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Fundamentals of Composite Sandwich Panels

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Objectives:

Teach students basic principals involved in the design of composite sandwich panels and why the panel are strong and lightweight. Construction and testing of simple "bridges" from commonly available materials such as wood veneer (thin slices of wood), insulating foam and double sticky carpet tape. Students will construct composite sandwich panels of various geometries (wood and foam thickness). Other variations include type of double sticky tape or adhesive, orientation of the wood grain, type of foam, size of panels, and/or separation of supports. The panels are then weighed and tested by placing container on bridge and adding pennies to see which geometry has the best strength to weight ratio. The different failure modes of the panels will be examined with respect to the panel geometry and constituent properties.

Grade Levels:

This activity is flexible enough to engage students from grade 4 though 12. Level can be adjusted by the amount of physics and theory introduced and the degree of analysis.

Time Required:

Time depends on number of variables included in the experiment. This can easily range from 1 to 3 hours.

Equipment and Supplies:

Balance (scale) nominally 5kg capacity, 1 gram accuracy
Loading device (container of pennies or other weights)- approximately 2 kgs (1000 pennies)
Supports 2 pieces of wood or pipe approximately 2 inches higher or diameter, 3-4 inches wide.
Wood veneer- strips approximately 2 inches wide and 24" long. Thickness variable but less than 0.1"
Rigid foam- such as blue insulating foam board available at Home Depot, Lowes. Etc. Same width and length as wood veneer strips. Thickness variable, between 0.5 and 2.0 inches
1 roll Double sticky carpet tape approx 2" wide.
1 box cutter knife
1 ruler/T-Square/ right angle for cutting guide if foam and wood need to be cut.

Steps

1) Cut foam and wood to same length and width, approx 24" X 2"
2) Apply double sticky carpet tape on to wood. Try to avoid touching the sticky part of the tape.
3) Remove any backing from double sticky tape (if present) and place on the foam. Apply firm even pressure over the whole surface
4) Repeat 2 &3 for other side of foam.
5) Weigh the sandwich panel, AKA Bridge
6) Place bridge on supports spaced 22" apart. Note it may be helpful to attach the supports to a board to stop them from moving during the test and to insure a repeatable span.
7) Place container on center of span and add pennies slowly until bridge breaks or deflects more than 1" downward.

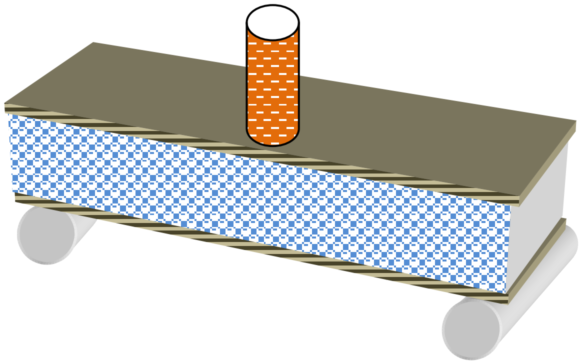

Figure 1. Sandwich panel on test fixture

Background

The design principle of a sandwich composite is similar to that of an I-beam, which is an efficient structural shape because as much as possible of the material is placed in the flanges situated farthest from the center of bending and neutral axis. In a sandwich structure, the faces resemble the flanges and the core acts as the web. The basic underlying concept of sandwich is that face sheets carry the bending stresses and the cores carry the shear stresses .The faces act together to form an efficient stress couple or resisting moment, counteracting the external bending moment. The core resists shear and stabilize the faces against buckling or wrinkling. The selection of the adhesive that bonds the faces to the core is important as it must be strong enough to resist the shear and tensile stresses set up between them. The strength of a beam in bending is a function of many factors including the properties of the materials used and the geometry of the beam. The material properties of main interest are the tensile strength, shear strength and elastic modulus. The geometrical parameters of greatest are the length of the beam (spacing of supports), the width and the height of the beam. For a composite or sandwich beam, the relative thickness of the layers and the shear strength of the bond between the layers are also Important.[1,2]

From elastic beam theory, the flexural stress, σ in a beam is σ =MY/I, where M is the moment, Y is distance from neutral axis (the centerline for a symmetric beam) and I is the 1st moment of inertia. For a rectangular cross section, I = bh3/12, where b is the width and h is the height of the beam. In 3 point flexure, the moment, M=FL/2 where F is the force and L is the distance between supports. For the geometry shown in the figure, the top of the beam is placed in compression and the bottom in tension and the shear stress is uniform

Beams can fail in several different manners depending on the materials and geometry they are constructed with. There are four different modes of failure of sandwich composites when loaded in bending. The structure will fail at the mode that occurs at the lowest load. The most common failure modes are buckling of the compressive skin, shear failure of the core, tension failure of tension skin and/or delamination between the skins and the core. Changing the geometry can affect mode of failure. For example decreasing the skin thickness, may change the mode from core shear to skin tension.[1]

References and resources

1) Bitzer, T.N, Honeycomb Technology: Materials, design, manufacturing, applications and testing , Chapman & Hall, ©1997.
2) http://composite.about.com/library/docs/mil-hdbk-23/bl1-2.htm