June 6, 1967 J. F. HORTON, JR 3,323,797

STRUCTURAL MEMBER WITH LAMINATIONS HAVING DIFFERING MODULI OF ELASTICITY AND GAME TABLE MADE THEREFROM

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Fig. 1.

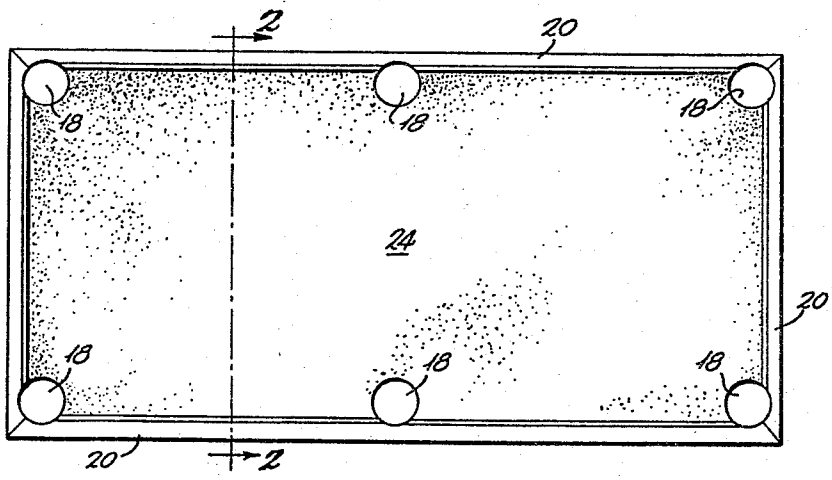


Fig. 2.

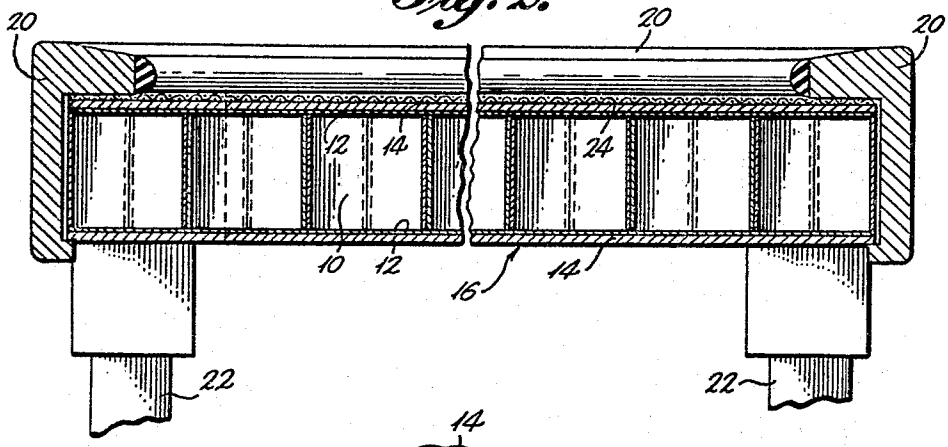
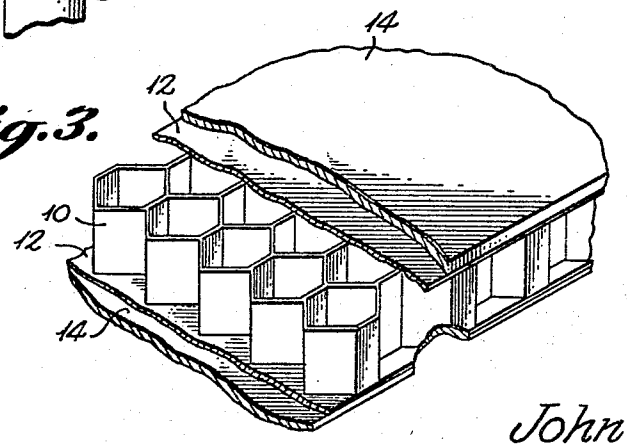


Fig. 3.



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STRUCTURAL MEMBER WITH LAMINATIONS HAVING DIFFERING MODULI OF ELASTICITY AND GAME TABLE MADE THEREFROM

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ABSTRACT OF THE DISCLOSURE

A rigid structural member having a core, a sheet of relatively high modulus of elesaticity bonded to each side of the core and a sheet of relatively low modulus of elasticity bonded to at least one of the relatively high modulus sheets, and pool table structures employing such core as the pool table bed.

This application is a continuation-in-part application with respect to copending application Ser. No. 500,640, filed Oct. 22, 1965, now abandoned.

This invention relates to structural members and to manufactures made therefrom and, more particularly, to structural members having significantly improved stability and rigidity and to manufactures made therefrom.

Since one of the particularly significant fields of application of the structural members of the present invention is in the fabrication of pool tables and the like, the ensuing comments will be directed to their applicability to pool table construction, though it will be made clear hereinafter that the advantages of the structures of the present invention are not restricted to pool table manufacture.

The requirements of pool table manufacture today are quite rigid, at least insofar as higher quality pool tables are concerned. High quality pool table beds in the first place must be sufficiently structurally sound to provide an exacting playing surface which is not only substantially exactly level (viz, it should have a surface flatness of no more than .015" total indicator reading over eight feet of length) but which will maintain such level quality despite continuing variations in temperature and humidity. In addition, the body of such pool table beds must be such as to provide a playing surface which has the proper tonal qualities, resilience and impact resistance which are required in structures of this sort.

In high quality pool tables fabricated today, the material finding the most widesperad use as the essential structural element in the pool table bed is slate. Conventionally, because of procurement and handling problems, slate slabs are available only in limited sizes. As a result, a given pool table bed is fabricated from approximately three pieces of slate which are normally mounted for support on a panel of plywood or particle board and then ground to provide an adequately level playing surface. Since this composite structure is non-structural in nature, additional support must be provided completely about the table to maintain the bed within the permissible degree of variation from the level. To facilitate this maintenance of a level playing surface, such pool table structures are ordinarily provided with levelers which support the slate bed at one or more points. In addition to the foregoing, in high quality pool table structures such as those described above using a slate bed, the table is constructed to provide support for the bed but, at the same time, to permit such bed to be "free floating" in the sense that the bed is not fixed against movement either longitudinally or laterally but only supported from top and bottom by means of the pool table frame structure.

In order to avoid many of the disadvantages involved in the fabrication of slate bed pool tables, not the least of which is the cost involved in the fabrication of such tables, pool table manufacturers have marketed a variety of attempted substitutes for such slate bed tables. Almost invariably, such substitutes utilize a one-piece bed (as distinguished from the three-piece slate bed) which may or may not be formed of conventional sandwich material comprised of a low-density core having two high-density sheets or skins intimately bonded to its exposed upper and lower surfaces. While such substitute structures have almost invariably resulted in a significant cost saving to the manufacturer, the disadvantages attendant the use of such structures have been many. First and foremost among the disadvantages is the extreme difficulty in providing a table whose bed has the resilience, impact resistance and tonal quality comparable to those provided by a slate bed. Other additional problems have resulted from the difficulty of maintaining level the playing surface of such substitute structures as a result of the difficulty of providing materials which have not only all the desirable qualities of the slate beds previously mentioned but which have sufficient strength-to-weight ratios to provide adequate resitsance to sagging under its own weight as well as resistance to warp and the like resulting from variations in the temperature and humidity conditions to which a pool table is subjected in normal use.

In accordance with the present invention, structrual members are provided which combine the advantages of slate and non-slate beds yet which either minimize or eliminate completely the various disadvantages of such beds previously described.

It is accordingly a primary object of the present invention to provide novel structural members and articles made therefrom which members have particular utility in the fabrication of pool tables.

It is another important object of the present invention to provide novel structural members and articles made therefrom, such structural members having excellent structural qualities in that their strength-to-weight ratios are such that they will not deflect more than a negligible amount under their own weight over a span relatively large in relation to their thickness and which are extremely dimensionally stable in response to variations in humidity and temperature.

It is another important object of the present invention to provide structural members having particular utility in the fabrication of pool tables and making possible the fabrication of low-cost pool table beds having excellent texture, impact resistance, low density, excellent appearance, resilience, tonal quality, strength-to-weight ratio and which may be made and maintained level without cumbersome supporting structures.

It is a further important object of the present invention to provide a structural member which, because of its structural rigidity, can be used as the basic frame or chassis of a pool table so that legs and side rails can be secured directly to it.

These and other additional objects and advantages of the present invention will become more apparent in connection with the ensuing description and claims, and drawings wherein:

FIGURE 1 is a top plan view of a pool table having a bed formed of the novel structural member of the present invention;

FIGURE 2 is an enlarged transverse section taken along lines 2—2 in FIGURE 1; and

FIGURE 3 is a fragmentary perspective view of the novel structural member of the present invention with parts broken away for clarity of illustration.

[NOTE: None of the foregoing figures is drawn to scale.]

FIGURE 3 illustrates a preferred embodiment of the structural member of the present invention. In this embodiment, the structural member is comprised of five elements: (a) a main vertical shear carrying component or core **10**, (b) a sheet or skin **12** having a relatively high modulus of elasticity bonded rigidly to each of the two faces of core **10**, and (c) a sheet or skin **14** having a relatively low modulus of elasticity bonded to each of the outer faces of said high modulus sheets **12**.

While the novel structural members of the present invention may, in their general appearance, resemble conventional sandwich structures which have been commercially available for many years for a variety of applications, the particular types of materials used in the fabrication of the present members and their relationships to one another have not heretofore been known or used and form an essential aspect of the present invention. One of the most significant considerations in the structures of the present invention involves the relative nature of the sheets **12** and **14** previously referred to and their association with the core **10**. More specifically, it is absolutely essential that the sheets **12**, which have a relatively high modulus of elasticity compared to outer sheets **14**, be in direct and intimately bonded contact with core **10**. Were the low modulus sheets **14** to be placed directly in contact with core **10** rather than the high modulus sheets **12**, the elasticity of the low modulus sheets would essentially destroy the structural properties of the panel.

There are still other reasons for placing the high modulus sheets **12** directly in contact with core **10**. For example, in order to obtain a structural member with the desired surface texture, degree of flatness and other necessary properties required in the end use of the product, it is ordinarily necessary to grind or otherwise finish at least one of the outer surfaces of the structural member to the desired degree. In pool table applications, this is done by microfinishing one of the outer sheets or skins to the desired degree of flatness and finish. This often results in an unbalanced structure in which the thickness of one sheet of outer material on one side of the structure is different from that on the other side of the structure. In such an unbalanced structure, temperature variations often create difficulties insofar as the stability of the structure is concerned, the greatest difficulty coming in the case of high modulus materials. By holding the modulus of elasticity of the outer sheets down, reasonable variations in thickness of the outer sheets become much more tolerable without resulting in the unbalancing of the entire structure. In addition, if the outer faces of the structure were dominant structurally, the warping stability of the structure would be seriously affected if the material of the outer faces was unstable under conditions of moisture.

For best results, the high modulus material **12** should have a modulus of elasticity of at least about 10 million p.s.i. and the relatively low modulus material **14** should have a modulus of elasticity of less than about 3 million p.s.i. The thickness of the relatively low modulus sheets **14** should also preferably be at least about five times greater than that of the high modulus sheets **12**, primarily to provide a structural material with greater impact strength, a quality particularly desirable when the structure is used to fabricate pool table beds. For maximum advantage, the low modulus sheets **13** should also be of lower density than high modulus sheets **12**.

Particularly important is the nature of the bond or tie between high modulus sheets **12** and the low density core **10**. More specifically, the horizontal shear strength between each of the high modulus sheets **12** and core **10** must be greater than the horizontal shear strength between low modulus sheets **14** and high modulus sheets **12** (and, necessarily, between low modulus sheets **14** and core **10**) to provide maximum structural strength to the material. For best results, the bond between the high modulus sheets **12** and core **10** must be extremely rigid to provide for a minimum amount of possible creep between the two, such horizontal shear strength preferably being at least about 3000 p.s.i. Such results are obtainable using, for example, adhesives such as modified epoxies, vinyl resins, phenolic resins, resorcinol adhesives and rigid silicones. A preferred adhesive is that sold under the name "Isochem 1217."

When the modulus of elasticity of the low modulus sheets **14** is sufficiently small compared to that of the high modulus sheets **12**, the former will stretch under variations of temperature and humidity without significant stress transferral to the latter or to core **10**. In such case (such, for example, as where sheets **14** are of hardboard and sheets **12** of steel), the bond between sheets **14** and sheets **12** may be rigid, in which situation the adhesives described above may be employed. When the modulus of elasticity of sheets **14** is sufficiently high in relation to that of sheets **12**, however (such, for example, as would occur if sheets **14** were of a synthetic slate material and sheets **12** of steel), the bond between low modulus sheets **14** and high modulus sheets **12** is desirably made flexible so as to result in a minimum of stress transferral from the low modulus sheets **14** to the high modulus sheets **12** as a result of changing humidity conditions. This may be accomplished by using an adhesive which will flexibly bond sheets **12** and **14** to one another. An example of such an adhesive is a low modulus, high strength adhesive "Fuller 642." Generally speaking, the horizontal shear strength of the bond between sheets **12** and **14** should be less than about 100 p.s.i. if a flexible bond is desired. Where the bond is to be rigid, the horizontal shear strength of the bond between sheets **14** and **12** will be at least about 3000 p.s.i., the same as that between sheets **12** and core **10**.

A particularly desirable material for fabricating high density sheets **12** is steel. A sheet of steel having a thickness of at least about .010" and a modulus of elasticity of about 30 million p.s.i. is exceptionally useful for pool table applications. A particularly desirable material for low modulus sheets **14** is one made of hardboard, oil treated, untempered hardboard being preferred. Sheets of hardboard having a thickness of about ⅛" and a modulus of elasticity of about ½ to 1 million p.s.i. are particularly desirable for pool table applications and provide a surface which has excellent properties of sandability, impact resistance, resilience and tonal quality. In addition, such surface facilitates attachment of other elements of the structure into which the member will be incorporated. Also advantageous for such applications are synthetic slates having moduli of elasticity up to about 3 million p.s.i.

In order to minimize the extent to which a structure according to the present invention will deflect under the stress of its own weight, it has been found necessary to maintain the ratio of the thickness of the core **10** to the thickness of the high modulus sheets **12** about a certain minimum. In any simply loaded panel, the material located nearest the top surface is subjected to the highest compressive stress and the material located nearest the bottom surface is subjected to the highest tensile stress. The material in between these surfaces is proportionately less stressed the closer it is located to the neutral plane, where its stress is zero. Consequently, if the sheets of high modulus material **12** are made any thicker than necessary to keep their plastic deformation and hence the deflection of the panel within the required limits, the excess material will add to the weight of the panel and to its tendency to deflect without carrying its proportionate share of the stress because of its proximity to the neutral plane. It will also increase the cost of the panel significantly. On the other hand, increasing the thickness of core **10** increases the mechanical advantage of the high modulus material with reference to the neutral plane and reduces the thickness of high modulus material required to remain within given deflection limits. In practice, it has been found that the ratio of the thickness of core **10** to the

thickness of the high modulus sheets **12** should be at least about 25:1 if the deflection of the panel under its own weight and the cost of the panel are to be kept to a minimum. Such a minimum ratio is reflected, for example, in the construction illustrated in FIGURE 2 of the drawing. While there is no critical upper limit on this thickness ratio, a preferred range is about 25:1 to about 300:1.

Also important to the obtaining of the advantages desired from the structures of the present invention is the strength-to-weight ratio of the structure material. More specifically, in order to provide a structural member which will require a minimum of support to level and which will, in use, maintain its level characteristics not only despite the stress of its own weight but the impostion of localized loads across the unsupported portion of the span, it is necessary that the weight of the structure relative to its thickness be maintained below certain limits. The structure of the present invention permits this characteristic to be obtained due to the particular arrangement of high and low modulus skins relative to the core and through use of an extremely low density core without sacrificing any of the necessary strength characteristics. For purposes of the present invention, best results are obtained using a core having a density of about 0.5 to 10 lbs. per cubic foot. Toward this end, excellent results are obtained utilizing a conventional honeycomb core fabricated of kraft paper or the like, such, for example, as is sold by the Weyerhaeuser Company under the trademark "Weycomb" or by the Douglas Aircraft Company under the trademark "Aircomb," honeycomb of about 2" thickness being particularly suited for pool table applications. Other types of core which are effective but which are non-honeycomb in nature include that sold by the Verticel Company under the trademark "Verticel" and that sold by Down River Packaging Corp. under the trademark "Dorkor." By the selection of the core and the high and low modulus sheets with the proper physical, mechanical and dimensional characteristics following the guidelines previously described, a structure can be obtained which will allow for a composite (when properly machined) which has a surface flatness within about .010" total indicator reading over eight feet of length, and which composite is sufficiently structurally rigid so that it will undergo less than about .005" of localized deflection when a localized load of about 25 lbs. is applied anywhere on the member over an area of about 9 square inches and within a span of about 4 feet. In addition, the relative mass of such low and high modulus sheets and said core is such that said member will not deflect more than about .003" under its own weight over a span the dimension of which relative to the thickness of such member is at least about 20/1.

In connection with the core of the structural member described above, it has previously been thought that in order to use sandwich structures for applications such as pool tables or the like, one had to use a paper core the material of which was impregnated with a suitable resinous substance to eliminate moisture problems since it was felt that the paper core portion of the sandwich structure was the most hygroscopic portion of the structure. In actuality, it is the expansion and contraction of the face materials which primarily determine warping; variations of the honeycomb portion of the structure (in a vertical direction) have a negligible effect on warping. Accordingly, it is not necessary to impregnate the core of the structural members of the present invention in order to achieve the advantages previously mentioned. Even without such impregnation, the structural members previously described will have significantly increased stability and rigidity as compared with conventional materials used for the purpose. Quite obviously, however, impregnated cores can be used if desired.

Similarly, while best results are obtained by using a honeycomb core as previously described due to its excellent structural characteristics and low density, other core materials may be utilized within the spirit of the present invention providing the conditions previously enumerated are maintained. An example of an alternative core material usable as the core is disclosed in Rapp Patent 2,963,128, issued Dec. 6, 1960.

The structural members of the present invention are quite remakable in their stability and rigidity in the presence of widely varying ambient conditions, including significantly fluctuating temperatures and humidity. Indeed, the ability of such structural members to resist significant deflection as a result of its own weight over a substantial span constitutes an important improvement over prior art structural members.

Because of these significant structural characteristics, the structural members of the present invention are peculiarly well adapted to use in the construction of pool tables. As has previously been indicated, in conventional pool tables the frame of the pool table is a primary supporting surface. In order to properly level (and maintain level) the pool table bed, it is necessary to install the bed in the pool table frame so that the bed floats free in the frame (that is to say, the pool table bed is not fixed against movement longitudinally or laterally but is only supported from its top and bottom surfaces). Such a construction is necessary to avoid compound curves in the pool table bed when levellers are adjusted. In the structure of the present invention, such precautions are not necessary to maintain a level surface. On the contrary, the use of the present structural members to form pool table beds requires neither the use of levellers nor the use of a frame to support the bed. Indeed, the great structural rigidity achieved as a result of the extraordinary strength-to-weight ratio of the structural members of the present invention makes possible the fabrication of pool tables merely by bolting legs and securing the side and end cushions directly to the bed with the bed itself being the main structural member, providing, of course, that the thickness of the structural member relative to its mass is maintained within reasonable limits. Even for extremely thin structures, however, the structural members of the present invention will be more stable and rigid than conventional structural members. Quite obviously, such a construction significantly lowers the cost of fabrication of pool tables without at all detracting from the high qualtiy of the resulting table.

Such a construction is illustrated in FIGURES 1 and 2. The structural member previously described in connection with FIGURE 3 is identified in FIGURES 1 and 2 by the numeral **16**, such member serving as the bed of the pool table. As particularly shown in FIGURE 1, the structural member has a plurality of peripheral cut-out portions **18** to provide pockets for the pool balls with ball return chutes (not shown) serving to return balls entering such pockets to a ball rack (not shown) located at one end of the table. Cushions **20** are secured to the edges of structural member **16** with the entire assembly being supported by legs **22** which are attached directly to the underside of the structural member by means of the lower outer sheet or skin **14**. As also shown in FIGURES 1 and 2, the upper side of the structural member **16** is covered with a piece of felt **24** to provide the playing surface of the pool table.

A typical pool table such as is illustrated in FIGURES 1 and 2 has a playing surface of approximately 44" x 88" (from cushion to cushion), outer sheets **14** constructed of oil treated, untempered hardboard approximately ⅛" thickness and having a modulus of elasticity of ½ million p.s.i., inner high modulus sheets **12** constructed of steel having a modulus of elasticity of approximately 30 million p.s.i. and a thickness of 0.010", and a core **10** constructed of kraft paper having a density of about 3 lbs. per cubic foot and about 2" in thickness.

In the previous discussion, the structural member of the present invention has been shown particularly as being adapted for use in connection with the construction of pool tables. Quite obviously, the significant structural advantages provided by such structural member adapts it for

use in environments other than pool tables. For example, such structural member may be used to form extremely high strength, non-warp partition or door members, wall panels, raised floor panels, inexpensive industrial surface plates, long span roof panels, long span floor or deck panels, and may also be used in any other environment in which such structural characteristics are advantageous. Needless to say, when the high modulus sheets are comprised of metal or the like, they will, in addition to providing the structural advantages previously noted, contribute to the thermal insulating qualities of the member as a result of the reflective surfaces provided by the metal, particularly if such metal is highly polished.

As previously described, it is preferred that the structural member of the present invention contain low modulus material on both of its outer surfaces, not only to provide dimensional stability to the structure but to provide outer surfaces which may be worked and which may also provide a fastening surface by means of which the member can be connected to other elements. It is within the contemplation of the present invention, however, to provide such a structural member with only one low modulus skin on its outer surface if the particular application for which the member is used does not require two low modulus skins or sheets.

[NOTE: When reference is made in this specification and claims to "shear strength" it is to be construed as defining "specific" shear strength rather than "overall" shear strength. This is significant since the bond between the high and low modulus sheets, which are in contact over their entire area, might have a higher overall shear strength, even with a flexible adhesive, than the bond between the high modulus sheets and the core would have since the area of the core would consist mostly of open cells which are not in contact with the high modulus sheets.]

This invention may be embodied in other specific forms without departing from the spirit or essential characteritsics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed is:

1. A rigid structural member comprising a core; a sheet having a relatively high modulus of elasticity bonded to each side of said core; and a sheet having a relatively low modulus of elasticity bonded to at least one of said high modulus sheets; the horizontal shear strength at the interface between said high modulus sheets and said core being at least about 3000 p.s.i.; the ratio of the thickness of said core to the thickness of each of said high modulus sheets being at least about 25 to 1.

2. A structural member as defined in claim **1** wherein said structural member undergoes less than about .005 inch of localized deflection when a localized load of about 25 pounds is applied anywhere on the member over an area of about 9 in.^{2} and within a span of about 4 feet; said member not deflecting more than about .003 inch under its own weight over a span the dimension of which relative to the thickness of said member is at least about 20 to 1.

3. A structural member as defined in claim **1** wherein said structural member undergoes less than about .005 inch of localized deflection when a localized load of about 25 pounds is applied anywhere on the member over an area of about 9 in.^{2} and within a span of about 4 feet.

4. A structural member as defined in claim **1** wherein said structural member will not deflect more than about .003 inch under its own weight over a span the dimension of which relative to the thickness of said member is at least about 20 to 1.

5. A structural member as defined in claim **1** wherein a sheet having a relatively low modulus of elasticity is bonded to each of said high modulus sheets.

6. A structural member as defined in claim **1** adapted for use in forming the bed of a pool table wherein the periphery of said member is cut away at a plurality of points to provide openings to permit ingress and egress of a pool ball.

7. A structural member as defined in claim **1** wherein the ratio of the thickness of said core to the thickness of each of said high modulus sheets is about 25–1 to about 300–1.

8. A pool table having a playing surface, rails positioned about the periphery of said playing surface and pockets for receiving pool balls and positioned at said rails, said pool table having a bed formed from the structural member defined in claim **1**.

9. A rigid structural member comprising a core; a sheet having a relatively high modulus of elasticity bonded to each side of said core; and a sheet having a relatively low modulus of elasticity bonded to at least one of said high modulus sheets; the horizontal shear strength at the interface between said high modulus sheets and said core being at least about 3000 p.s.i. and being greater than the horizontal shear strength at the interface between said high modulus sheets and said low modulus sheets and between said low modulus sheets and said core.

10. A structural member as defined in claim **9** wherein the ratio of the thickness of said core to the thickness of each of said high modulus sheets is at least about 25 to 1.

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