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Engineering Notes

ENGINEERING NOTES are short manuscripts describing new developments or important results of a preliminary nature. These Notes cannot exceed 6 manuscript pages and 3 figures; a page of text may be substituted for a figure and vice versa. After informal review by the editors, they may be published within a few months of the date of receipt. Style requirements are the same as for regular contributions (see inside back cover).

Development of a Wing Preliminary Structural Analysis Code

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Nomenclature

A = cross-sectional area, mm^2
E = Young's modulus of elasticity, MPa
F_C = column critical stress, MPa
F_{cs} = crippling stress, MPa
F_{cy} = compressive yield stress, MPa
L = equivalent column length, mm
t = thickness, mm
w = effective sheet width, mm
ρ = radius of gyration, mm

Introduction

THE typical aircraft structural design process contains numerous iterations from the conceptual design phase to the determination of final configuration. In the conceptual design phase and in the early stages of the preliminary design, careful sizing of the structural elements has vital importance. Accurate sizing of these elements ensures accurate preliminary strength and weight estimates, changes to which can be extremely costly in the ensuing design stages. To reduce the costs, man-hours, and delays in schedule, the aircraft industry developed analysis tools at different levels of sophistication for nearly three decades. Equivalent Laminated Plate Solutions (ELAPS),[1,2] Generic Transport Aircraft Knowledge-Based Design Tool (GTA-KBDT),[3] and ALACA[4] are some of those.

Wing Preliminary Structural Analysis Code (WPSAC) is similar to those computer codes in some aspects. It is being developed in the TAI, Structural Design Department, Structural Analysis Group with the intention of utilization between the conceptual and preliminary design phases. The main purpose of WPSAC is the accurate sizing of structural elements. It also conveniently enables one to easily and rapidly investigate different possible geometries. Presently the package is not capable of automatic sizing; however, developments are in progress. By examining the resulting margins of safety, the required improvements on the dimensions are done manually.

This study presents the developed program and gives the theory for spar caps and stringers stress analyses. As failure mode criteria, crippling is chosen for spar caps, and the column buckling is analyzed for stringers. A conceptual aircraft wing is studied, and the relevant stress results are also shown.

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Description of the Developed Code

The program package WPSAC consists of two parts. The first part is entitled Wing Preliminary Finite Element Modeling Code (WPFEMC), and its task is to create the wing finite element model based on the given inputs. Finite element models of various wing configurations (any forward and backward swept, any dihedral and incidence, any airfoil shape for each wing box, flap and aileron, etc.) can be created. The second part is entitled Wing Preliminary Stress Analysis Code (WPSTAC). This portion is responsible for all stress analysis calculations. The structure of the package is shown in Fig. 1, as are detailed individual tasks of the each code.

However, the program has some limitations mostly in the modeling. For example, no leading-edge high-lift device or control surface can yet be located. Furthermore composites cannot be modeled yet. In addition, stringers have to be continuous through the span, and the skin thicknesses must be constant between two ribs.

Modeling of Wing Structural Elements

Because spar caps are assumed to have bending capability, in the modeling of the spar caps the bar elements are utilized. Spar web elements and ribs primarily carry shear and some normal stresses,

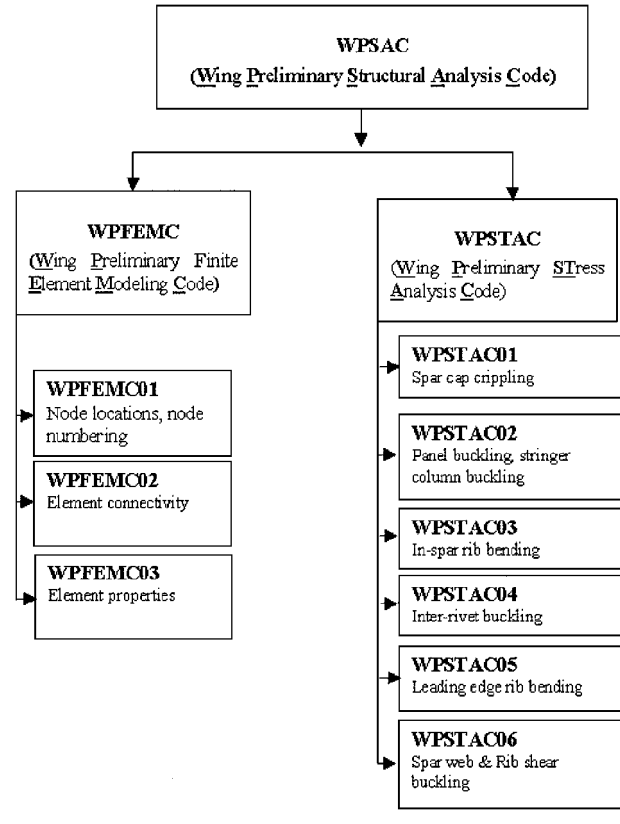

Fig. 1 General layout of the WPSAC code.