STUDIES IN DYNAMICS OF SKEW PLATES

by

NARESH CHAND BHANDARI
Department of Mechanical Engineering

Submitted
in fulfilment of the requirements
of the degree of
Doctor of Philosophy
to the

Indian Institute of Technology, Delhi

June, 1979

ABSTRACT

This thesis reports the analytical and experimental work done on free vibration, loss factor and response of some types of skew plates.

For the three types of skew plates considered i.e. plates parabolically varying in thickness, integrally rib stiffened plates with ribs of rectangular cross section and plates having intermediate spring supports, the assumed mode variational method of Ritz has been employed for determining the natural frequencies and mode shapes. Deflections of the plate at different natural frequencies are assumed as a series of 'admissible beam characteristic functions' appropriate to the boundary conditions and approximate mode shapes for such structures. Flexural as well as torsional effects of the ribs have been included in the analysis.

Three types of edge conditions of the plates considered are,(i) all edges simply supported, (ii) simply supported at the ribs and the other two clamped, and (iii) all edges clamped.

With a view to increase the loss factors of integrally rib stiffened plate, stiff viscoelastic strips have been added across the free end of the ribs. Such a resulting structure has been analysed for obtaining loss factor and both the flexural and the extensional effects of the viscoelastic strips have been

considered in this analysis. Apart from these two effects the experimental value of the structural loss factors have also been utilized in forming a complex eigen value problem for determining the total loss factors of the resultant structure. The loss factors of the structure and damping material are introduced in the analysis by making the modulii complex.

Transient responses to the half sine pulse and exponentially decaying impulsive load have been computed for spring supported skew plates by modal analysis using previously computed values of natural frequencies and normalized mode shapes.

The computations have been carried out on a ICL-1909 Digital Computer at the Indian Institute of Technology, Delhi. Apart from using computer library subroutines for solving symmetric and non-symmetric real eigen value problems, the EISPACK and IBM 360 version of Eberlein's procedure subroutines have been used for solving complex eigen value problems. The convergence in the results have been obtained by going upto the matrix size of 50x50 in most of the cases.

The frequencies, mode shapes and the loss factors have also been determined experimentally for various rib stiffened plates having different aspect ratio, skew angle, thicknesses of the plate and the ribs, number and positions of ribs and edge conditions. Loss factors for these plates with and without viscoelastic strips at first few natural frequencies have been

determined experimentally by drawing Kennedy-Pancu diagrams as well as by the 'Frequency Band-Width' method.

The results obtained by Ritz method for the rectangular plates have been compared with those obtained by other authors. The computed frequencies are found to have a maximum variation of one per cent from the exact values in cases of spring supported and parabolically varying thickness plates. The disagreement in the frequency values for the plate with symmetric stiffeners from the existing results are of the order of 0.21 per cent to 1.5 per cent, whereas for eccentric stiffeners it varies from 1 per cent to 10 per cent. There is also reasonably good agreement in the computed and experimentally obtained frequencies, mode shapes and loss factors in the present case.

For the same aspect ratio plate there is a increase in natural frequencies and reduction of response with the increase in skew angle. There is a significant increase of loss factors at all the frequencies due to the addition of viscoelastic strips of relatively small weight.

The advantage of the analytical approach presented in the thesis is its ability to handle problems involving variations in skew angle, number of supports and their positioning and boundary conditions, without much additional computer storage and time requirements. The method can be used for more complex problems of say a ribbed and supported skew plate with variable plate thickness.

CERTIFICATE

This is to certify that the Thesis entitled 'Studies in Dynamics of Skew Plates' being submitted by Mr. N.C. Bhandari to the Indian Institute of Technology, Delhi, for the award of the Degree of Doctor of Philosophy in Mechanical Engineering, is a record of bonafide research work carried out by him. He has worked under our guidance and supervision and has fulfilled the requirements for the submission of this Thesis, which has reached the requisite standard.

The results contained in this Thesis have not been submitted in part or in full, to any other University or Institute for the award of any degree or diploma.

(B.L. Juneja)
Professor

(K.K. Pujara)
Assistant Professor

Mechanical Engineering Department
Indian Institute of Technology,
New Delhi-110029

ACKNOWLEDGEMENTS

It is with great pleasure that the author wishes to express his profound gratitude to Dr. K.K. Pujara and Dr. B.L. Juneja for suggesting the problem and for supervising the work on this thesis. Their inspiring guidance, valuable discussions and constant encouragement helped the author to accomplish this work.

The author wishes to thank Small Industrial Service Institute, Okhla for completing the difficult task of machining the integrally stiffened skew plate.

The unswerving help and cooperation extended by the staff of 'Vibration and Instrumentation Laboratory' especially Mr. H.L. Sharma and Mr. Gamdur Singh in the experimental work, is gratefully acknowledged.

Thanks are also due to the staff of Computer Centre, the Departmental Workshop, the Production Laboratory, the I.D.D. Centre, Photographic Section and Library for their help and cooperation.

The study leave provided to the author by the Principal, Malaviya Regional Engineering College, Jaipur for the present work is gratefully acknowledged.

A special word of thanks for Mr. V.P. Gulati for typing this manuscript.

Finally, the author offers his heartfelt thanks and apologies to his near ones for patiently enduring certain unavoidable difficulties which resulted from the author's preoccupation with the present work.

(N.C. Bhandari)

CONTENTS

CONTENTS (Contd.)

CONTENTS (Contd.)

CONTENTS (Contd.)

CONTENTS (Contd.)

==