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3,238,690

COMPOSITE BEAM

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2 Sheets-Sheet 1

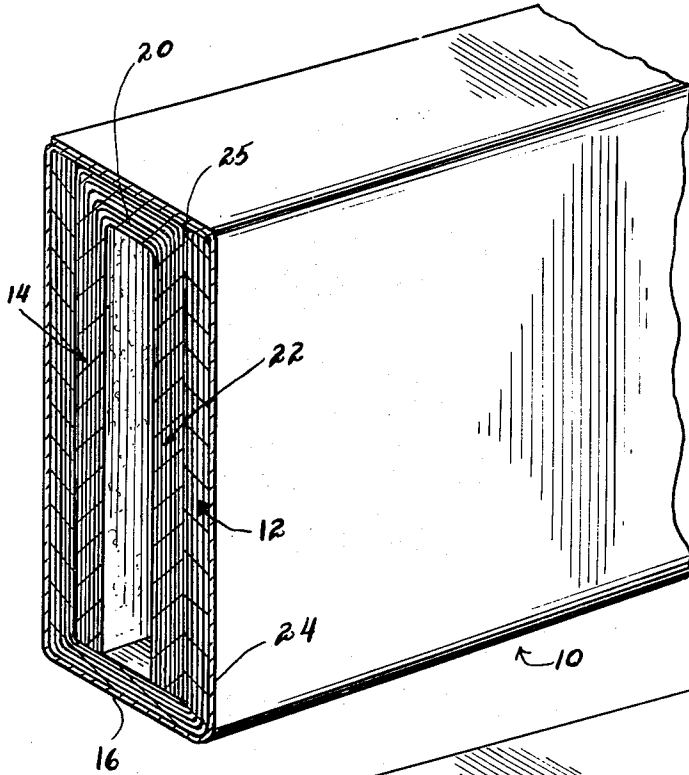


Fig. 1

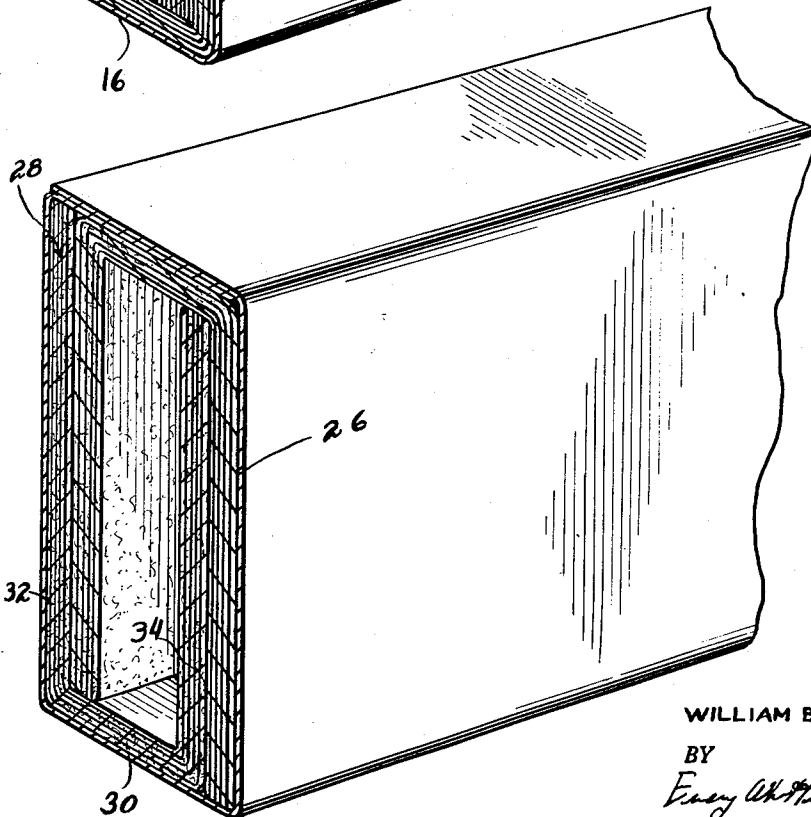


Fig. 2

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Fig. 3

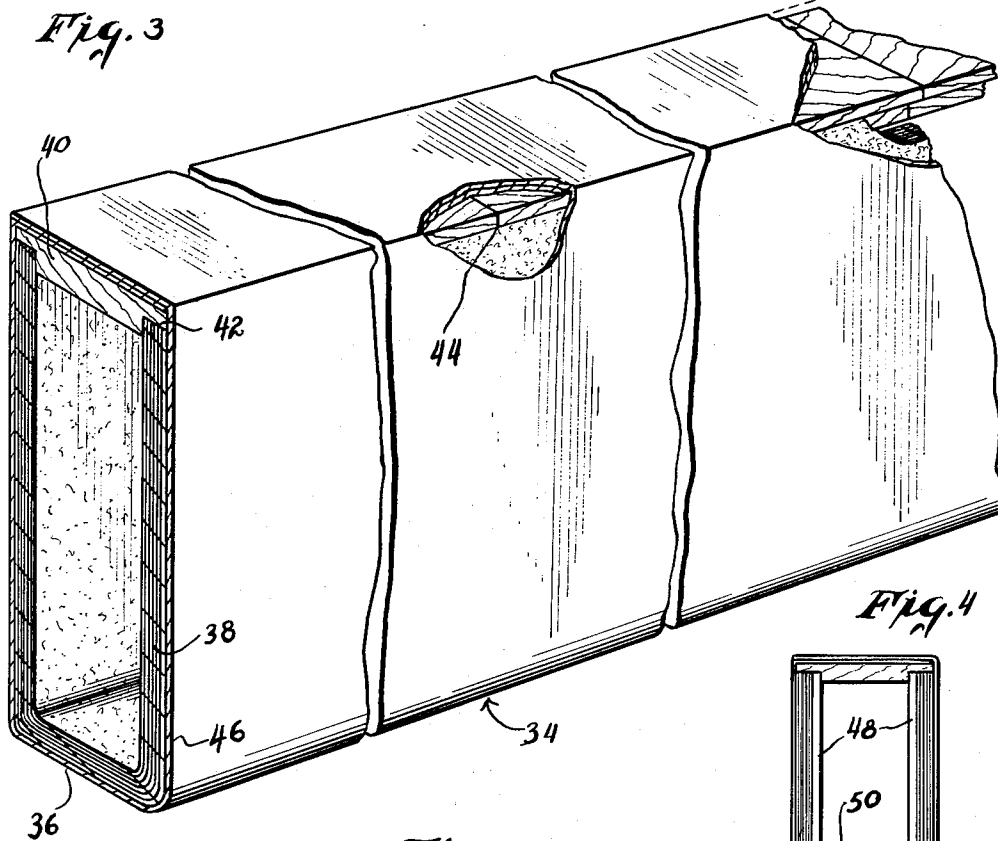


Fig. 4

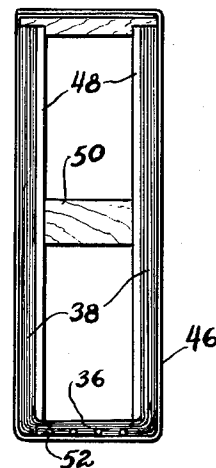


Fig. 5

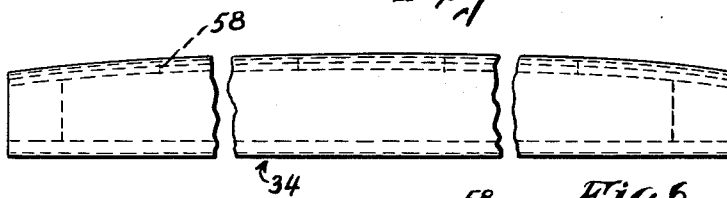
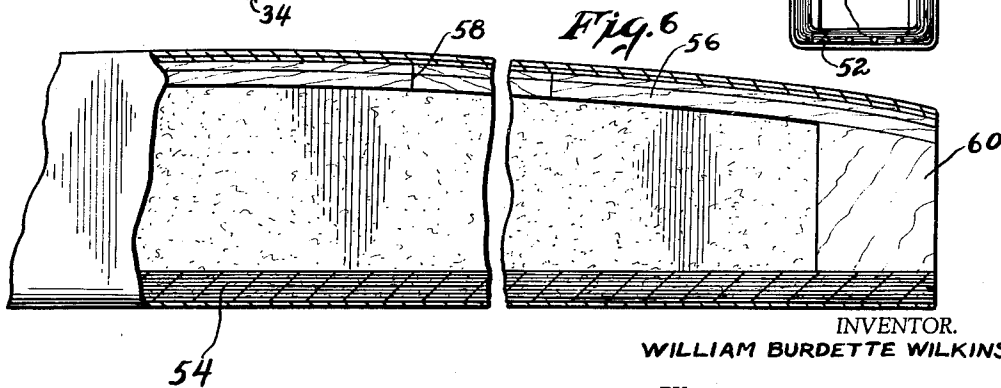


Fig. 6



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COMPOSITE BEAM

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This invention relates to structural beams and, more particularly, to a rigid composite beam fabricated entirely from non-metallic elements.

In many forms of building construction relatively long beams, say twenty feet or more in length, are desirable, and it is desirable that such beams be relatively light in weight. Such beams are customarily supported at their ends, and it is also desirable that they be extremely rigid when subjected to loads applied at intermediate points along the length of the beam. Solid wooden beams do not meet these requirements, and steel or other metal beams, while satisfactory for many purposes, are not suitable for many other purposes where light weight and extreme rigidity are important.

It is, therefore, an object of the invention to provide a composite non-metallic beam adaptable to fabrication in long lengths, and which is relatively light in weight and extremely rigid.

It is a further object of my invention to provide a rigid composite beam adaptable to fabrication with a curved upper surface.

Other objects and advantages will be described hereinafter.

A preferred embodiment is illustrated in the accompanying drawing of which:

FIGURE 1 is a partially sectioned perspective view of a beam in accordance with one embodiment of this invention.

FIGURE 2 is a partially sectioned perspective view of a beam in accordance with another embodiment of this invention.

FIGURE 3 is a partially sectioned perspective view of a beam in accordance with still another embodiment of this invention.

FIGURE 4 is a cross-section of a beam with internal spacers and increased side wall thickness in accordance with this invention.

FIGURE 5 is an elevation view of a beam in accordance with still another embodiment of this invention, and

FIGURE 6 is a sectional view of a portion of the beam shown in FIGURE 5.

According to the present invention, I provide a hollow, rectangular composite beam having a bottom wall and upwardly extending side walls forming a longitudinally extending, substantially U-shaped channel. The bottom and side walls are formed from a plurality of paper laminations bonded together. A top compression wall extends between the ends of the side walls to form a hollow beam. The compression wall may be formed of a plurality of paper laminations integrally formed with downwardly extending legs which are bonded to the side walls or may be formed of a compression member directly bonded to the top edge of the side walls. Fiberglass cloth is wrapped around the beam and bonded to the outside surfaces thereof.

Referring to FIGURE 1, there is shown a rectangular, hollow, composite beam 10 comprising a first and a second substantially U-shaped channel member, 12 and 14, respectively.

The first channel member 12 extends the length of the beam, providing the bottom wall 16 and the outside side walls thereof. The second channel member 14 is inverted and fitted between the side walls of the first channel

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member to provide a top wall 20 of the beam. The side walls 22 of the second channel member are bonded to the side walls of the first channel member to complete the beam.

The first channel member 12 and the second channel member 14 are each formed from a plurality of paper laminations bonded together. In the fabrication of each channel, lengths of paper are passed through an adhesive spreader and placed in layers upon a male die shaped in accordance with the desired shape and dimensions of the U-shaped channel. After the required wall thickness has been built up, the U-shaped channel is formed by insertion of the die and the paper laminations within a suitably shaped, heated female die. The dies are mated until the adhesive between laminations has hardened or cured.

It is usual to employ paper of a uniform width. Therefore, the stacked layers will form a ladderlike edge which is trimmed so that the side wall is of the desired length and is properly squared. The beam channels can thus be fabricated into any desired length.

Various types of papers and paper thicknesses may be employed to form the paper laminations. Both channels may be formed of the same papers. However, since the channels are subjected to different stresses, I prefer to form the channel members from different paper stock.

Preferably the first channel 12 is formed from paper laminations of a kraft paper which has a high wet strength such as a 2% malamine treated paper. Such paper, 25 thousandths of an inch thick, has been found satisfactory.

To bond the paper laminations together, various types of bonding adhesive may be used such as glues, synthetic resins and the like, including phenolic resins, epoxy resins and the like, including phenolic resins, epoxy resins and urea resins, but I prefer to use thermosetting resins and, particularly urea resins. The resin characteristics such as viscosity and the spreader pressure is adjusted to prevent complete impregnation of the paper, allowing resin penetration into the paper of only 8 to 9 thousandths of an inch. After curing the resin, therefore, the channels will comprise a plurality of alternating layers of resin impregnated paper separated by layers of unpenetrated resilient paper. The impregnated paper layers will supply the required rigidity. The resilient paper layers will allow the necessary movement to distribute the beam load, thus preventing localized overstressing with resultant progressive failure. Additionally, the resilient layers provide cushioning between the relatively brittle resin impregnated layers to prevent migrating fracture under shock loading.

The second channel member is fabricated in the same manner as set forth in explanation of the method of fabricating the first channel. However, since this channel member is subjected primarily to compressive stresses, I prefer to use newsprint or other low cost paper stock for economy. The compressive strength is primarily a factor of the thickness of the top wall and the use of papers having high tensile strength is not necessary.

When the channels have been formed and the side walls trimmed to the desired dimensions they are interleaved and bonded together to form the hollow core beam. The side walls of the second channel number 14 need not of course extend the full depth of the first channel member for bonding and location of the top wall alone. However, I have found it advisable in many applications to fabricate the side walls of the second channel member so that it will extend the full depth of the first channel member to augment the buckling resistance of the beam walls. Under destructive test loads, beam failure is usually attributable to side wall buckling.

The thickening of the side walls by the interleaving of the channel 14 greatly increases the beam resistance to buckling. As set forth in the discussion of the top wall, low cost paper may be advantageously used for this purpose since I have found that the buckling resistance is dependent on wall thickness, and the higher quality paper is not necessary.

In order to provide the requisite tensile strength, particularly along the bottom surface of the beam, on which the tensile stress is the highest under load, a reinforcing layer of fiberglass cloth 24 is applied to the outside surface of the beam and bonded thereto. For ease in manufacture, I have found it preferable to wrap the fiberglass cloth completely around the beam with an overlap of fiber glass cloth at the top compression wall. The complete overlap results in a smooth top surface, although a butt joint may be satisfactory for some purposes. The fiberglass cloth is bonded to the beam by a suitable adhesive, preferably a polyester resin. It will be noted that a small gap 25 will exist in the top wall due to the rounding of the corners in building up the paper laminations. However, the gap may be filled with resin to form a flat surface to which the fiberglass cloth is bonded.

It will be recognized that, by fabricating the channels with lengths of paper drawn lengthwise thereon from a roll of paper stock, the grain of the paper will be oriented to extend along the length of the beam giving maximum strength in resistance to tensile stress imposed thereon.

A typical beam may be fabricated with a width of 7 inches, a height of 48 inches, and a length of 30 feet or more. The channel member 12 may be formed of kraft paper built up to a thickness of $\frac{1}{4}$ inch. The channel member 14 is formed of newsprint built up to a thickness of approximately one inch.

In many applications, extremely long beams are required. If the production quantities required are relatively low, the cost of the molds to form two channels may be excessive. In such applications, the embodiment shown in FIGURE 2 may be advantageously employed.

In FIGURE 2 there is shown a hollow, rectangular composite beam comprising channel members 26 and 28. Both channel members are identical, consisting of an integrally formed wall 30 having vertically upstanding legs, 32 and 34. Leg 34 is shorter than leg 32 by an amount equal to the thickness of the channel walls. By so dimensioning the channels, one channel may be inverted, the channels interleaved and bonded together along the abutting surfaces thereof to form the beam.

Each channel member may be formed as set forth in connection with the explanation of the formation of the channels shown in FIGURE 1. By this method of fabrication it will be recognized that only a single mold is required for beam fabrication. Thus the initial cost of beam manufacture is lower even though the beam does not have the same flexibility in matching different load conditions as that afforded by the beam illustrated in FIGURE 1. The mode of assembly used will depend inherently upon the economics of the application requirements.

Alternatively, a beam may be fabricated using a single mold in accordance with the embodiment shown in FIGURE 3.

In FIGURE 3 there is shown a rectangular, hollow, composite beam 34 having a bottom wall 36 extending longitudinally of the beam. Side walls 38 extend upwardly from the bottom wall to form a substantially U-shaped channel extending the length of the beam. A top compression wall 40 extends between and is bonded to the top edges of the side walls. A shoulder 42 is provided in the top wall to increase the bonding area. The channel member may be formed as set forth in connection with the explanation of FIGURE 1.

The top compression wall may be formed of a single suitably shaped wooden section or of a plurality of shaped wooden inserts abutting at the surfaces 44. Since the com-

pression wall is required to resist only compressive stresses, the abutting wooden inserts are completely satisfactory. Since the top compression wall can be formed of a plurality of inserts, it can be constructed of relatively cheap material. If desired, the top compression wall can be constructed of molded sawdust, composition board, or particle board.

In order to provide the requisite tensile strength, particularly along the bottom surface of the beam, which is in tension, when loaded, a reinforcing layer, preferably of fiberglass cloth 46 is applied to the outside surface of the beam and bonded thereto. For ease in manufacture and to prevent absorption of moisture, I have found it preferable to wrap the fiberglass cloth around the beam and to give a complete overlap of the fiberglass cloth at the top compression wall. The complete overlap results in a smooth top surface. However, a butt joint is satisfactory for some purposes, and for some purposes the top wall may be left uncovered. The fiberglass cloth is bonded to the composite beam by a suitable adhesive, preferably a polyester resin.

While the desired increase in rigidity may be achieved by a fiberglass skin bonded to the bottom wall only, I have found it desirable to bond the fiberglass cloth to the entire surface of the beam. By such procedure, the top compression wall is protected from weather-cracking and deterioration at a slight increase in total cost. Such protection ensures longer beam life under conditions where it is exposed to weather.

In a typical beam of this type, the width of which is 7 inches, the height 48 inches, and the length 30 feet, it has been found that beam failure under destructive test loads usually occurs through buckling of the side walls. In order to increase resistance to side wall buckling, the side wall thickness may be increased as shown in FIGURE 4.

In FIGURE 4 there is shown a composite beam in which the side wall thickness is increased by a layer of paper laminations 48 bonded together and to each side wall of the beam. Various types of paper of various thicknesses may be used to form the layer 48, but I prefer to use newsprint or similar inexpensive stock since I have found that buckling resistance is dependent primarily upon wall thickness and higher quality paper is not necessary. It has been found convenient to add the layer 48 to the inside of the formed side walls since the manufacturing control over steps of such application, such as adhesive penetration, is far less critical than in forming the side walls.

Side wall buckling resistance may be increased by the insertion of spacer blocks 50 extending between and bonded to the side walls. The spacer blocks may be formed of wood or particle board and may be easily inserted into the U-shaped channel before attaching the top compression wall. The blocks may be used in addition to or as an alternative for increasing the side wall thickness.

In order to increase the tensile strength, a layer of reinforcing roving 52 is extended along the bottom of the beam and bonded thereto before the reinforcing layer 46 is applied. The roving may be any fiber selected for the application intended, such as glass for rigid beams.

In many applications it is desired that the beam support a light weight roof which is laid directly upon the beam. Since most light weight roofs must have a slight curvature for added strength and water shedding, the top compression wall of the beam should also be curved during manufacture as shown in FIGURES 5 and 6.

Referring to FIGURES 5 and 6 there is shown the composite beam 34 having a substantially U-shaped longitudinally extending channel 54, the top edge of which is formed in a longitudinally extending curve. The curve is easily formed into the curve desired for the particular application by merely trimming the top edges of the side walls along a pattern.

To follow the curvature of the top with a minimum of trimming, the top compression wall is formed from

a plurality of compression members 56. Since these compression members must resist compression forces in the beam, they are beveled to abut at a plane surface 58, extending along radius of curvature. The length of the compression sections may be varied to accommodate the various radii of curvature with easily formed compression sections.

In order to augment the load capabilities of a light beam, a block of wood 60 may be inserted within the hollow core of the beam at bearing positions. In this manner the resistance to compressive failure is greatly increased without unnecessarily increasing the overall size of the beam.

This invention may be variously embodied and modified within the scope of the subjoined claims.

What is claimed is:

1. A composite beam comprising a bottom wall, side walls, and a top compression wall, said bottom and side walls being formed from a plurality of paper laminations bonded together, each of said paper laminations having a resilient unimpregnated layer between the bonded surfaces.

2. A composite beam in accordance with claim 1 in which said bottom wall comprises a fiberglass cloth bonded to the outer surface thereof.

3. A composite beam in accordance with claim 1 in which said bottom wall comprises a plurality of longitudinally extending glass fibers bonded to the outer surface thereof and a fiberglass cloth enclosing said glass fibers and being bonded to the outer surface of said bottom wall.

4. A composite beam in accordance with claim 1 in which said bottom wall comprises a plurality of longitudinally extending fibers bonded thereto.

5. A composite beam in accordance with claim 1 in which said bottom wall and said side walls comprise a plurality of paper laminations of substantially U-shaped cross-section bonded together.

6. A composite beam in accordance with claim 1 in which said top wall is integrally formed with downwardly extending legs from a plurality of paper laminations bonded together, and in which said legs are bonded to said side walls.

7. A composite beam comprising a bottom wall, side walls, said bottom and side walls being formed of a plurality of paper laminations bonded together, each of said paper laminations having a resilient unimpregnated layer between the bonded surfaces, a top compression member bonded to said walls to form a rectangular, hollow-core beam, and a fiberglass cloth extending the length of said beam and bonded to the periphery thereof.

8. A composite beam comprising a bottom wall, side wall and a top compression wall, said bottom and side wall integrally formed from a plurality of paper laminations bonded together, each of said paper laminations having a resilient unimpregnated layer between the bonded surfaces, said compression wall being arranged

in a longitudinally extending arc and being bonded to said side walls.

9. A composite beam comprising a bottom wall, side walls, a top compression wall, said bottom and side walls formed from a plurality of paper laminations bonded together, each of said paper laminations having a resilient unimpregnated layer between the bonded surfaces, and means to increase the wall strength of said beam.

10. A composite beam in accordance with claim 9 in which said means comprise a plurality of spacers spaced along said beam, each of said spacers extending between opposite side walls in supporting relationship therewith.

11. A composite beam in accordance with claim 9 in which said means comprise a compression block inserted in the space defined by the walls of said beam, each of said blocks being positioned to prevent compressive failure at a support.

12. A composite beam in accordance with claim 9 in which said means comprise a plurality of paper laminates bonded together and to the side wall.

13. A composite beam comprising a first and second channel member, each of said channel members comprising a substantially U-shaped member having side walls integrally formed with and separated by an end wall, said channel members being formed of a plurality of paper laminations bonded together, each of said paper laminations having a resilient unimpregnated layer between the bonded surfaces, said channel members being interleaved and bonded together to form a rectangular beam.

14. A composite beam comprising a channel member, said channel member being formed of a plurality of paper laminations bonded together by a thermo-setting resin applied to the surfaces thereof, said resin impregnated only a short distance into each lamination to provide a resilient unimpregnated paper layer between each bonded surface.

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