June 1967

Brief 67-10217

NASA TECH BRIEF

A Modal Combination Computer Program for Dynamic Analysis of Structures

The problem:

To determine the undamped modes of a composite structure and to get response to sinusoidal forcing functions, which are required for problems related to current testing practices and closed-loop stability of autopilot controlled space vehicles. Models of components (basic systems) in forms of geometry, normal modes, frequencies, lumped masses, and elastic properties are also required.

The solution:

Determine the response of a composite linear structure subjected to low-frequency sinusoidal base motion of a restrained structure or low-frequency sinusoidal forces at points of a free structure.

How it's done:

Systems are developed from basic systems when the required compatibility with the composite is imposed. Operation is divided into five parts: (1) basic system processing, (2) system processing, (3) composite processing, (4) force response calculation, and (5) point acceleration and member stress calculation. Any adjacent parts of the program may be used in a single computer run.

Basic System Processing: (1) geometry, member properties, normal mode shapes, frequencies, and modal damping coefficients are read in; (2) rigid body modes, modes describing the independent motion of redundant supports (constraint modes), modes associated with concentrated loads at unrestrained points (attachment modes), and associated reactions are calculated, and (3) the modal matrix, mass matrix, stiffness matrix, and damping matrix are formed.

System Processing: (1) required compatibility is imposed, and (2) transformations from composite coordinates to system coordinates, mass, stiffness, and damping matrices of composite are developed.

Composite Processing: (1) undamped eigenvalues and eigenvectors are found, (2) the transformation from uncoupled coordinates to composite coordinates and the uncoupled combined mass and damping matrix are developed, and (3) point accelerations of undamped mode shapes are punched by the computer if desired.

Response Calculation: (1) the generalized forcing function matrix is formed, (2) response of given control points is calculated and plotted, and (3) composite system generalized displacements for frequencies which have the largest response are punched by the computer.

Point Acceleration and Stress Calculation: (1) point accelerations are calculated from composite system generalized displacements punched on cards and transformations saved on tape, (2) mass acceleration "forces," the associated static displacements and related accelerations, are calculated, and (3) member loads are found using the deflections associated with either modal accelerations or inertial loading.

Ingenuity is required in the use of the program primarily in defining realistic idealizations of the components.

Notes:

1. The program was written for the IBM 7094.
2. The programming language used is Fortran IV.
3. Future extensions of the program will allow non-sinusoidal forcing functions, as most of the program is not limited by this restriction.
4. Inquiries concerning this innovation may be directed to:

   COSMIC
   Computer Center
   University of Georgia
   Athens, Georgia 30601
   Reference: B67-10217

(continued overleaf)

Patent status:

No patent action is contemplated by NASA.

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