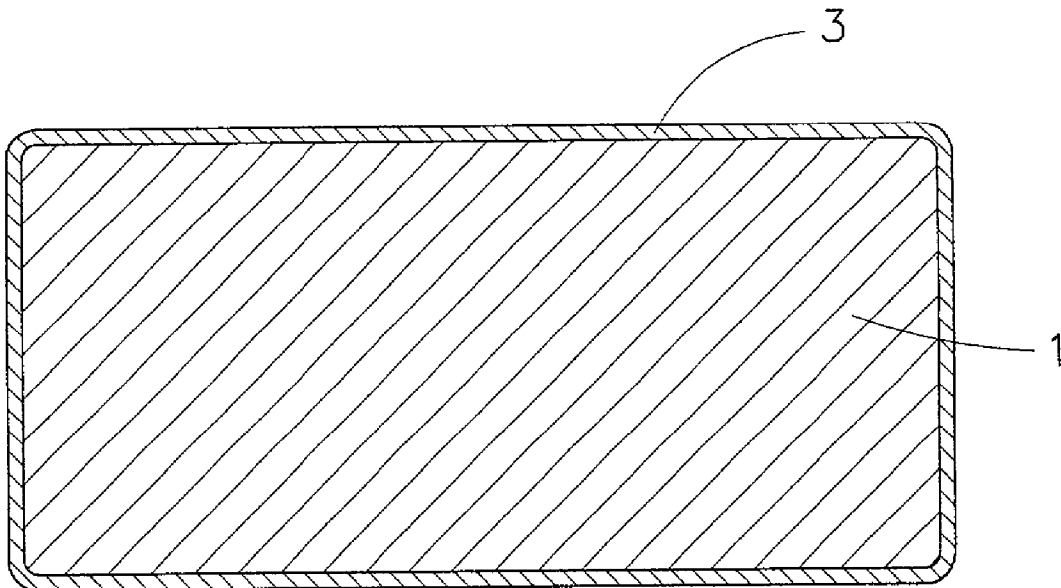
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(57) **ABSTRACT**

An innovative composite decking concept employing a wooden core surrounded by a fiber-reinforced plastic material is described. The invention is low-cost, durable, and performs well structurally.

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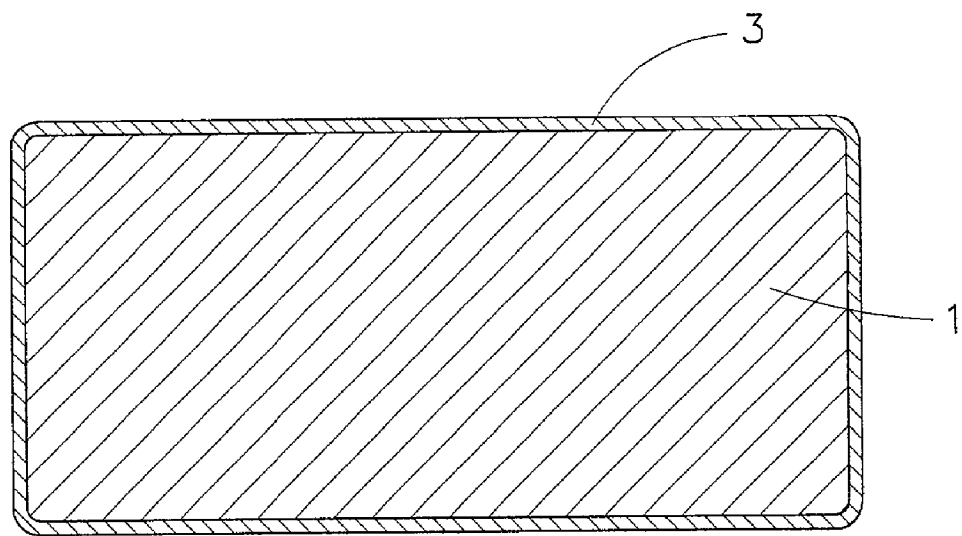


FIG. 1

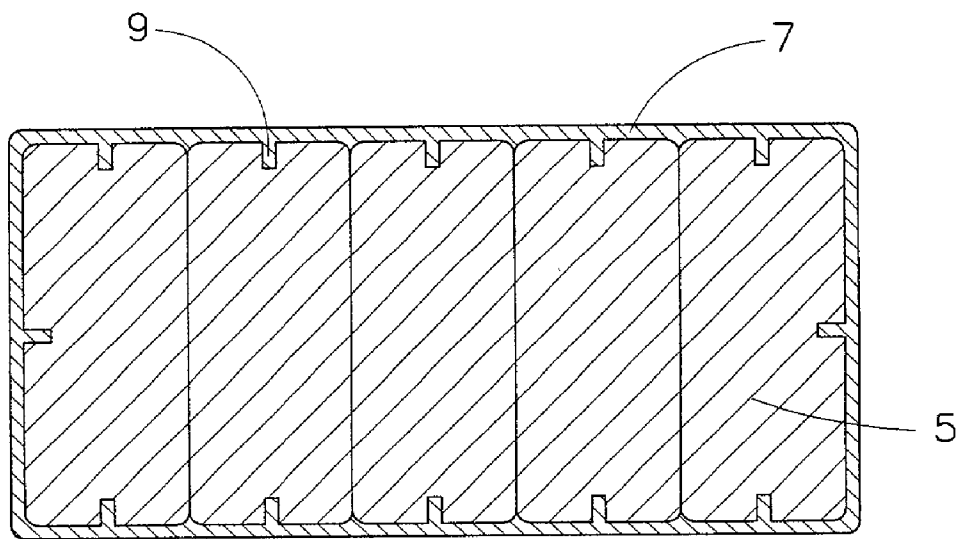


FIG. 2

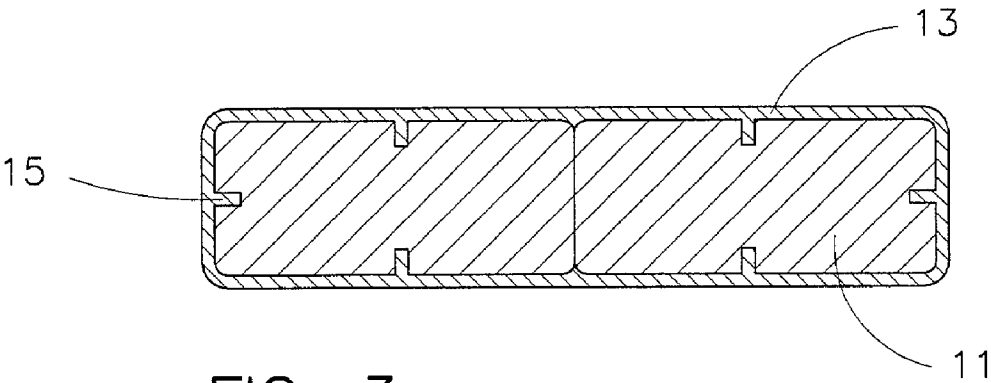


FIG. 3

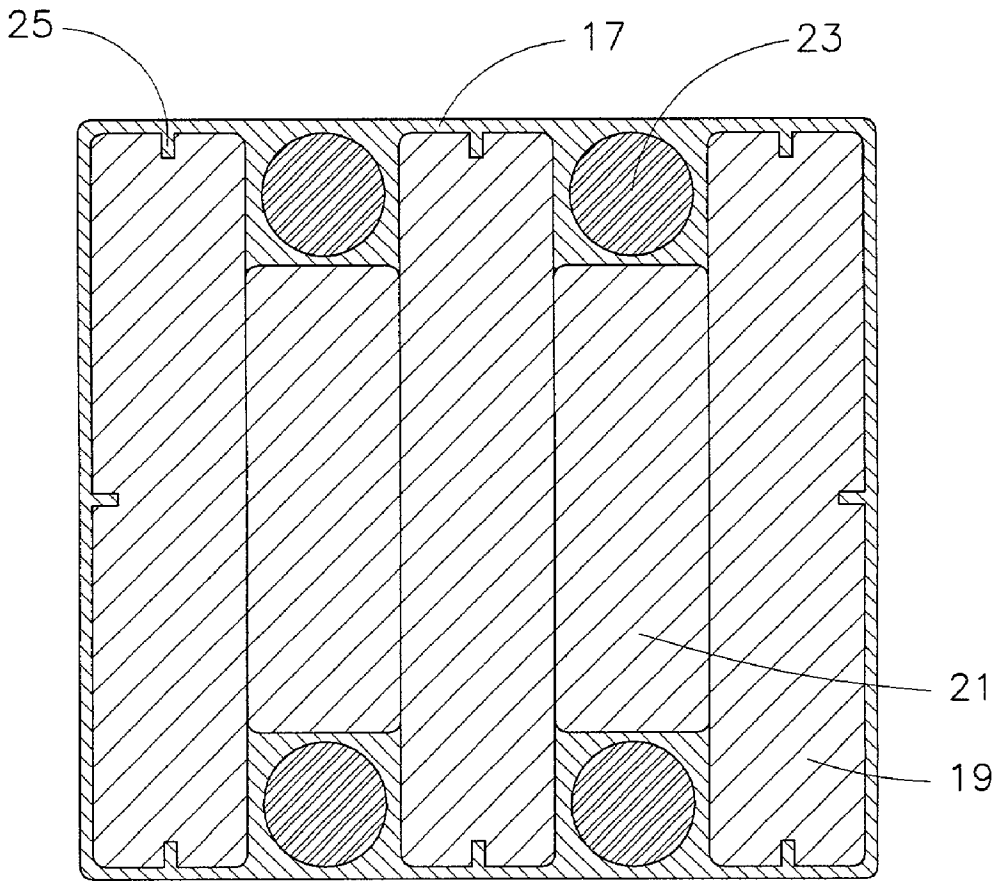


FIG. 4

WOODEN BRIDGE DECK WITH FIBER-REINFORCED PLASTIC COATING

[0001] The present application claims priority from U.S. Provisional Application No. 60/224,835, filed Aug. 11, 2000.

BACKGROUND OF THE INVENTION

[0002] Many secondary and county bridges use wooden 2 by 4s set on edge and covered with asphalt for the decking. See AASHTO LRFD Bridge Design Specifications, American Association of State Highway and Transportation Officials, Washington, D.C., 1998. These decks have performed well structurally, and have the advantage of low cost, but since the wood is exposed to the elements, it eventually rots. Galvanized corrugated steel decks covered by asphalt are initially more expensive than wooden bridge decks but they last longer and therefore are more economical. Still, corrugated steel decks need replacement because the steel corrodes. Salt applied to roads in the winter for ice removal is especially hard on these decks.

[0003] In recognition of these problems, several groups have attempted to develop all-composite bridge decks. See Marketing Alliance of the FRP Composites Industry, Website: www.mdacomposite.org. Fiber-reinforced plastics such as fiberglass have proven their durability in harsh environmental conditions. In the marine industry, fiberglass boats have become the standard for recreational boats. However, the all-composite bridge deck concepts to date have been much more expensive than current decks, and face the additional problem of requiring certification for public use.

SUMMARY OF THE INVENTION

[0004] The present invention relates to a deck bridge comprising a wooden core (such as regular lumber, laminated veneer lumber, plywood, glulam beams, and combinations thereof) encased by a layer of a fiber-reinforced plastic (such as fiberglass-reinforced plastic, carbon fiber-reinforced plastic, and combinations thereof). The fiber-reinforced plastic is corrosion resistant and helps to protect the wooden core from moisture. The layer of fiber-reinforced plastic is preferably less than about 5 mm (0.2 inch) thick.

[0005] The same technology can also be used to construct manhole covers.

[0006] The present invention also encompasses a building material comprising a wooden core (such as regular lumber, laminated veneer lumber, plywood, glulam beams, and combinations thereof), encased within a layer of a fiber-reinforced plastic (such as fiberglass-reinforced plastic, carbon fiber-reinforced plastic, and combinations thereof).

DETAILED DESCRIPTION OF THE INVENTION

[0007] Our innovative deck combines the advantages of a wooden deck (low cost, proven structural performance) with the durability and long life of composite materials. Traditional wooden decks rely on the strength and stiffness of the wood to support the loads. Composite bridge designs to date have relied on the strength and stiffness of the composite to support the loads. One of the features that distinguishes our innovative deck from other decks is the use of a layer of

composite material as a "thick paint" to protect the wood from rotting, and not as a significant structural element. Regular lumber is a cheap material while balsa wood and composites are relatively much more expensive. End-grain balsa wood has been used in structural sandwich panels, but the balsa wood core does not contribute very much to the bending stiffness of the panel since end-grain balsa wood has a relatively low bending modulus. It is the panel skins that provide the sandwich panel stiffness. In contrast, our innovative deck is cheaper to make than an all-composite bridge deck or a balsa wood cored composite deck, it will last much longer than a traditional wooden deck, and the wooden core provides a majority of the bending stiffness of the deck.

[0008] There are additional features that can make our inventive decking more useful in various applications. For instance, the wood used as the core material can be treated with chemicals that make the wood rot resistant. The type and degree of treatment will depend on the application and will be known to those skilled in the art. It is preferred that the wood be kiln dried after treatment to remove most of the moisture. Then, when the layer of fiber-reinforced plastic encases the wooden core, there will be relatively little moisture in the wood.

[0009] Another useful feature that can be added to the decking is a non-skid wearing surface that provides traction and protects the fiberglass skins. It can be made as follows. First, catalyzed resin is spread over the top surface of the molded deck panel. Then, a generous layer of coarse particles (for example, metal blasting grit) is spread over the layer of catalyzed resin. The resin is allowed to cure and thereby attaches a layer of grit to the surface of the decking. The excess grit is then removed leaving a non-skid surface. The non-skid surface can be painted the desired color.

[0010] The wooden core can be made from pieces of regular lumber. The size of the pieces of lumber will depend on the requirements of the application. Spikes can be used to join several small pieces of wood into a single core. Or, the wooden core can be made from various forms of engineered lumber such as LVL (laminated veneer lumber), plywood, or glulam beams. In some applications, it may be useful to include a rot resistant layer of material between pieces of wood or engineered lumber in the core.

[0011] The deck can be attached to the support by several means. The preferred method will depend on the particular application. Lag screws can be used to attach the deck to wooden support beams. Other attachment methods are possible.

[0012] The fiber used in the fiber-reinforced plastic will usually be fiberglass. However, higher modulus fibers such as carbon fibers can be used. Additionally, rebar or reinforcement rods such as those used in concrete construction can be added to the core to increase the strength and stiffness of the core. The layer of fiber-reinforced plastic will also protect the rebar.

[0013] There are several methods by which the decking may be manufactured such as hand lay-up, resin transfer molding (RTM), vacuum-assisted resin transfer molding (VARTM) and pultrusion. Presently, the preferred method of making the decking is to use a VARTM process involving small grooves that are cut into the wood to aid in the distribution of resin and vacuum during molding.

[0014] A sample wooden deck may be made by the following process. First, using a table saw, small resin grooves going the entire length of several 2 by 4s are made on both of the 2-inch sides of the boards. Then, the 2 by 4s are stapled together to form a core. A main resin distribution groove is cut in the end of the assembled wooden core, and side grooves connect the distribution groove with the long small grooves. The main resin distribution groove is used to feed the smaller grooves with resin. Next, the wooden core is wrapped with a layer of fiberglass fabric. The fiberglass-wooden core assembly is then enclosed in a vacuum bag. A resin supply line is connected between a source of catalyzed resin and the main resin distribution groove. The resin supply line is clamped shut. A vacuum source line is attached to the fiberglass fabric at the end opposite from the main resin distribution groove. A vacuum is drawn on the cavity formed by the vacuum bag, which contains the fiberglass-wooden core assembly. Once full vacuum has been achieved, the resin supply line is opened by removing the clamp. Resin quickly flows into the small resin grooves and from the small resin grooves into the spaces between the boards and into the fiberglass fabric. After about 6 minutes, the 16 foot by 1 foot deck is fully infused with resin and both the vacuum and resin source lines are clamped shut. Once the resin has cured, the vacuum bag is removed. For those skilled in the art of composite molding, there are variations on the above method that can produce similar results. For instance, a mold can be used instead of a vacuum bag. Examples of useful resin materials include polyester and vinyl ester. A preferred resin material is fire-resistant polyester resin with UV inhibitor and pigments.

[0015] Typically, the layer of fiber-reinforced plastic formed on the wooden core will be less than about 5 mm (0.2 inch) thick. The bridge deck formed has a deck bending stiffness; the layer of fiber-reinforced plastic typically provides less than about one-half of said deck bending stiffness.

[0016] While the above description has focused on bridge decks, the innovative combination of a wooden core with a protective fiber-reinforced plastic covering can be used to make beams, curbs, barriers, and manhole covers as well as combinations such as decking with an integral curb or decking with integral beams or girders.

DESCRIPTION OF THE FIGURES

[0017] The figures show cross-sectional views in the direction of the span between support beams of various deck configurations.

[0018] FIG. 1 shows a solid wood core 1 encased by a layer of fiber-reinforced plastic 3. The wooden core could be laminated veneer lumber or a solid piece of lumber, and the layer of fiber-reinforced plastic could be fiberglass composite. There are no resin grooves in the figure. There are several molding methods capable of applying the fiber-reinforced plastic to the wooden core that do not require grooves.

[0019] FIG. 2 shows several pieces of solid wood core 5 encased by a layer of fiber-reinforced plastic 7. The wooden core is made of 2 by 4s that are spiked together. Small resin grooves 9 supply the resin to the layer of fiber-reinforced plastic during infusion.

[0020] For thinner decks, the boards can be laid flat.

[0021] FIG. 3 shows two pieces of solid wood core 11 encased by a layer of fiber-reinforced plastic 13. Small resin grooves 15 supply the resin to the layer of fiber-reinforced plastic during infusion.

[0022] For larger span applications requiring a greater deck thickness, more layers of the core can be used or larger width lumber, such as 2 by 8s, may be used.

[0023] Alternatively, the wood may consist of pieces of plywood. The preferred orientation, type, and arrangement of the wooden core pieces will depend on the particular application. Composite or steel reinforcing bars can be added to the core to increase the bending stiffness and strength of the structure.

[0024] FIG. 4 shows several pieces of solid wood core encased by a layer of fiber-reinforced plastic 17. Wider boards 19 go from the bottom to the top of the deck, while narrower boards 21 have rebar 23 placed between them and the layer of fiber-reinforced plastic. Small resin grooves 25 supplied the resin to the layer of fiber-reinforced plastic during infusion.

What is claimed is:

1. A bridge deck comprising a wooden core and a layer of a corrosion resistant fiber-reinforced plastic, said layer of said fiber-reinforced plastic encasing said wooden core.

2. The bridge deck according to claim 1 wherein the wooden core is selected from regular lumber, laminated veneer lumber, plywood, glulam beams, and combinations thereof.

3. The bridge deck according to claim 2 wherein said fiber-reinforced plastic comprises a fiberglass reinforced plastic.

4. The bridge deck according to claim 2 wherein said fiber-reinforced plastic comprises a carbon fiber reinforced plastic.

5. The bridge deck according to claim 2 wherein said wooden core comprises a plurality of wooden core elements.

6. The bridge deck according to claim 5 further comprising rot resistant barriers between said wooden core elements.

7. The bridge deck according to claim 2 wherein said wooden core additionally comprises rebar.

8. The bridge deck according to claim 2 wherein said wooden core is pressure treated with a chemical to help prevent rotting.

9. The bridge deck according to claim 2 wherein said fiber-reinforced plastic is attached to said wooden core using a vacuum infusion process.

10. The bridge deck according to claim 2 further comprising a non-skid wearing surface that provides traction and protects said fiber-reinforced plastic.

11. The bridge deck according to claim 2 wherein said bridge deck has a deck bending stiffness, and said layer of said fiber-reinforced plastic provides less than about one-half of said deck bending stiffness.

12. The bridge deck according to claim 2 wherein said layer of said fiber-reinforced plastic is less than about 5 mm (0.2 inch) thick.

13. A manhole cover comprising a wooden core, and a layer of a corrosion resistant fiber-reinforced plastic, wherein said wooden core is selected from regular lumber, laminated veneer lumber, plywood, glulam beams, and

combinations thereof, and said layer of said fiber-reinforced plastic encases said wooden core.

14. A building material comprising a wooden core selected from regular lumber, laminated veneer lumber, plywood, glulam beams and combinations thereof, encased within a layer of corrosion resistant fiber-reinforced plastic.

15. The building material according to claim 14 wherein the fiber-reinforced plastic comprises a fiberglass-reinforced plastic.

16. The building material according to claim 14 wherein the fiber-reinforced plastic comprises a carbon fiber-reinforced plastic.

17. The building material according to claim 14 wherein the layer of said fiber-reinforced plastic is less than about 5 mm (0.2 inch) thick.

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