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STRUCTURAL ANALYSIS OF LIGHT AIRCRAFT USING NASTRAN

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The finite-element method has been used extensively for the analysis of major aerospace structures. However, there seems to have been little application of the method to light aircraft generally designated in the homebuilt or sport category. There are two principal reasons for the lack of utilization of computer methods in this area. First, designers of homebuilt aircraft have limited awareness of the ability of the method. Second, the high cost generally associated with any computer analysis frightens potential users away. The purpose of the present study was to determine whether application of NASTRAN to the structural analysis of light aircraft can be economically justified.

For a particular application a NASTRAN model has been made of the "Baby Ace" D model, a homebuilt design whose plans are distributed by the Ace Aircraft Company, Asheville, North Carolina. The basic design consists of a fabric-covered tubular steel fuselage and tail section. The wing is a fabric-covered spruce frame utilizing a Clark-Y airfoil. The aircraft is single place and designed for engines ranging from 48 to 63 kW (65 to 85 hp).

The NASTRAN model of the craft is shown in figure 1. It consists of 193 grid points connected by 352 structural members. All members are either rod or beam elements, including bending of unsymmetrical cross sections and torsion of noncircular cross sections. The model also contains pretensioned members to account for the preloaded drag wires on the wing and tail sections.

In the determination of the mass of the craft, consideration was given to both structural and nonstructural mass. The nonstructural mass consisted of such items as engine, fuel, instruments, pilot, wheels, fabric, and paint. This nonstructural mass made up approximately 83.4 percent of the total mass and was included by using numerous concentrated masses. The portion of the mass due to fabric, paint, welds, nails, and control wires amounted to 9.3 percent of the total mass and was "smeared" across the entire craft.

The aerodynamic loads applied to the Baby Ace were in accordance with FAA regulations governing the utility category aircraft. Using the flight envelope specified in these regulations, several flight conditions were selected, including a 4.4g stall condition at the maximum angle of attack of 19° and a 4.4g nonstall pullup at a low angle of 1.8°. In each case the analysis included the inertia relief feature of NASTRAN. The lift, drag, and aerodynamic moment of the wing were calculated in a consistent manner from the performance curves of the Clark-Y airfoil. Furthermore, aerodynamic forces

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were also applied to the tail section, assuming zero pitching acceleration. All loads were entered as concentrated forces at the grid points, and these forces were distributed over the wing and tail in a statically equivalent manner.

A summary of the results is presently being made. Preliminary analysis indicates that approximately 71 percent of the members have a factor of safety in excess of 5. No structural inadequacies have been determined at this time. Thus, it appears that the aircraft is overdesigned. Should further study of the data confirm this conclusion, areas will be designated where the weight can be reduced to save money and improve flight performance.

In addition, this problem is being studied by means of the substructure feature available in Level 15.

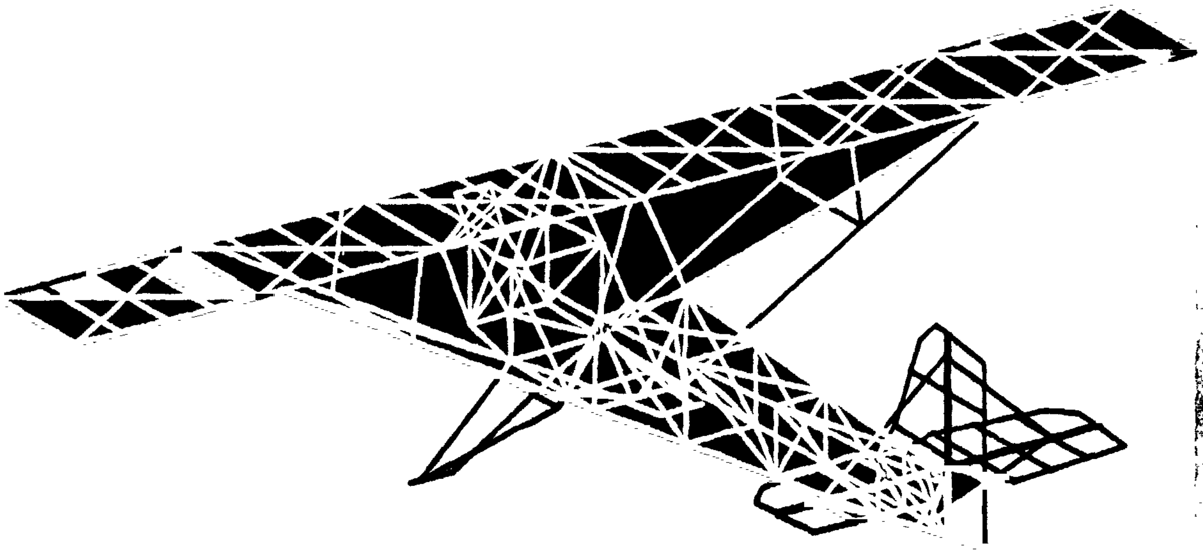

Figure 1.- Structural members of Baby Ace.