SANDWICH BEAMS WITH MID-PLANE ASYMMETRY SUBJECTED TO LATERAL LOADS ANALYSIS AND OPTIMIZATION

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INTRODUCTION

Sandwich construction offers many advantages over conventional monocque construction particularly when the loads result in the ending of the structure. This is well known, and the analogy between sandwich beams and I-beams is often used. In many cases both for strength critical structures and stiffness critical structures using sandwich construction results in the lowest weight structure possible. The use of composite materials in the faces of sandwich structures provides another means to reduce weight, while incorporating many of the other advantages of composites such as high damping, corrosion resistance, and very high strength to weight and stiffness to weight ratio. For sandwich structures foam or solid (balsa) core or a honeycomb core are the most widely used materials both from a weight and a cost point view.

Traditionally, sandwich construction has employed faces of the same material and thickness such that regardless of the many materials used for the face the sandwich is mid-plane symmetric.

Recently attempts have been made to investigate and exploit the use of mid-plane asymmetric sandwich construction for many reasons. In some applications it is desirable to have the outer face be thicker than the inner face due to impact, wear or thermal loads, while the inner face may require special consideration regarding chemical attack, toxicity or fire retardance.

Equally important is the advantage of employing mid-plane asymmetry to reduce the bending curvature resulting from the load, which introduces bending stresses into the face in addition to the in-plane membrane loads, as well as increases the concern of buckling of the compression face. Thus mid-plane asymmetry, which inevitably results in bending-stretching coupling, can be used to effectively produce a superior sandwich structure.

In the present research, the simplest of structures, the beam is used to investigate the effects, advantages and disadvantages of using mid-plane asymmetry in sandwich construction when the beam is subjected to a variety of loads often encountered in beams and other structures. All of the various combinations of boundary conditions will be studied, i.e. clamped, simply supported and free.

In each case methods of analysis are presented to analyze and design mid-plane asymmetric sandwich beam structures and methods are presented to insure that the beam is minimum weight for the loads applied.

The variables included in these analyses and optimizations include several frequently encountered lateral loads and associated with these are all combinations of boundary conditions. The effects of employing an improved theory that includes transverse shear deformation are compared to those obtained using the classical beam theory. The results of using a honeycomb, polymeric, foam or solid cores such as balsa wood, are compared. Finally the use of various face materials are included. Generically with composite materials there are graphite (carbon), Kevlar, and glass-reinforced composites. These will be compared in two ways. One employs using the same material for each face, but since the compressive strength

in most composites differs from their tensile strength, different thicknesses are desirable to optimize the structure for minimum weight. The second utilizes different materials (as well as thickness) in the faces to take advantage of the basic properties of various composites.
In the optimization there are three restrictions, maximum compressive strength for one face, maximum tensile strength for the other face, and a maximum deflection. Fortunately there are three geometric variables for investigating the design of a sandwich of stated face and core materials, namely the two face thicknesses and core depth. Thus there exists a unique optimal configuration.
Among the variables (described above) to investigate are the factor of safety, and the allowable maximum deflection. The effects of various values of each will be investigated.

CONCLUSION:

The paper will thus present sets of useful equations to use in the design and optimization of sandwich beams under a variety of lateral loads and boundary conditions, and conclusions of which face materials and core configuration result in minimum weight structure for sandwich beams. In addition when and how to utilize mid-plane asymmetry, the effects of factor of safety, maximum allowable deflection, and transverse shear deformation effects will be presented.

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