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VIBRATION OF UNIDIRECTIONAL FIBER REINFORCED PLANAR FRAME STRUCTURES

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SUMMARY

In this research work, theoretical and experimental techniques have been used to determine the natural frequencies and natural modes of unidirectional fiber reinforced planar frame structures. Finite element techniques have been applied to construct the mass and stiffness matrices. Consentrated mass, mass moment of inertia and consentrated spring have been considered. Experimental work has been carried out to measure eigen frequencies and structure loss factor of the planar frame composite structure. Finally a comparison between theoretical and experimental results have been presented.

KEYWORDS: Vibration; natural frequency; unidirectional fiber; composite materials; finite element.

EQUATION OF MOTION

In the finite element method the principle of virtual displacement yields the equation :

$$M \ddot{U} + K U = 0 \qquad (1)$$

The eigen value problem of composite structure has the form:

$$(K - \omega^2 M). U = 0 \qquad (2)$$

In general form eq.(2). is re-written as:

$$K U = \lambda M U \qquad (3)$$

where $\lambda = \omega^2$, and ω is the circular frequency. The proper choice ofsolution method is most important in the analysis of large structures. Jacobi's method provides a convenient scheme to compute all eigenvalues and eigenvectors.

STRUCTURE LOSS FACTOR

The structure loss factor can be calculated as follows:

$$\eta^{**} = \eta_{mx} (1 - V_f) \frac{E_m}{E_c} \qquad (4)$$

where:

η_{mx} is the material loss factor of Polyester matrix $= \frac{E_m^{*}}{E_m'}$

E_m is the elastic modulus of matrix = 3.958 Gpa

E_c is the effective elastic modulus of composite = 24.49 Gpa

REFERENCES

1- T.J.Dudek " Young's and shear moduli of unidirectional composites by resonant beam method." .J. Sound & Vib., Vol.4, pp. 232-241, 1970.

2- R.B. Abarcar and P.F.Cunniff " The vibration of cantilever beams of fiber reinforced material " J. Composite Materials. ,Vol. 6, pp. 504-517, 1972.

3- L.S.Teh and C.C.Huang " The vibration of beams of fiber reinforced material " J. Sound & Vib., Vol. 51, pp. 433-449, 1975.

4- K.K.Teh and C.C.Huang " The effects of fiber orientation on free vibrations of composite beams " J. Sound & Vib., Vol.69 (2), pp. 327-337, 1980.

5- R.Davis,R.D.Henshel and G.B.Warburton " A Timoshenko beam element " J. Sound & Vib., Vol.22, pp. 475-487, 1972.

6- D.L.Thomas, J.M.Wilson and R.R.wilson "Timoshenko beam finite elements " J. Sound & Vib., Vol.31, pp. 315-330, 1973.

7- Alex.T.Chen and T.Y.Yang " Static and dynamic formulation of a symmetric laminated beam finite element for a Microcomputer " J. composite materials, Vol. 19., pp. 459., 1985.

8- S.S.Rao " The finite element method in Engineering " Pergamon Press, Second Edition , 1989.

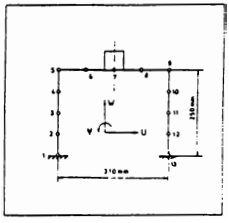

Fig. 1 Planar frame composite structure

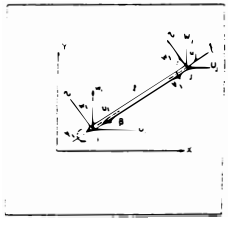

Fig. 2 Type of element and sings convention

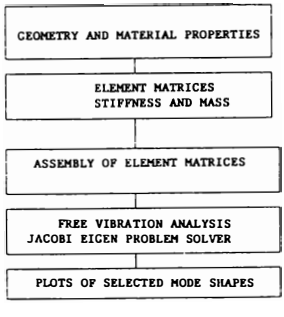

Fig.3. Flow chart of the program

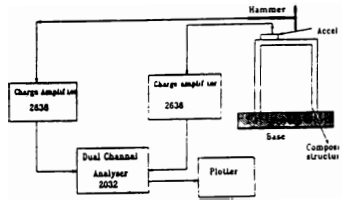

Fig. 4 Block diagram of apparatus for vibration tests of composite structure without concentrated mass

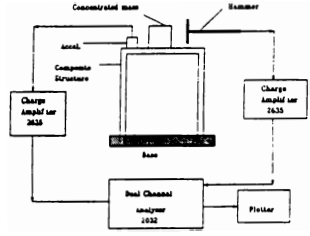

Fig. 5 Block diagram of apparatus for vibration tests of composite structure with concentrated mass.

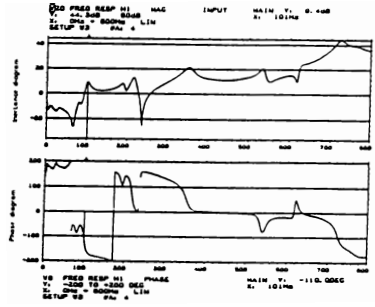

Fig. 6 Inertance and Phase diagrams for composite structure without concentrated mass

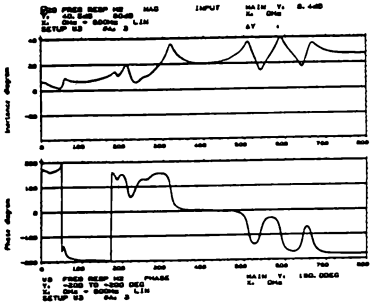

Fig. 7 Inertance and Phase diagram for composite structure with concentrated mass

Table 1. Experimental results of (f_n) and (η) of composite structure without concentrated mass

FEM results		Exper. results	Theoretical loss factor	Experimental loss factor
Mode No.	f_n Hz	f_n Hz	η^{**}	η^{*}
1	34	30	.00213	.0016
2	110	101	.00213	.0544
3	230	218	.00213	.025
4	393	358	.00213	.0311
5	632	625	.00213	.012
6	718	720	.00213	.0172

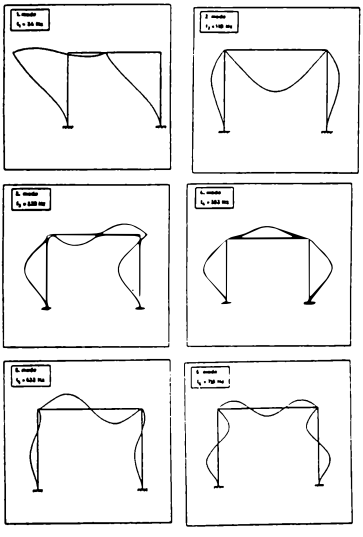

Fig. 8 Eigen modes of the composite structure without concentrated mass

Table 2. Experimental results of (f_n) and (η) of composite structure with concentrated mass

FEM results		Exper. results	Theoretical loss factor	Experimental loss factor
Mode No.	f_n Hz	f_n Hz	η^{**}	η^{*}
1	27	20	.00213	.001
2	65	60	.00213	.03
3	214	185	.00213	.028
4	224	217	.00213	.025
5	342	320	.00213	.0156
6	554	521	.00213	.010

where

η^{*} is measured experimentally

η^{**} is calculated from equation (4)

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