Effect of Outer Fiber Stress on Brace Design

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Many bracemakers have probably wondered when a badly bent brace is returned to them for repairs how it is possible for a person who weighs only about a hundred pounds to bend a steel bar which, according to steel company reports, should not deform unless a pressure of 80,000 pounds per square inch were used. That would mean that a bar 1/8 inch by 1/8 inch, or 1/64 square inch cross section, would not stretch until a load of 1,250 pounds were placed on it; yet every bracemaker knows that a bar of orthopedic steel, 3/16 inch by 5/8 inch about two feet long, will take a permanent set if it is fastened by one end in the flat position in a vise and a twenty-pound weight is attached to the other end. How can there be such a difference between fact and figures? The answer is, of course, that forces not apparent to the observer are involved. A very simple but fundamental principal of engineering explains the discrepancy: it is stress on the outer fiber or stress variation in a beam.

In a bar of steel subjected to a pure tensile load, all the material offers the same amount of resistance to the applied load (Fig. 1). This is the method applied by the steel company to get the 80,000 pounds per square inch mentioned in the first paragraph.

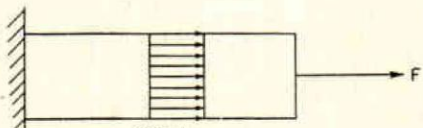

FIG 1

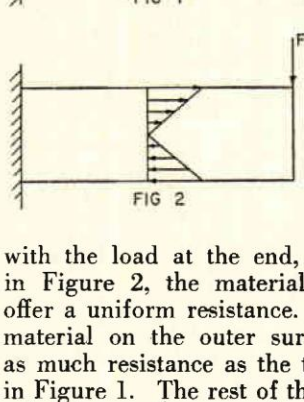

FIG 2

If the same bar is used as a beam with the load at the end, as shown in Figure 2, the material does not offer a uniform resistance. Only the material on the outer surface gives as much resistance as the tensile bar in Figure 1. The rest of the material offers less resistance and some of the material offers no resistance at all. Naturally, since some of the material is not carrying its proper share of the load, the steel used as a beam cannot carry as much load as when used as a tensile bar.

One other factor lowers the amount of load that a beam can carry, and that is the effective increase in load due to leverage. The load on a tensile bar is not increased owing to any leverage, since no leverage is involved, but the load on a beam is effectively increased because of leverage.

A ring stretcher helps to explain both of these factors (Fig. 3). If

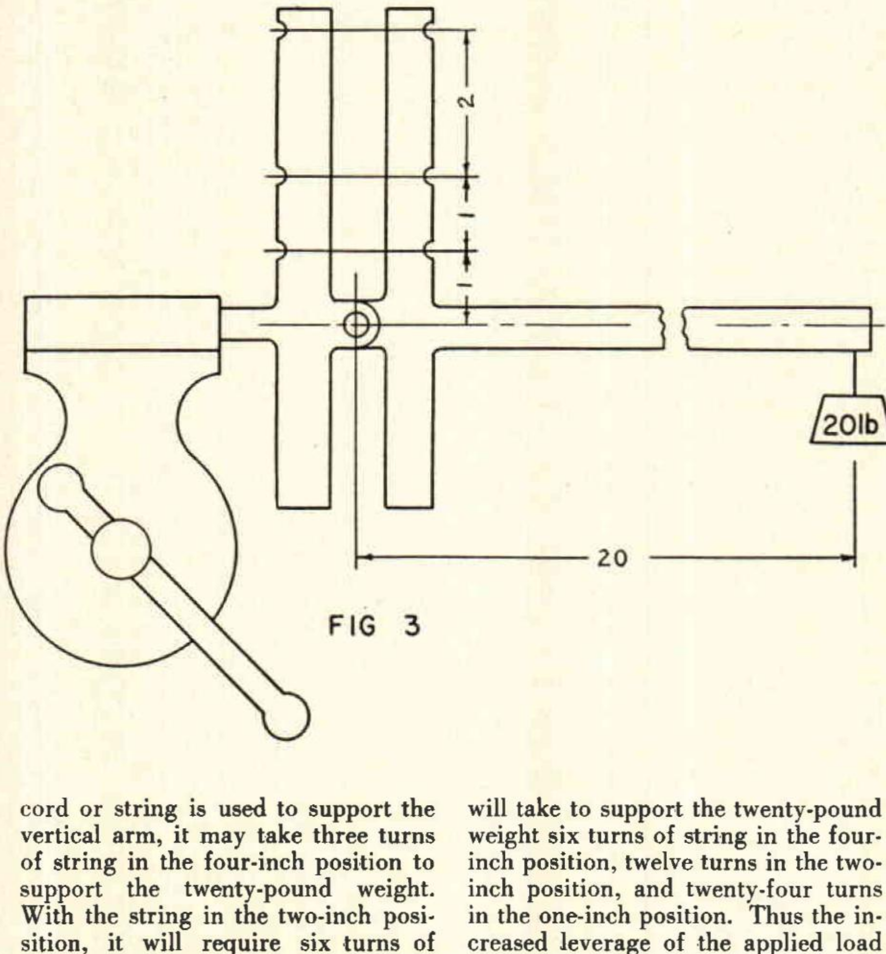

FIG 3

cord or string is used to support the vertical arm, it may take three turns of string in the four-inch position to support the twenty-pound weight. With the string in the two-inch position, it will require six turns of string; and in the one-inch position, twelve turns of string. This fact demonstrates that the material on the outer surface can offer more resistance to the load than the same material can when located close to the hinge.

If the twenty-pound weight remains on the ring stretcher, but the arm is lengthened to forty inches, it will take to support the twenty-pound weight six turns of string in the four-inch position, twelve turns in the two-inch position, and twenty-four turns in the one-inch position. Thus the increased leverage of the applied load acts the same as an increased load.

A beam acts the same as the ring stretcher in that it behaves as though it had a hinge in the center, and the material furthest away from the hinge can provide the greatest resistance to the load. That is why tubing makes a strong, light brace. By increasing the length of the arm on the ring

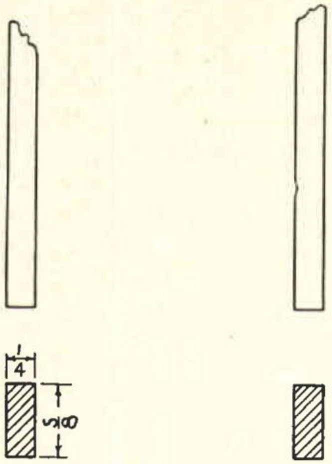

FIG 4

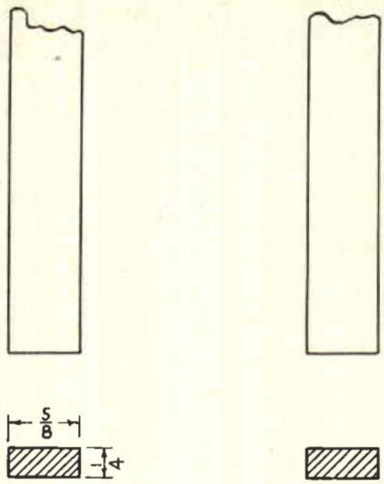

FIG 5

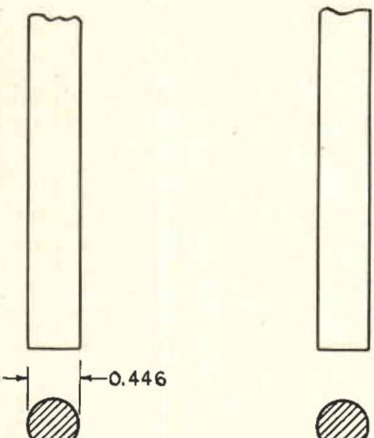

FIG 6

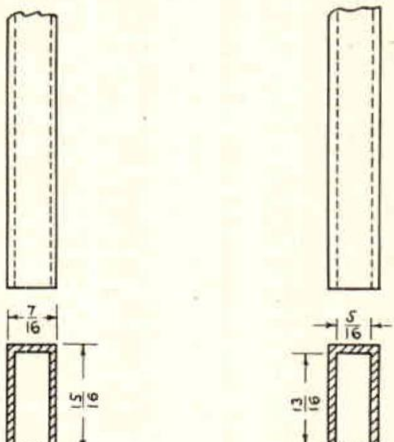

FIG 7

stretcher it was shown that more turns of string were required to support the twenty-pound weight. Obviously the amount of load that a beam can support depends upon how much leverage is involved. It is apparent that a short beam can hold a greater load than a long beam.

By understanding how a beam offers resistance to loads, a bracemaker can often make corrections to various braces that are returned for repairs. He can also alter the design of braces to suit extra heavy patients or very light patients. A slight change in the cross-sectional shape of a beam often times means the difference between quick failure of a brace or long, safe service. It can mean the difference between a heavy, awkward brace and a light, easily handled brace.

The importance of the shape of a