6-1 and 6-2 that are disposed on a front side and a rear side of the structure 5, respectively, and a rib 7 that is provided on a flat surface f1 opposite from a front-side laminate 6-1's surface in contact with the structure 5 and protrudes from the flat surface f1. The rib 7 corresponds to the protruding portion in the present invention. Fig. 1 does not show the second resin and the second reinforced fibers contained in the laminates 6-1 and 6-2. The rib 7 is provided in a center portion of the flat surface f1 over the entire length-wise distance (from one end to the other end) of the laminate 6-1. The rib, however, may be provided only in one length-wise portion. The rib 7 is linear but is not limited to this shape, and the rib may be zigzag-shaped or wave-shaped. Further, a plurality of ribs 7 may be provided in parallel or the rib may also be provided in a lattice shape. Further, when the composite structure is semispherical, it is possible to provide the rib in a radial shape extending from the center of the semisphere.

[0015]

Fig. 2 is a perspective view of a composite structure 1A according to a modified example 1 of the embodiment of the present invention. In the composite structure 1A, laminates 6-1A and 6-2 are disposed on a front side and a rear side of the structure 5, respectively, and a plurality

of bosses 7A are provided on the flat surface f1 opposite from a front-side laminate 6-1A's surface in contact with the structure 5 and protrude from the flat surface f1. The bosses 7A correspond to the protruding portion. The bosses 7A are columnar but are not limited to this shape, and the bosses may be prismatic column-shaped such as a hexagonal column shape and may be hollow.

[0016]

Fig. 3 is a perspective view of a composite structure 1B according to a modified example 2 of the embodiment of the present invention. In the composite structure 1B, laminates 6-1B and 6-2 are disposed on a front side and a rear side of the structure 5B, respectively, and a protruding portion 7B is formed on the flat surface f1 opposite from a front-side laminate 6-1B' surface in contact with the structure 5B. The protruding portion 7B is formed by flexures 8a, 8b, 8c, and 8d flexed at a nearly right angle. In the modified example 2, the flexures are flexed at a nearly right angle, allowing the protruding portion to protrude outward from the plane of the laminate. The flexure angle, however, may be an acute angle or an obtuse angle and the flexure direction may be toward the inside of the laminate. The protruding portion that is rectangular as shown in Fig. 3 may also be hat-shaped or corrugated plate-shaped. The rib, the bosses, and the

particularly limited as long as it is two or more. The layers in the laminate, however, are preferably quasi-isotropically laminated from a viewpoint of homogenizing the flexural modulus that contributes to the flexural rigidity. Specifically, in order to homogeneously obtain a high flexural rigidity, the layers in the laminate preferably attain cross lamination with a unit of [0/90] or isotropic lamination with a unit of [+45/0/−45/90] or [0/±60].

[0022]

The second reinforced fibers of the laminate included in the composite structure according to the present invention are discontinuous fibers and have a thickness-wise average fiber orientation angle in a range of 0° to 5° in the closest layer to the structure. The second reinforced fibers that are discontinuous fibers facilitate formation of the laminate into a complicated shape when an external force is applied to the laminate for molding. Further, the second reinforced fibers having a thickness-wise average fiber orientation angle in the range of 0° to 5° in the closest layer to the structure make the laminate itself have excellent mechanical properties, particularly a flexural property. The second reinforced fibers having a thickness-wise average fiber orientation angle of more than 5° are too much thickness-wise oriented to satisfy the flexural property in some cases. The second reinforced fibers

preferably have an average fiber orientation angle of 3° or less in the closest layer to the structure from a viewpoint of further satisfying the mechanical properties.

[0023]

Here, it is possible to obtain the thickness-wise average fiber orientation angle of the second reinforced fibers in the closest layer to the structure by obtaining the orientation angles of the second reinforced fibers in the closest layer to the structure in the laminate's sectional direction (thickness direction). The average fiber orientation angle is the degree of inclination with respect to the laminate’s sectional direction, in other words, the degree of inclination of the reinforced fibers with respect to the laminate’s thickness direction. The reinforced fibers having a larger value for the average fiber orientation angle suggest their state of being inclined nearer to upright along the thickness direction, and the value is given in a range of 0° or more and 90° or less. That is, the second reinforced fibers having a thickness-wise average fiber orientation angle in the range of 0° to 5° in the closest layer to the structure are capable of more effectively exerting a reinforcing function in the laminate. The second reinforced fibers have a thickness-wise average fiber orientation angle of 5° or less in the closest layer to the structure in view of exertion of the flexural rigidity when formed into the laminate. The second reinforced fibers more preferably have a thickness-wise average fiber

orientation angle of 3° or less.

[0024]

[0025]

In the present invention, the laminate integrated with the structure to form the composite structure has a variation in volume content of the second reinforced fibers in a range of 0 to 10%. This setting homogenizes the mechanical properties represented by the flexural modulus. The laminate having a variation in volume content of the second reinforced fibers of 0 to 10% suggests its state of being small in variability in volume content of the second reinforced fibers depending on the measured location when

formed into the composite structure. In other words, such a laminate shows a preferable result for easy designing of a final product and shape stability. From the above viewpoint, the laminate has a variation in volume content of the second reinforced fibers of preferably 5% or less, more preferably 0%.

[0026]

Here, it is possible to obtain the variation in volume content of the second reinforced fibers by a known method. For example, the density of the laminate extracted from the composite structure is measured in advance by a water substituted method, a coefficient of variation (CV value (%)) as an indicator of the variability is calculated from an average value of measured volume contents, the number of measured pieces, and a standard deviation, and the coefficient of variation is applicable as the variation in volume content.

[0027]

Each layer in the laminate of the present invention has substantially all the second reinforced fibers thereof divided by a cut. The second reinforced fibers divided by the cut preferably have a mass average fiber length Ls in a range of 10 to 100 mm. The division of the second reinforced fibers by the cut facilitates deformation of the second reinforced fibers together with the second resin in

flexural rigidity, an angle in a range of 4° or more and 90° or less between the orientation direction of the second reinforced fibers in one layer and the orientation direction of the second reinforced fibers in another layer adjacent to the one layer in the laminate. The laminate having excellent flexural rigidity is preferable because it results in enabling improvement in flexural rigidity of the composite structure.

[0032]

Each layer in the laminate preferably has an absolute value of an angle θ between the cut and the second reinforced fibers of 2 to 25° from a viewpoint of formativeness. Each layer having an absolute value of 25° or less exerts a preferable effect of improving the mechanical properties. On the other hand, each layer having an absolute value of the angle θ of 2° or less is capable of obtaining flowability and the mechanical properties, but it is sometimes difficult to stably make such a cut. This is because a cut at an acute angle with respect to the second reinforced fibers makes the contact of the second reinforced fibers with a blade unstable in making the cut. In addition, with the absolute value of the angle θ being less than 2°, provision of the second reinforced fibers having a mass average fiber length Ls of 10 to 100 mm at least excessively reduces the distance

and the second reinforced fibers;

step 2: disposing the laminated structure in molds having a flexure shape, an uneven shape (e.g., a boss), or a rib shape in at least the laminating direction of the laminated structure and curing the thermoset resin to form a composite-structure precursor while forming the laminated structure into the shape of the molds by heating and pressing; and

step 3: adjusting a thickness of the composite-structure precursor while melting or softening the thermoplastic, to expand the structure precursor and thus form a structure, giving a composite structure.

[0061]

The structure precursor "containing substantially no voids" used in the step 1 refers to the structure precursor having a volume content of the voids of 5 vol% or less. The structure precursor having a volume content of the voids of 5 vol% or less gives a sufficient flexural modulus in the step 1 even when having a small thickness, to satisfy handleability.

[0062]

The thermoset resin in the laminate precursor used in the step 1 is uncured thermoset resin and is cured in the step 2.

[0063]

The step 1 is a step obtaining a laminated structure

formed by laminating the laminate precursor on the structure precursor. The step 2 is a step disposing the laminated structure obtained in the step 1 in a pair of male and female molds having a reinforcing or functional member shape such as a flexure shape, an uneven shape (e.g., a boss), or a rib shape and forming the laminated structure into the shape by heating and pressing. In the step 2, it is preferable to give the laminate structure sufficient heat for allowing the thermoset resin contained in the laminate to form a cross-linking structure for curing. The pressure in the step 2 is sufficient if only it allows the laminated structure, preferably the laminate precursor to flow into the protruding portion, and a pressure of 0.3 to 10 MPa suffices.

[0064]

The step 3 is a step adjusting the thickness of the composite-structure precursor obtained in the step 2 while heating the composite-structure precursor, to expand the structure precursor and thus form a structure having voids, giving a composite structure. The heating temperature at this time is preferably high enough to give a sufficient amount of heat for melting or softening the thermoplastic contained in the structure, from viewpoints of controlling the thickness of the composite structure manufactured and of a manufacturing rate. Specifically, it is preferable to

apply a temperature of 10℃ or more higher than the melting temperature of the thermoplastic (first resin) and of the pyrolysis temperature or lower of the thermoplastic (first resin). The pressure is sufficient if only it prevents the molds from opening during the control of thickness, and a pressure of 3 to 10 MPa suffices.

[0065]

As a method for performing the steps 2 and 3, any method can be employed as long as it allows, by heating, the thermoset resin in the laminate precursor to form a cross-linking structure for curing and expands the thermoplastic in the structure precursor to enable control of the thickness of the composite structure to a target thickness. Exemplified as a preferable method from a viewpoint of simple manufacturing is a method for restraining the thickness of the composite-structure precursor with, for example, a metal plate or a method for controlling the thickness of the composite-structure precursor by pressure applied to the composite-structure precursor. As equipment for implementing the above methods, it is possible to suitably use a compression molding machine. When a batch-type method is used, it is possible to improve the productivity by employing an intermittent-type press system including two or more machines for heating and cooling in combination.

epoxy resin and polished such that a section in parallel with the thickness direction is an observation surface, to produce a sample. The sample was observed with a laser microscope (VK-9510, manufactured by KEYENCE CORPORATION) at a magnification of 400 times.

The average fiber orientation angle of the laminate was observed such that the closest layer of the sample to the structure came along the fiber longitudinal direction of the second reinforced fibers. The measurement of the fiber orientation angle was performed by measuring, with the boundary surface between the laminate and the structure set as a standard level (0°), the angles between the standard level and a total of 400 second reinforced fibers in the extracted observation sample, and obtaining an arithmetic average value of the measured values as the average fiber orientation angle of the second reinforced fibers.

[0069]

(2) Ratio (As)/(Ap) between projected area (Ap) of surface (referred to as plane of projection) having protruding portion and actual survey area of plane of projection (As) in composite structure

As regards the composite structures produced in the examples and the comparative examples, an image vertical to a surface portion of the composite structure was obtained with a digital camera. The area of the surface portion was calculated from the scale of the obtained image and defined as a projected area (Ap). Next, the length, the depth, and

[0079]

[PA6 resin]

A resin film was produced that was formed of nylon 6 resin ("AMILAN" (registered trademark) CM1021T manufactured by Toray Industries, Inc.) with a weight per unit area of 124 g/m^2. Table 1 shows the properties of the obtained resin film.

[0080]

[PEs resin]

A resin film was produced that was formed of polyester resin ("Hytrel" (registered trademark) SB754 manufactured by Toray Industries, Inc.) with a weight per unit area of 121 g/m^2. Table 1 shows the properties of the obtained resin film.

[0081]

[Epoxy resin]

An uncured epoxy resin composition was prepared by heating and kneading, with a kneader, epoxy resin (30 parts by mass of “EPIKOTE (registered trade mark)” 828, 35 parts by mass of “EPIKOTE (registered trademark)” 1001, and 35 parts by mass of “EPIKOTE (registered trademark)" 154 manufactured by Japan Epoxy Resins Co., Ltd.) and 5 parts by mass of thermoplastic polyvinyl formal ("Vinylec (registered trademark)" K manufactured by CHISSO CORPORATION) to uniformly dissolve polyvinyl formal, and

Table 2 shows the properties of the structure C.

[0086]

[Structure D]

A laminated product was obtained in the same manner as the structure A by changing the first resin from the PP resin to the epoxy resin. Next, the laminated product was subjected to the following steps (I) to (V) to give a structure D. Table 2 shows the properties of the structure D.

(I) The laminated product is disposed in a press-molding mold cavity that has been preliminarily heated at 150°C and the molds are closed.

(II) Next, the molds are further retained for 20 seconds while pressed at a pressure of 1 MPa.

(III) After the step (II), the mold cavity is opened and a metal spacer is inserted at an end of the cavity to adjust the thickness of an obtained structure to 3.3 mm, and then the molds are closed again and a pressure of 1 MPa is retained for 30 minutes.

(IV) Thereafter, the mold cavity is closely closed again, and the molds are cooled to a cavity temperature of 30°C while the pressure is retained.

(V) The molds are opened and a structure is extracted.

[0087]

[Structure E]

A structure E was obtained in the same manner as the

as not to make the prepreg into pieces by continuous cuts (cuts were inserted only in a range of 290 × 290 mm). The length of the fibers divided by the cuts was 50 mm. Cut-out prepregs with cuts were laminated to form four layers [0°/90°/90°/0°], with the orientation direction of the second reinforced fibers defined as 0° direction and the direction rightward shifted by 90 degrees from the orientation direction of the second reinforced fibers defined as 90°, and thus give a laminate A. Table 3 shows the properties of the laminate A.

[0092]

[Laminate B]

A laminate B was obtained in the same manner as the laminate A except that the length of the fibers by the cuts was set at 10 mm, and prepregs with cuts were laminated to form four layers [0°/-45°/90°/45°]. Table 3 shows the properties of the laminate B.

[0093]

[Laminate C]

A laminate C was obtained in the same manner as the laminate A except that no cut was inserted. Table 3 shows the properties of the laminate C.

[0094]

[Laminate D]

A laminate D was obtained in the same manner as the

laminate A except that the cut angle was set at 30°, and prepregs with cuts were laminated to form four layers [0°/-45°/90°/45°]. Table 3 shows the properties of the laminate D.

[0095]

[Laminate E]

A laminate E was obtained in the same manner as the laminate A except that the fiber volume content Vf was set at 70%. Table 3 shows the properties of the laminate E.

[0096]

[Laminate F]

A laminate F was obtained in the same manner as the laminate A except that the cut length of the laminate was set at 150 mm, the fiber volume content Vf was set at 45%, and prepregs with cuts were laminated to form four layers [0°/0°/0°/0°]. Table 3 shows the properties of the laminate F.

[0097]

(Example 1)

Molds for forming the composite structure has been processed to form a straight line-shaped rib having a width of 300 mm, a thickness of 2 mm, and a height of 20 mm, transversely in the planar center of a plate shape having a length of 200 mm and a width of 300 mm. The molds have a shear edge structure at an end thereof.

Step 1: a precursor of the structure A was used as the structure and the laminate A was used as the laminate. These members were laminated as [laminate A/precursor of structure A/laminate A] to give a laminated structure. Next, the laminated structure was disposed in a press-molding mold cavity that had been preliminarily heated at 150°C.

Step 2: next, the molds were closed, pressed at a pressure of 1 MPa, and further retained for 10 minutes while pressed.

Step 3: after the temperature of the mold cavity was raised to 220°C, the molds were opened, and a metal spacer was inserted at an end of the molds to adjust the thickness of a structure to 3.4 mm.

Step 4: thereafter, the mold cavity was closely closed again, and the molds were rapidly cooled to a cavity temperature of 50°C while the pressure was retained at 3 MPa.

Step 5: the molds were opened and a composite structure was extracted.

In the composite structure obtained through the steps, a protruding portion (rib shape) protruded from the plate shape, and the second reinforced fibers derived from the laminate filled as far as the tip of the protruding portion. The precursor of the structure A had the thickness thereof adjusted by the step 4 and gave the same properties

(density, volume content of each element in structure, flexural modulus, and specific flexural rigidity) as the structure A (Table). Table 4 shows the properties of the obtained composite structure.

[0098]

(Example 2)

A composite structure was obtained in the same manner as in Example 1 except that a precursor of the structure C was used as the structure, the temperature was set at 200°C in the step 3, and the laminated structure was formed by lamination in an order of [laminate A/precursor of structure C]. Table 4 shows the properties of the obtained composite structure. The structure in the obtained composite structure gave the same properties (density, volume content of each element in structure, flexural modulus, and specific flexural rigidity) as the structure C.

[0099]

(Example 3)

Used as the molds were molds that had been processed to form a boss as a protrusion shape having φ100 mm, a thickness of 2mm, and a height of 2 mm, in a planar center portion of a plate shape having a length of 200 mm and a width of 300 mm. A composite structure was obtained in the same manner as in Example 1 except that a precursor of the structure B and the laminate D were used as the laminated

structure and the temperature was set at 240℃ in the step 3. Table 4 shows the properties of the obtained composite structure. The structure in the obtained composite structure gave the same properties (density, volume content of each element in structure, flexural modulus, and specific flexural rigidity) as the structure B.

[0100]

(Example 4)

Used as the molds were box-shaped molds that had been processed to form an upright wall shape having a thickness of 1 mm and a height of 40 mm, on the periphery, or four sides of a plate shape having a length of 200 mm and a width of 300 mm. A composite structure was obtained in the same manner as in Example 1 except that a precursor of the structure A and the laminate B were used as the laminated structure. Table 4 shows the properties of the obtained composite structure. The structure in the obtained composite structure gave the same properties (density, volume content of each element in structure, flexural modulus, and specific flexural rigidity) as the structure A.

[0101]

(Example 5)

Used as the molds were molds that had been processed to form, with a semispherical shape having a diameter of 150 mm and a height of 100 mm used as a base, a rib shape

having a width of 100 mm, a thickness of 2 mm, and a height of 5mm, in four directions, with an equal interval, from the top toward ends of the semispherical shape. A composite structure was obtained in the same manner as in Example 1 except that a precursor of the structure E and the laminate B were used as the laminated structure. Table 4 shows the properties of the obtained composite structure. The structure in the obtained composite structure gave the same properties (density, volume content of each element in structure, flexural modulus, and specific flexural rigidity) as the structure E.

[0102]

(Example 6)

Used as the molds were the molds used in Example 4. A composite structure was obtained in the same manner as in Example 1 except that a precursor of the structure G and the laminate E were used as the laminated structure. Table 4 shows the properties of the obtained composite structure. The structure in the obtained composite structure gave the same properties (density, volume content of each element in structure, flexural modulus, and specific flexural rigidity) as the structure G.

[0103]

(Example 7)

Used as the molds were the molds used in Example 1.

A composite structure was obtained in the same manner as in Example 1 except that a precursor of the structure D and the laminate D were used as the laminated structure and the temperature was set at 150℃ in the step 3. Table 5 shows the properties of the obtained composite structure. The structure in the obtained composite structure gave the same properties (density, volume content of each element in structure, flexural modulus, and specific flexural rigidity) as the structure D.

[0104]

(Example 8)

Used as the molds were the molds used in Example 1. A composite structure was obtained in the same manner as in Example 1 except that a precursor of the structure F and the laminate B were used as the laminated structure. Table 5 shows the properties of the obtained composite structure. The structure in the obtained composite structure gave the same properties (density, volume content of each element in structure, flexural modulus, and specific flexural rigidity) as the structure F.

[0105]

(Comparative Example 1)

Used as the molds were the molds used in Example 1. A composite structure was obtained in the same manner as in Example 1 except that a precursor of the structure H and

the laminate C were used as the laminated structure and the composite structure was obtained without the step 3 in Example 1. Table 5 shows the properties of the obtained composite structure. The structure in the obtained composite structure gave the same properties (density, volume content of each element in structure, flexural modulus, and specific flexural rigidity) as the structure H.

[0106]

(Comparative Example 2)

Used as the molds were the molds used in Example 3. A composite structure was obtained in the same manner as in Example 1 except that a precursor of the structure A and the laminate C were used as the laminated structure. Table 5 shows the properties of the obtained composite structure. The structure in the obtained composite structure gave the same properties (density, volume content of each element in structure, flexural modulus, and specific flexural rigidity) as the structure A.

[0107]

(Comparative Example 3)

Used as the molds were the molds used in Example 1. A composite structure was obtained in the same manner as in Example 1 except that a precursor of the structure F and the laminate F were used as the laminated structure. Table 5 shows the properties of the obtained composite structure.

The structure in the obtained composite structure gave the same properties (density, volume content of each element in structure, flexural modulus, and specific flexural rigidity) as the structure F.

[0108]

(Comparative Example 4)

Used as the molds were the molds used in Example 1. A composite structure was obtained in the same manner as in Example 1 except that a precursor of the structure E and the laminate E were used as the laminated structure. Table 5 shows the properties of the obtained composite structure. The structure in the obtained composite structure gave the same properties (density, volume content of each element in structure, flexural modulus, and specific flexural rigidity) as the structure E.

[0109]

[Study]

The present examples clarify that all the produced composite structures resulted in having excellent shape formativeness because used were the composite structures including the structure that contained the first reinforced fibers and the first resin and the laminate that was disposed on at least one surface of the structure and had a plurality of layers containing the second reinforced fibers and the second resin and further because the first

reinforced fibers contained in the structure were discontinuous fibers and had a thickness-wise average fiber orientation angle in a range of 5 to 60° and the second reinforced fibers contained in the laminate were discontinuous fibers and had a thickness-wise average fiber orientation angle in a range of 0 to 5°. Further, Examples 1, 2, 3, and 7 clarify that changing the type of the first resin in the structure does not affect the effects of the structure. Further, it is also clarified that all the produced composite structures result in having excellent shape formativeness. The composite structure obtained in each of the examples was not only excellent in lightness because the structure used had a density in a range of 0.01 to 1 g/cm^3, but was also small in variability of the product properties because the laminate had a variation in volume content of the reinforced fibers in a range of 0 to 10%. Further, it is clarified that the composite structure obtained in each of the examples is capable of including a functional component by having at least one protruding portion as the shape of the composite structure, the composite structure is excellent in mechanical properties, particularly flexural modulus because the second reinforced fibers and the second resin that are derived from the laminate fill the rib, the boss, or the upright wall as the protruding portion, and the composite

CLAIMS

1. A composite structure comprising a structure that contains first reinforced fibers and first resin and a laminate that is disposed on at least one surface of the structure and has a plurality of layers containing second reinforced fibers and second resin, with the structure and the laminate integrated,

the first reinforced fibers being discontinuous fibers and having a thickness-wise average fiber orientation angle in a range of 5 to 60°,

the second reinforced fibers being discontinuous fibers and having a thickness-wise average fiber orientation angle in a range of 0 to 5° in the closest layer to the structure,

the structure having a density in a range of 0.01 to 1 g/cm^3,

the laminate having a variation in volume content of the second reinforced fibers in a range of 0 to 10%, and

the composite structure having a protruding portion on a laminate's surface opposite from a laminate's surface in contact with the structure.

2. The composite structure according to claim 1, having a ratio (As)/(Ap) in a range of more than 1 and 2.5 or less

between a projected area (Ap) of a surface (referred to as a plane of projection) having the protruding portion and an actual survey area of the plane of projection (As).

3. The composite structure according to claim 1 or 2, wherein the protruding portion is a rib and/or a boss.

4. The composite structure according to any of claims 1 to 3, wherein the protruding portion contains the laminate in a proportion of 80 vol% or more and 100 vol% or less.

5. The composite structure according to any of claims 1 to 4, wherein a ratio Ls/Lc is in a range of 1 to 50, with a mass average fiber length of the second reinforced fibers defined as Ls and a mass average fiber length of the first reinforced fibers defined as Lc.

6. The composite structure according to any of claims 1 to 5, wherein each layer in the laminate has substantially all the second reinforced fibers thereof divided by a cut and the second reinforced fibers divided by the cut have a mass average fiber length Ls in a range of 10 to 100 mm.

7. The composite structure according to any of claims 1 to 6, wherein the laminate has an angle in a range of 4° or

more and 90° or less between an orientation direction of the second reinforced fibers in one layer and an orientation direction of the second reinforced fibers in another layer adjacent to the one layer.

8. The composite structure according to claim 6 or 7, wherein each layer in the laminate has an absolute value of an angle θ between the cut and the second reinforced fibers of 2 to 25°.

9. The composite structure according to any of claims 1 to 8, wherein each layer in the laminate has a fiber volume content of the second reinforced fibers Vf in a range of 45 to 65%.

10. The composite structure according to any of claims 1 to 9, wherein each layer in the laminate contains carbon fibers as the second reinforced fibers and thermoset resin as the second resin.

11. The composite structure according to any of claims 1 to 10, wherein the first reinforced fibers in the structure have a mass average fiber length of 1 to 15 mm.

12. The composite structure according to any of claims 1

to 11, wherein

the structure contains voids, and

the structure has a volume content of the first reinforced fibers in a range of 0.5 vol% or more and 55 vol% or less, a volume content of the first resin in a range of 2.5 vol% or more and 85 vol% or less, and a volume content of the voids in a range of 10 vol% or more and 97 vol% or less.

13. The composite structure according to any of claims 1 to 12, wherein the structure has a specific flexural rigidity in a range of 3 or more and 20 or less, the specific flexural rigidity being represented by $Ec^{1/3} \bullet \rho^{-1}$ with a flexural modulus defined as Ec and a density defined as ρ, and the structure has a flexural modulus Ec of 3 GPa or more.

14. The composite structure according to any of claims 1 to 13, wherein the structure contains carbon fibers as the first reinforced fibers and thermoplastic as the first resin.

15. A method for manufacturing the composite structure according to any of claims 1 to 14, the method at least comprising following steps 1, 2, and 3 in this order:

step 1: laminating a laminate precursor on at least one surface of a structure precursor to form a laminated structure, the structure precursor containing thermoplastic as first resin and first reinforced fibers and containing substantially no voids, and the laminate precursor containing thermoset resin as second resin and second reinforced fibers;

step 2: disposing the laminated structure in molds having a flexure shape, an uneven shape, or a rib shape in at least a laminating direction of the laminated structure and curing the thermoset resin to form a composite-structure precursor while forming the laminate precursor into the shape by heating and pressing; and

step 3: adjusting a thickness of the composite-structure precursor while melting or softening the thermoplastic, to expand the structure precursor and thus form a structure.