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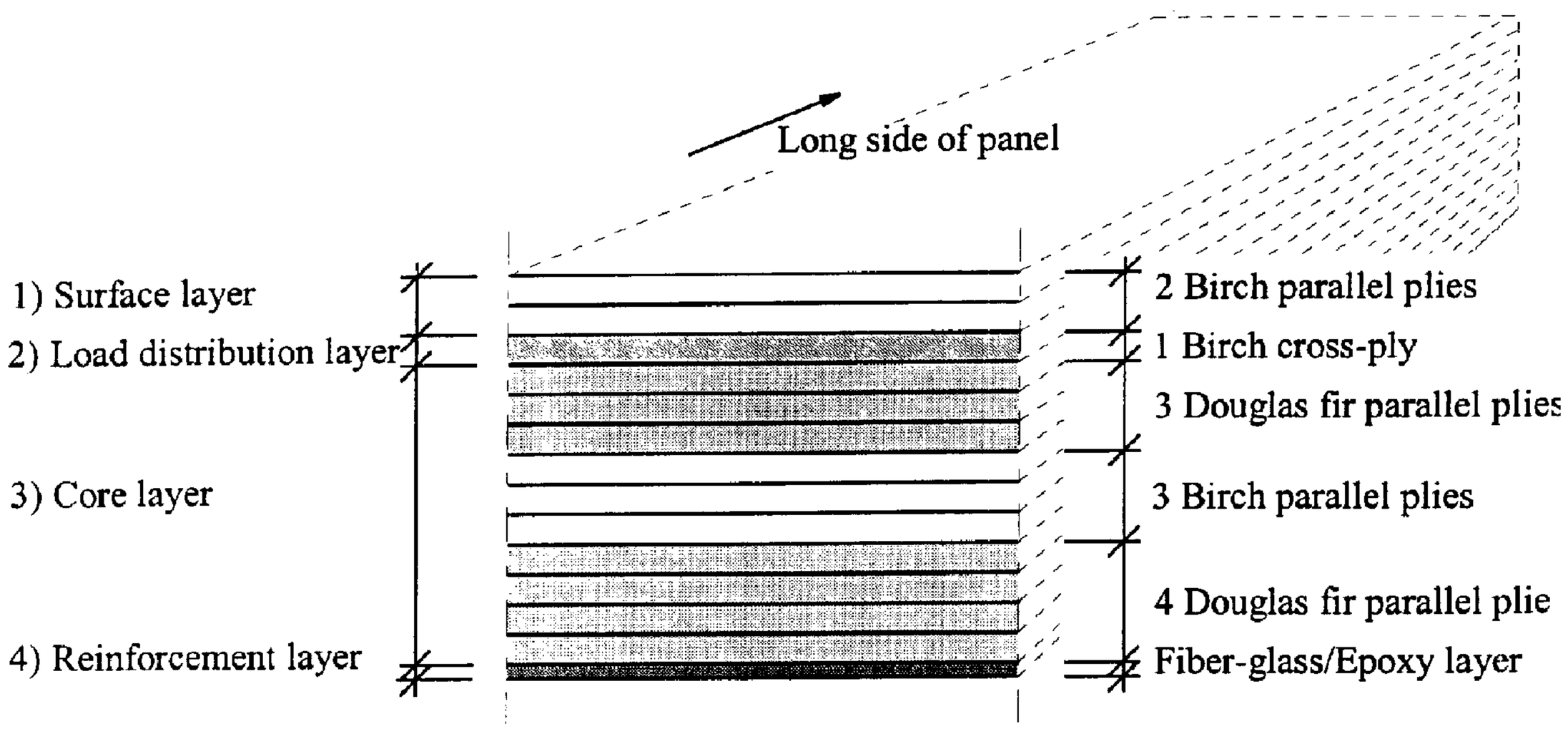

Panel cross section.

(57) Abrégé/Abstract:
An engineering wood based laminated panel for use as structural flooring for vehicle decking systems replaces a traditional hardwood decking and is cheaper plus having superior structural and wear properties. The panel has a plurality of layers in order down from a top surface, comprising a surface layer having at least two high density wood veneer plies oriented parallel to one side of the panel, a load distribution layer having at least one high density wood veneer ply cross oriented to the one side of the panel; a core layer having from about 8 to 14 wood veneer plies oriented parallel to the one side of the panel with centre plies of the core layer being high density wood plies, and a resin impregnated reinforcement layer.

ABSTRACT OF THE INVENTION

An engineering wood based laminated panel for use as structural flooring for vehicle decking systems replaces a traditional hardwood decking and is cheaper plus having superior structural and wear properties. The panel has a plurality of layers in order down from a top surface, comprising a surface layer having at least two high density wood veneer plies oriented parallel to one side of the panel, a load distribution layer having at least one high density wood veneer ply cross oriented to the one side of the panel; a core layer having from about 8 to 14 wood veneer plies oriented parallel to the one side of the panel with centre plies of the core layer being high density wood plies, and a resin impregnated reinforcement layer.

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WOOD BASED COMPOSITE DECKING PANEL

In North America platform trailers, van trailers, and intermodal containers and chassis are commonly used to transport goods. The floors of these vehicles are load bearing elements required to resist repeated applications of gravity loads from wheels of lift trucks carrying goods into and out of the vehicles. The floors typically consist of wood based decking elements and steel supporting beams.

In terms of the steel supporting beams, the basic structural system of a typical platform trailer is very different from that of typical van trailers and/or intermodal containers and chassis. Usually there are two main steel girders spaced 1.2 m apart and two smaller C-channels spaced 2.4 m apart, running along the length of a platform trailer. Perpendicular to the length of the trailer, light weight high strength steel I-beams are mounted onto the main girders forming the basic steel supporting elements. These heavy girder elements stiffen the floor and allow weaker wood based flooring panels to be used effectively to service the applied loads. Van trailers and/or intermodal containers and chassis, however, usually only consist of two small C-channels running along the length of the vehicle spaced 2.4 m

apart. In effect this monocoque construction require stronger flooring material to be used effectively to service the applied loads.

The flooring panels are subjected to loading from wheels of lift trucks carrying goods into and out of the vehicles. Such loading results in shear and bending stresses in the flooring panels. Throughout the panel depth, the shear stress is highest close to the neutral axis near the centre of the panel and very small close to the edges. The bending stress, on the other hand, is zero at the neutral axis near the centre of the panel and reaches maximum value at the edge. Consequently, two common failure modes are encountered with laminated wood panels in flooring applications: shear failure near the centre of the panel or bending tension failure at the bottom face of the panel.

Hardwood species are traditionally used for vehicle decking, either a tropical species group Apitong or laminated oak. These species have superior structural and wear and tear properties compared to softwood species. In the late 80's the continued availability of the hardwoods at a reasonable price became an issue. Furthermore, if alternate vehicle decking made from less dense softwoods were available, it would be possible to increase vehicle payloads which is an important cost incentive for the vehicle owners.

Existing softwood based panels can fulfil the industry requirements for service on platform trailers but have not been able to meet the structural requirements of the larger van trailers and intermodal containers and chassis market. The structural requirements on the flooring as stipulated by the Truck and Trailer Manufacturer Association consist of carrying a repeatedly applied front axle load for 3000 cycles without failure. The load rating for the van trailers and intermodal containers market spans from 73 kN to 107 kN front axle load.

An engineered wood based laminated panel has been developed intended for use as structural flooring material in transportation vehicles via attachment to the steel frame of the vehicle.

According to one embodiment of the invention, there is provided a wood based laminated panel with a plurality of layers in order down from a top surface, comprising: a surface layer having at least two high density wood veneer plies with the grain oriented parallel to one side of the panel; a load distribution layer having at least one high density wood veneer ply with the grain cross oriented to the one side of the panel; a core layer having from about 8 to 14 wood veneer plies with grain orientation parallel to the one side of the panel with

high density wood plies, and a resin impregnated reinforcement layer.

In another embodiment there is provided a method of manufacturing the wood based laminated panel as described comprising the steps of coating the veneer plies with resin, arrange the plies in a predetermined lay-up together with the resin impregnated reinforcement layer; placing a resin impregnated paper layer on top of the lay-up, and pressing the lay-up together at predetermined temperature and pressure to cure the resin and form the panel.

In another embodiment there is provided a wood based laminated panel as disclosed herein wherein the core layer comprises wood veneer plies selected from the group consisting of birch, oak, beech, tropical hardwoods, Douglas fir, western hemlock, spruce and pine.

In another embodiment there is provided a wood based laminated panel as disclosed herein wherein the core layer has three high density wood veneer plies sandwiched between three top and four bottom low density wood veneer plies.

In another embodiment there is provided a wood based laminated panel as disclosed herein wherein the high density wood veneer plies are birch and the low density wood veneer plies are Douglas fir.

In another embodiment there is provided a wood based laminated panel as disclosed herein wherein the surface layer comprises high density wood veneer plies selected from the group consisting of birch, oak, beech, tropical hardwoods, Douglas fir, western hemlock, pine and spruce.

In another embodiment there is provided a wood based laminated panel as disclosed herein wherein the load distribution layer comprises at least one high density wood veneer ply selected from the group consisting of birch, oak beech, tropical hardwoods, Douglas fir, western hemlock, pine and spruce.

In another embodiment there is provided a wood based laminated panel as disclosed herein wherein the load distribution layer is selected from the group consisting of organic fibre in the polyamide family, carbon, nylon, vinyl and glass fibres saturated with a resin selected from the group consisting of epoxy, phenol formaldehyde, melamine formaldehyde, phenol resorcinol formaldehyde, urea formaldehyde and polyester.

In another embodiment there is provided a wood based laminated panel as disclosed herein wherein the reinforcement layer is selected from the group consisting of organic fibre in the aromatic polyamide family, carbon, nylon, vinyl and glass fibres saturated with a resin selected from the group consisting of epoxy, phenol

formaldehyde, melamine formaldehyde, phenol resorcinol formaldehyde, urea formaldehyde, and polyester.

In another embodiment there is provided a wood based laminated panel as disclosed herein including an additional reinforcement layer on the top surface of the panel.

In another embodiment there is provided a wood based laminated panel as disclosed herein wherein the additional reinforcement layer is selected from the group consisting of organic fibre in the aromatic polyamide family, carbon, nylon, vinyl and fibre-glass.

In another embodiment there is provided a method of manufacturing a wood based laminated panel as disclosed herein comprising coating the veneer plies with a resin and arranging the veneer plies in a pre-determined lay-up together with a resin impregnated reinforcement layer; placing a resin impregnated paper layer on top of the lay-up; and pressing the veneer plies coated with the resin, the impregnated reinforcement layer and the resin impregnated paper layer in the lay-up together at predetermined temperature and pressure to cure the resin and form the panel.

In another embodiment there is provided a method of manufacturing a wood based laminated panel as disclosed herein wherein an additional wood veneer ply is added to the bottom of the stack and pressed to the panel.

In another embodiment there is provided a method of manufacturing a wood based laminated panel as disclosed herein wherein an additional resin impregnated paper layer is added to the bottom of the stack and pressed to the panel.

In another embodiment there is provided a method of manufacturing a wood-based laminated panel as disclosed herein wherein the pressing step comprises two stages: pressing the resin coated veneer plies, and the resin impregnated paper layer, thereby producing a coated veneer-resin impregnated paper pressing; and pressing the impregnated reinforcement layer to the coated veneer-resin impregnated paper pressing, to produce the panel.

In another embodiment there is provided a method of manufacturing a wood based laminated panel as disclosed herein wherein the second stage comprises a manually applied reinforcement layer.

In another embodiment there is provided a method of manufacturing a wood based laminated panel as disclosed herein wherein the pressing step is a continuous pressing.

In another embodiment there is provided a method of manufacturing a wood based laminated panel as disclosed herein including the additional step of squaring off edges of the panel and applying moisture sealant to the edges.

In another embodiment there is provided a method of manufacturing a wood based laminated panel with a plurality of layers in order down from a top surface, comprising: a surface layer having at least two high density wood veneer plies with grain orientation parallel to one side of the panel; a load distribution layer having at least one high density wood veneer ply with the grain cross-oriented to the one side of the panel; a core layer having from about 8 to 14 wood veneer plies with the grain oriented parallel to the one side of the panel with center plies of the core layer being high density wood plies; a resin-impregnated reinforcement layer; and an additional wood veneer ply; comprising the steps of: coating the veneer plies with a resin and arranging the veneer plies in a predetermined lay-up together with the resin-impregnated reinforcement layer; placing a resin-impregnated paper layer on top of the lay-up; and pressing the veneer plies and impregnated reinforcement layer in the lay-up together at predetermined pressure and temperature to cure the resin and form the panel.

In another embodiment there is provided a method of manufacturing a wood based laminated panel with a plurality of layers in order down from a top surface, comprising: a surface layer having at least two high density wood veneer plies with grain orientation parallel to one side of the panel; a load distribution layer having at least one high density wood veneer ply with the grain cross-oriented to the

one side of the panel; a core layer having from about 8 to 14 wood veneer plies with the grain oriented parallel to the one side of the panel with center plies of the core layer being high density wood plies; a resin-impregnated reinforcement layer; and an additional resin-impregnated paper layer; comprising the steps of: coating the veneer plies with a resin and arranging the veneer plies in a predetermined lay-up together with the resin-impregnated reinforcement layer; placing a resin-impregnated paper layer on top of the lay-up; and pressing the veneer plies and impregnated reinforcement layer in the lay-up together at predetermined pressure and temperature to cure the resin and form the panel.

In another embodiment there is provided the method as disclosed herein, further comprising coating an additional wood veneer ply with a resin and arranging the additional wood veneer ply in a predetermined lay-up together with the panel; pressing the additional wood veneer ply and the panel in the lay-up together at predetermined temperature and pressure to cure the resin and form a new panel.

In another embodiment there is provided the method as disclosed herein, further comprising coating an additional resin-impregnated paper layer with a resin and arranging the additional wood veneer ply in a predetermined lay-up together with the panel; pressing the resin-impregnated paper layer and the panel in the lay-up together at

predetermined temperature and pressure to cure the resin and form a new panel.

In drawings which illustrate embodiments of the invention,

Figures **1A** and **1B** are schematic views showing vehicle decking systems,

Figure **2** is a schematic view showing shear and bending stresses for a panel,

Figure **3** is a panel cross-sectional view showing the layers according to one embodiment of the invention.

A typical van trailer structure is shown in Figure **1A** which differs from the structure of a platform trailer shown in Figure **1B**. The flooring panels are subjected to

loading from wheels of lift trucks and the like and Figure 2 shows the shear and bending stresses over a cross-section of a typical flooring panel.

The panel has been engineered such that a desired mode of failure and maximum load capacity is achieved. In one embodiment the panel is made up of thirteen layers of 2.54 mm thick laminated veneers and an additional reinforcement layer. The veneer layers can be divided into three basic components; surface layer, load distribution layer, and core layer as shown in Figure **3**. Each component has a specific role to fill with regard to the over all load carrying capacity of the panel.

Typically the loads transferred to the panel surface from the wheels of lift trucks are highly concentrated and very abrasive to the panel surface. Hence, the surface layer is made up from veneer layers with high density to improve the wear and tear resistance of the panel. The surface layer consists of two 2.54 mm thick Birch veneers oriented parallel to the long side of the panel (parallel plies).

In order to improve load carrying capacity of a panel, it is imperative that the load is distributed to as large a volume of material as possible. The load distribution layer consists of a single layer of birch veneer oriented such that its fibre direction is perpendicular to the parallel plies (cross ply). A cross ply has lower shear strength

than parallel plies, therefore, in order to avoid shear failures of the load distribution layer it consists of a veneer with high density and thus higher shear strength.

The function of the core layer is to carry the shear stresses. Another important function of the core is to increase the rigidity of the panel without making it too heavy. Rigidity is partly obtained by an increase of the panel depth. The core consists of two types of veneers, higher density (birch) and lower density (Douglas fir) veneers both oriented with the grain parallel to the long side of the panel. The lower density veneers are weaker in shear compared to the higher density veneers, but offer weight and cost savings which is an important criteria for vehicle flooring. The veneers in the core layer are arranged in a 3 Douglas fir - 3 birch - 4 Douglas fir scheme such that the higher density birch veneers are placed in the zone where the highest shear stresses can be expected.

The main function of the reinforcement layer is to carry the majority of the bending tension stresses. The reinforcement layer also adds additional stiffness to the panel and because of its high load strength it eliminates the bending tension failure mode and forces the panel to fail in shear under high loads. The reinforcement layer

consist of glass fibre fabric saturated by an epoxy resin.

Examples of materials and veneer species that can be used in the various panel components are:

Surface layer:	birch, oak, beech, tropical hardwoods, Douglas-fir, western hemlock, pine, spruce, KEVLAR[1]*, carbon, fibre-glass, nylon, vinyl, and aluminum
Load distribution layer:	birch, oak, beech, tropical hardwoods, Douglas-fir, western hemlock, pine, spruce, KEVLAR*, carbon, nylon, vinyl, and fibre-glass
Core layer:	birch, oak, beech, tropical hardwoods, Douglas-fir, western hemlock, spruce, and pine.

The reinforcement layer can be made up from of KEVLAR*, carbon, nylon, vinyl, or glass fibres saturated by epoxy, phenol formaldehyde, melamine formaldehyde,

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[1]*DuPont's trade-mark for organic fibre in the aromatic polyamide family.

phenol resorcinol formaldehyde, urea formaldehyde, or polyester resin according to preference.

By making adjustments to the various components of the panel, the load carrying capacity of the panel can be adjusted to fit the high or low ends of the market. This can be achieved by:

1) Altering veneer thickness (1.5 mm to 3.2 mm). The thinner the veneer, the higher the strength.
2) Changing the number of veneers in the core layer (8 to 14).
3) Changing the species of the veneers in the core layer. Higher density is equivalent to higher strength.
4) Changing the properties of the reinforcement layer in terms of material/resin combination and/or layer thickness.

Consequently, variants of the panel can be manufactured to service the various load sectors of the market. In order to achieve load carrying capacity for the high end market 24,000 lbs load rating) an additional reinforcement layer on the top of the panel (above the surface layer) is necessary.

The panel is manufactured in a standard plywood mill. The procedure follows with the exception of the reinforcement layer the normal manufacturing process of a plywood panel. The Veneers are initially coated with a phenol formaldehyde resin and arranged in the predetermined lay-up together with the resin impregnated reinforcement layer on the bottom and a resin impregnated paper layer on top. Then, the stack is pressed together under high temperature (130°C- 170°C) and pressure (1.2 MPa - 1.5 MPa) until the resin has cured and a panel has been formed in a single stage process. The resin impregnated paper layer is used to provide the panel with moisture resistance. When the panel has cooled down the edges are squared off and supplied with a moisture sealant.

The manufacturing procedure is, however, susceptible to changes. It is possible to use a two stage process to manufacture the panel; first hot-press the veneers together and later add the reinforcement layer by manual method or by hot-pressing. Another option is the use of a continuous press for manufacture of over sized panels. An additional wood veneer layer may be applied at the bottom of the panel at the time of the press such that the reinforcement layer is sandwiched between two veneer layers. The additional wood veneer ply does not fulfil any structural purposes but is used to protect the press platens from resin. This can also be achieved by adding

a second resin impregnated paper layer to the bottom of the stack at the time of the press.

The development work took place in a laboratory environment. For practical and economical reasons the majority of the tests have focused on the evaluation of the short term strength of small scale test specimens (10 cm wide and 40 cm long). Based on the test results, an understanding of the failure behaviour of laminated soft wood panels has been established and different modes of failure have been identified. A number of different lay-up combinations have been tested and compared to the existing panel materials. In house tests of small panel specimens indicate a substantial increase in short term capacity (+37%) compared to the existing market competition of soft wood based panels. Such increase in short term capacity is judged to allow the panel to compete structurally with the traditional hardwood flooring.

A sample of full scale (1.2 m wide and 2.4 m long) prototype panels were manufactured in a plywood mill. The mill trial experience indicated that the panel can indeed be manufactured in a mill environment with little modification to the current production method of the mill.

Prototype panels were installed into three vehicles for field testing. Close records of the loads applied to the decking have been kept. So far the vehicles have been in services for up to twelve months and good performance in terms of durability and load carrying capacity has been reported.

Various changes may be made to the embodiments shown herein without departing from the scope of the present invention which is limited only by the following claims.

WE CLAIM:

1. A wood based laminated panel with a plurality of layers in order down from a top surface, comprising:

a surface layer having at least two high density wood veneer plies with grain orientation parallel to one side of the panel;

a load distribution layer having at least one high density wood veneer ply with the grain cross oriented to the one side of the panel;

a core layer having from about 8 to 14 wood veneer plies with the grain oriented parallel to the one side of the panel with centre plies of the core layer being high density wood plies, and

a resin impregnated reinforcement layer.

2. The wood based laminated panel according to claim 1 wherein the core layer comprises wood veneer plies selected from the group consisting of birch, oak, beech, tropical hardwoods, Douglas fir, western hemlock, spruce and pine.

3. The wood based laminated panel according to claim 2 wherein the core layer has three high density wood veneer plies sandwiched between three top and four bottom low density wood veneer plies.

4. The wood based laminated panel according to claim 3 wherein the high density wood veneer plies are birch and the low density wood veneer plies are Douglas fir.

5. The wood based laminated panel according to claim 1 wherein the surface layer comprises high density wood veneer plies selected from the group consisting of birch, oak, beech, tropical hardwoods, Douglas fir, western hemlock, pine and spruce.

6. The wood based laminated panel according to claim 1 wherein the load distribution layer comprises at least one high density wood veneer ply selected from the group consisting of birch, oak, beech, tropical hardwoods, Douglas fir, western hemlock, pine and spruce.

7. The wood based laminated panel according to claim 1 wherein the load distribution layer is selected from the group consisting of organic fibre in the polyamide family, carbon, nylon, vinyl and glass fibres saturated with a resin selected from the group consisting of epoxy, phenol formaldehyde, melamine formaldehyde, phenol resorcinol formaldehyde, urea formaldehyde and polyester.

8. The wood based laminated panel according to claim 1 wherein the reinforcement layer is selected from the group consisting of organic fibre in the aromatic polyamide family, carbon, nylon, vinyl and glass fibres saturated with a resin selected from the group consisting of epoxy, phenol formaldehyde, melamine formaldehyde, phenol resorcinol formaldehyde, urea formaldehyde, and polyester.

9. The wood based laminated panel according to claim 1 including an additional reinforcement layer on the top surface of the panel.

10. The wood based laminated panel according to claim 9 wherein the additional reinforcement layer is selected from the group consisting of organic fibre in the aromatic polyamide family, carbon, nylon, vinyl and fibre-glass.

11. A method of manufacturing a wood based laminated panel according to claim 1 comprising:

coating the veneer plies with a resin and arranging the veneer plies in a pre-determined lay-up together with a resin impregnated reinforcement layer;

placing a resin impregnated paper layer on top of the lay-up, and;

pressing the veneer plies coated with the resin, the impregnated reinforcement layer and the resin impregnated paper layer in the lay-up together at predetermined temperature and pressure to cure the resin and form the panel.

12. The method of manufacturing a wood based laminated panel according to claim 11 wherein an additional wood veneer ply is added to the bottom of the reinforcement layer and pressed to the panel.

13. The method of manufacturing a wood based laminated panel according to claim 11 wherein an additional resin

impregnated paper layer is added to the bottom of the reinforcement layer and pressed to the panel.

14. The method of manufacturing a wood-based laminated panel according to claim 11 wherein the pressing step comprises two stages:

pressing the resin coated veneer plies, and the resin impregnated paper layer, thereby producing a coated veneer-resin impregnated paper pressing; and

impregnated paper pressing, to produce the panel pressing the impregnated reinforcement layer to the coated veneer-resin.

15. The method of manufacturing a wood based laminated panel according to claim 14 wherein the second stage comprises a manually applied reinforcement layer.

16. The method of manufacturing a wood based laminated panel according to claim 11 wherein the pressing step is a continuous pressing.

17. The method of manufacturing a wood based laminated panel according to claim 11 including the additional step of squaring off edges of the panel and applying moisture sealant to the edges.

18. A method of manufacturing a wood based laminated panel with a plurality of layers in order down from a top surface, comprising:

a surface layer having at least two high density wood veneer plies with grain orientation parallel to one side of the panel;

a load distribution layer having at least one high density wood veneer ply with the grain cross-oriented to the one side of the panel;

a core layer having from about 8 to 14 wood veneer plies with the grain oriented parallel to the one side of the panel with center plies of the core layer being high density wood plies;

a resin-impregnated reinforcement layer; and

an additional wood veneer ply; comprising the steps of:

coating the veneer plies with a resin and arranging the veneer plies in a predetermined lay-up together with the resin-impregnated reinforcement layer;

placing a resin-impregnated paper layer on top of the lay-up; and

pressing the veneer plies and impregnated reinforcement layer in the lay-up together at predetermined pressure and temperature to cure the resin and form the panel.

19. A method of manufacturing a wood based laminated panel with a plurality of layers in order down from a top surface, comprising:

a surface layer having at least two high density wood veneer plies with grain orientation parallel to one side of the panel;

a load distribution layer having at least one high density wood veneer ply with the grain cross-oriented to the one side of the panel;

a core layer having from about 8 to 14 wood veneer plies with the grain oriented parallel to the one side of the panel with center plies of the core layer being high density wood plies;

a resin-impregnated reinforcement layer; and

an additional resin-impregnated paper layer; comprising the steps of:

coating the veneer plies with a resin and arranging the veneer plies in a predetermined lay-up together with the resin-impregnated reinforcement layer;

placing a resin-impregnated paper layer on top of the lay-up; and

pressing the veneer plies and impregnated reinforcement layer in the lay-up together at predetermined pressure and temperature to cure the resin and form the panel.

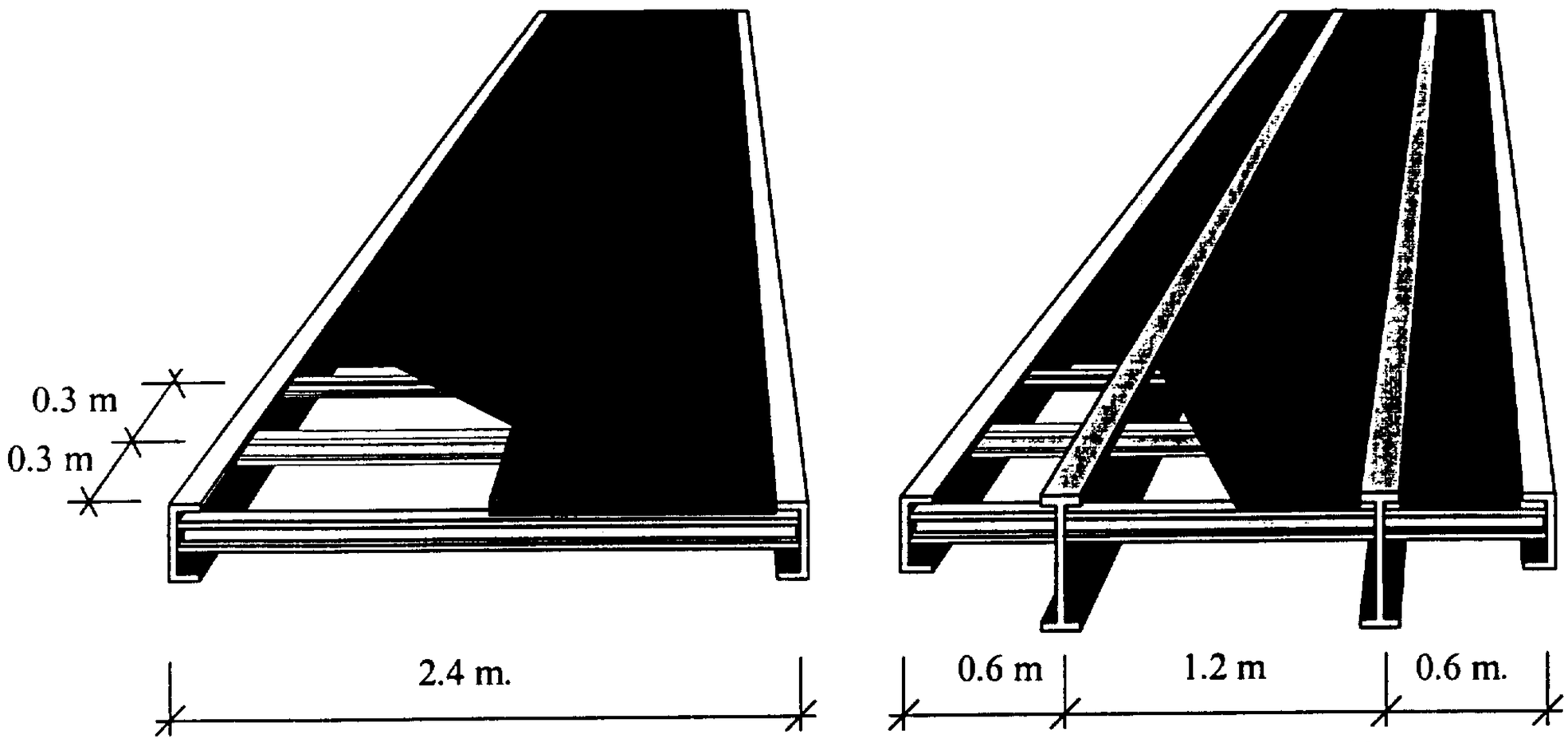
20. The method of claim 11, further comprising coating an additional wood veneer ply with a resin and arranging the additional wood veneer ply in a predetermined lay-up together with the panel;

pressing the additional wood veneer ply and the panel in the lay-up together at predetermined temperature and pressure to cure the resin and form a new panel.

21. The method of claim 11, further comprising coating an additional resin-impregnated paper layer with a resin and

arranging the additional wood veneer ply in a predetermined lay-up together with the panel;

pressing the resin-impregnated paper layer and the panel in the lay-up together at predetermined temperature and pressure to cure the resin and form a new panel.



a) Van trailers b) Platform trailers

Figure 1. Schematic views of vehicle decking systems.

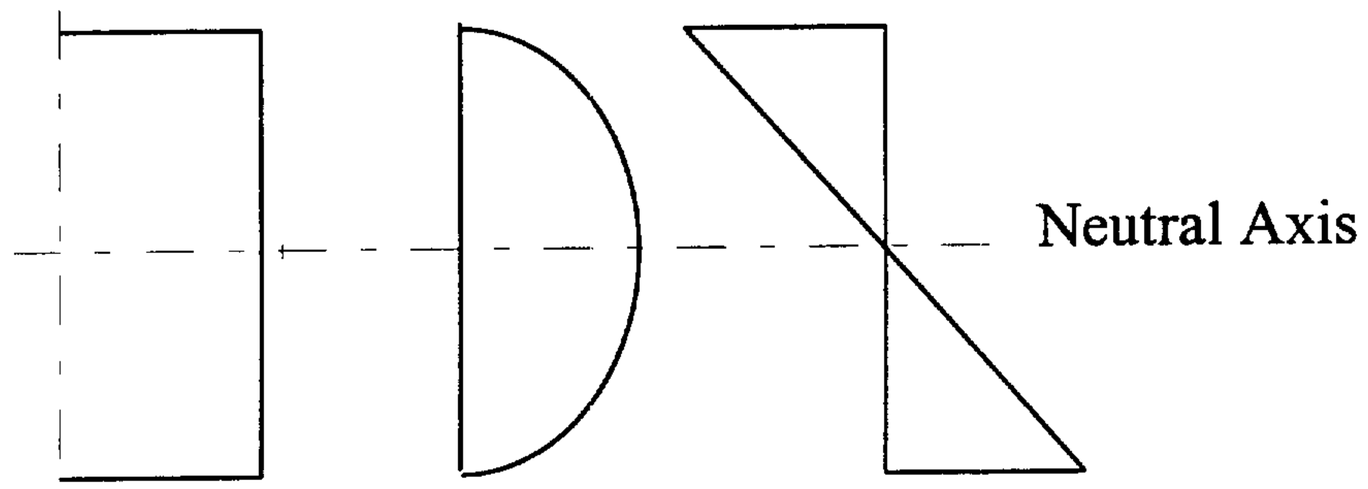


Figure 2. Schematic description of shear and bending stresses over panel depth.

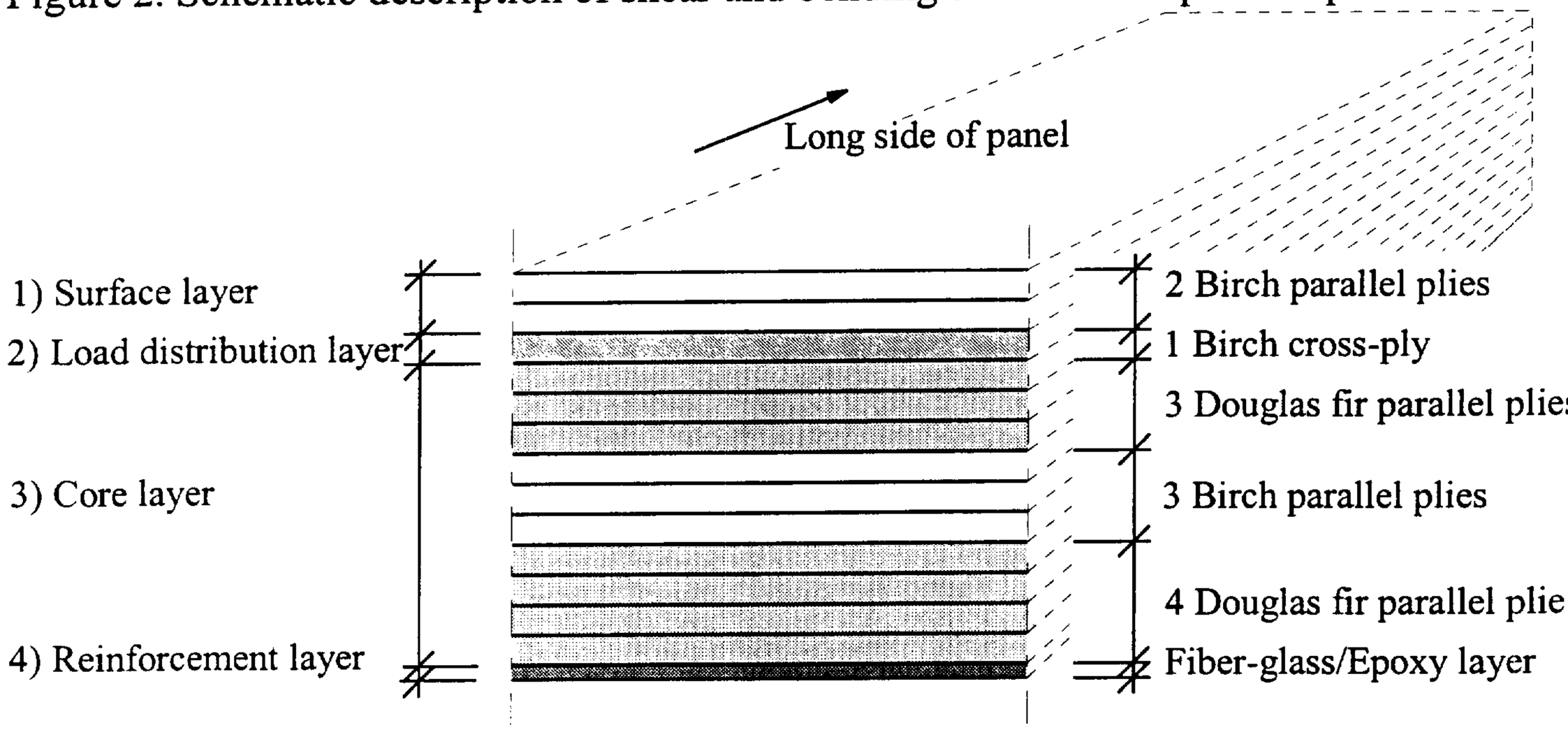
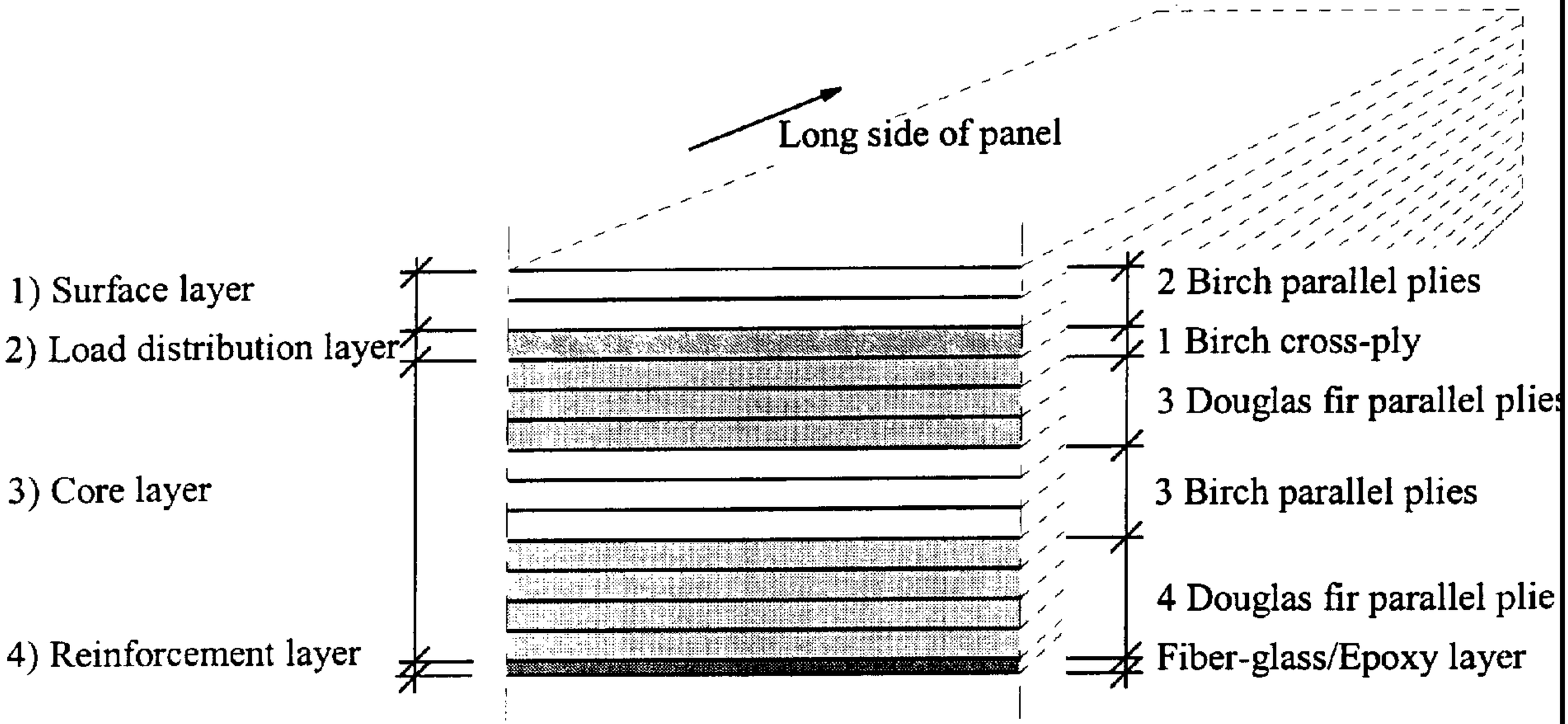


Figure 3. Panel cross section.



Panel cross section.