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DYNAMIC BEHAVIOUR OF ORTHOTROPIC PLATES USING FINITE DIFFERENCE TECHNIQUE

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Introduction

Dynamic characteristics of isotropic plates and stiffened plates considered as orthotropic plates have been investigated by several authors. These have been documented by Leissa[1]. Consideration of the behaviour of orthotropic plates has mainly been based on the extension of the exact analysis as applied to isotropic plates and by superimposing beam and plate theory in the case of stiffened plates.

In this presentation equilibrium method has been used for the Finite difference formulation leading to the characteristic equations of vibration of an orthotropic plate. Unequal intervals have been used throughout. Finite difference formulation for points within the boundary which are at least two intervals away from the boundary is fairly straight-forward. It is the points on or near the boundary which cause difficulties. These difficulties have been overcome by employing a combination of 2nd and 4th order polynomials and Langhagian interpolation. This interpolation has been used for the Finite difference formulation of the equation of motion of an orthotropic plate in eigenvalue form.

Using this formulation the effect of variation of interval size in the Finite difference formulation required for the prediction of the dynamic characteristics of orthotropic plates has been investigated. Different boundary conditions have been considered and results have been compared with reference 1. Results obtained by finite difference method using equal intervals are also presented.

The variation of interval sizes in orthogonal directions were chosen according to the shape of the first mode. Interval size variation parameter β can be defined as the variation rate of the intervals in X direction corresponding to the deflected form of a rectangular plate in the fundamental mode. The parameter in Y direction is 2β to correspond with the ratio of the dimensions. Mesh size variation for a particular value of $\beta = 0.05$ is shown in table 2.

It is know that a finite difference solution using equal intervals underestimates the values. To some degree results can be improved by utilizing unequal intervals. In the presented work it has been established that frequency parameter increases with β and for suitable values of β increased accuracy is obtained. This is because increasing values of β give a faster decrease in intervals and the deflection curve of the plate is more faithfully simulated in boundary regions. It is possible to select the values of β to achieve this while keeping the number of equations constant for a given case. It must be noted that the variation of intervals have to be selected individually for different modes.

For all the cases 55 equations were used to solve the eigenvalue problem. It should be noted here that in the simply supported case using equal intervals 105 equations had to be used to achieve the same accuracy as with unequal intervals with 55 equations and a value of $\beta = 0.04$.

Conclusions:-

The present analysis makes it possible to increase the accuracy of the predicted dynamic behaviour of orthotropic plates. Increase in accuracy is a function of the interval variation which has to be selected judiously for various modes of vibration. Savings in computation time and core storage can be achieved by the use of unequal intervals as compared to equal interval formulation for a desired degree of accuracy. Since the error in Finite difference method using equal intervals increases for higher modes, the present formulation would be useful in obtaining high accuracy.

Results

Table 1. Fundamental Frequency Parameters for a 5 - Ply Maple-Plywood Rectangular Orthotropic Plate having Various Boundary Conditions

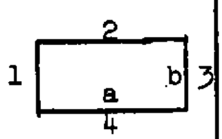
Boundary Conditions	$\omega a^2\sqrt{\rho/D_2}$			Physical Dimensions & Parameters
	Reference 1	Equal Intervals	Unequal Intervals	
SS-SS-SS-SS	48.65	47.97	48.55	$\frac{a}{b} = 2.0$
SS-C -SS-SS	68.53	67.31	68.32	$\frac{D_1}{D_2} = 3.117$
SS-C -SS-C	94.57	92.56	94.26	
				$\frac{D_3}{D_2} = 0.648$

Table 2. Mesh Size Variation with $\beta = 0.05$ in Orthogonal Directions

Boundary Conditions	Axis	Mesh Size Variation In X direction from mid-point of the side, in Y direction from side to side					
SS-SS-SS-SS	X	1.0	0.95	0.90	0.85	0.80	0.75
	Y	0.775	0.875	0.975	0.975	0.875	0.775
SS- C-SS-SS	X	1.0	0.95	0.90	0.85	0.80	0.75
	Y	0.875	0.775	0.975	0.975	0.875	0.775
SS- C-SS-C	X	1.0	0.95	0.90	0.85	0.80	0.75
	Y	0.875	0.775	0.975	0.975	0.775	0.875

References

1. Leissa, A.W. Vibration of Plates
NASA Report SP-160, 1969