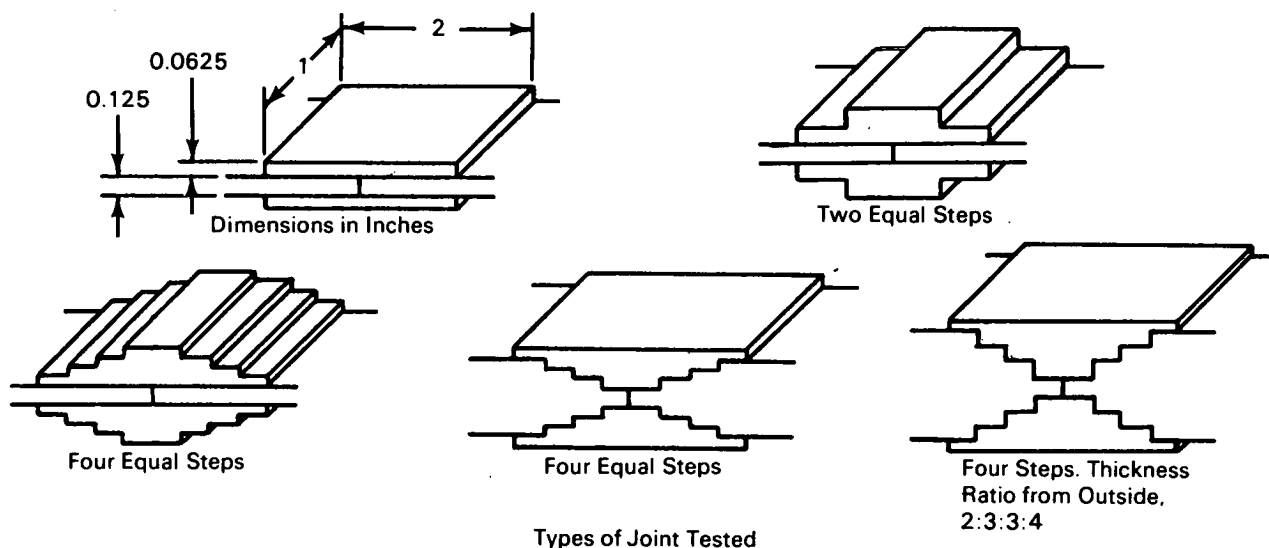


NASA TECH BRIEF



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Improvement of Adhesive-Bonded Structural Joints



Methods for obtaining uniform shear stress distribution in adhesives used in double-lap bonded joints were investigated. The lap-joint configurations usually found in adhesive bonding are based on riveted and welded-joint technology, and are not ideally suited to match the properties of adhesives. Conventional simple-lap joints, for example, often develop less than 20% of the adhesive strength potential because adherend strain mismatches result in adhesive stress concentrations.

The principal main-plate materials studied were boron-epoxy composites, aluminum, and titanium. The doublers were aluminum, titanium, or steel. Typical joints tested appear in the figure. Metlbond-328 was used because it is brittle and has a high shear modulus.

The criterion developed for joint design is shown

to be independent of adhesive properties and adherend shear stiffness. Adhesive peak shear stresses can be reduced if the following rules are applied in design: (1) local strains in the adherends must match as closely as possible at each point on the bond line; (2) adherend shear stiffness must be reduced as much as the overall constraints of the application permit; and (3) adhesive shear strength should be high, with ductility as high as the overall joint-deformation constraints permit.

Full exploitation of these reduced shear stress peaks further requires that the shear strengths of the adherends and the adherend-to-adhesive interface exceed that of the adhesive.

The unique tailoring possibilities of fibrous composite materials may be applied toward the realization of optimum designs suggested by design criterion. By carefully choosing layup patterns, joint strength

(continued overleaf)

can be improved without changing the geometry of the stepped-lap or straight-lap configurations. Procedures for tailoring composite adherends are included in the study.

An improved analysis of straight-lap joints accounted for adherend shear properties and adhesive nonlinearities, factors which are important to the performance of adhesive joints in fibrous composites. A finite-element program was employed to study the stepped-lap joint and to verify the simplified design criterion developed in this investigation.

Tests of the joint designs developed showed that their relative strengths agreed well with the relative strengths predicted. A photoelastic study showed that adherend shear deformations preclude accurate determination of adhesive stresses, but the technique is still applicable when the salient features of the stress field must be monitored visually.

The study report includes recommendations for improved joint-design procedures; a recommendation for a study of joint-fabrication parameters; and a proposed procedure for characterizing adhesives based on the analytical results. Computer programs for analyzing lap joints with nonlinear adhesives and finite adherend shear stiffness are included.

Note:

The following documentation may be obtained from:

National Technical Information Service
Springfield, Virginia 22151
Single document price \$3.00
(or microfiche \$0.65)

Reference:

NASA-CR-108973 (N70-20593), Research
Study to Develop Means of Manufacturing
Bonding Clips, Brackets and Joints, and
Pressure Sealing Joints with Uniform Stress
Distribution

Patent status:

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