POSTPROCESSOR FOR AUTOMATIC MODE IDENTIFICATION FOR MSC/NASTRAN STRUCTURAL DYNAMIC SOLUTIONS WITH EMPHASIS ON AIRCRAFT FLUTTER APPLICATIONS

by

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ABSTRACT

A practical procedure and postprocessor FORTRAN program which sums strain energies for an aircraft structure, elastic element by elastic element for each component as outputted by MSC/NASTRAN Solution 103 or Solutions 145 and 146 is described and an example is provided showing an output table of strain energies for a hybrid finite element model of a twin turboprop aircraft and comparison with a few plotted mode shapes. The application of the procedure to the .f06 output of one of the structural dynamic solutions results in automatic naming of the analytical modes of vibration, a powerful aid for the flutter analyst.

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1.0 Introduction and History of the Method

The correct identification of calculated modes of vibration is essential to understanding the results of flutter analyses, a fact not always appreciated sufficiently.

In the not too distant past, a time which middle aged and older flutter engineers well remember, each Aircraft Company had its own set of vibration and flutter analysis procedures, using a variety of methods. Unfortunately, no references are available and in any case, they would be too numerous to mention. A common feature of most of the in-house-type structural dynamics procedures was the strain energy calculation and summation procedure which helped with the identification and the naming of the calculated modes of vibration, along with mode shape plots.

Reference 1 presents a method of modal identification using kinetic energy as calculated by any of the MSC/NASTRAN structural dynamic solutions.

No originality is claimed for the work presented here, as there is none. It is nevertheless felt that the publication of the present paper would be of interest to flutter analysts and other users of the MSC/NASTRAN structural dynamics solutions who might not yet have developed their own similar modal identification procedure.

The first version of the present method was developed at Gulfstream Aerospace Corporation, Savannah, Georgia, in early 1992 by the first author.

The procedure was completely redeveloped and vastly improved at DeHavilland Inc., in late 1995 by both authors of this paper, making it into a very powerful tool for naming analytical modes of vibration. It has been wildly successful with the average audience of two to three people using it in the average flutter group.

2.0 Description of the Method

The present modal identification method works the same way for a stick model which has only beam or bar elements, or for a hybrid finite element model which, in addition to the beam and bar elements, has other types of structural elements modeling the junctions between various aircraft components.

The numbering of the elastic elements must be arranged in a logical fashion in order to make the programming task easier.

No DMAP ALTERs are necessary for this procedure.

The ESE=ALL card must be present in the case control deck.

A FORTRAN program has been written to process the output file .f06 of the MSC/NASTRAN structural dynamics run. Besides the .f06 input file, another input file prepared by the user, containing the elastic elements summation sequence numbers is required.

The strain energy for all the wing elastic elements are summed up and similarly for the rest of the aircraft components, for each mode. As the sums are displayed, a picture emerges about the strain energy content of each component and deformation type for each mode and the modes come out automatically named.

The output of the FORTRAN program is a table listing the mode number, frequency and the strain energy content in each aircraft component for each mode of vibration. This table is in a format readable by Microsoft EXCEL. The component strain energies are rounded off and printed in integer format because of space limitations, since an attempt is made to keep the EXCEL table to one page for convenience, while at the same time maintaining a high level of detail.

The amount of time from the beginning of processing the .f06 file to arriving at the report-quality printed EXCEL table of automatically named modes is of the order of two minutes. This time can be improved to mere seconds if a macro is written to do the data transfer automatically from the postprocessor output file to the EXCEL spreadsheet.

The strain energy table is used in complementary fashion with the corresponding mode shape plots for the best possible mode identification.

3.0 Modal Identification Using Strain Energy and Mode Shape Plots

Figure 1 shows the hybrid finite element model of a twin turboprop aircraft.

Table I shows the calculated component strain energy distribution in percent for each mode. The reading of this table is self-explanatory.

Figures 2.a, 2.b, 2.c and 2.d show four selected mode shape plots which also include the node lines for comparison with the strain energy distribution table.

The reader is invited to compare the named mode shape plots and strain energy table for the same modes, verify the mode names and reconcile apparent discrepancies such as the one seen in Figure 2.d, where the mode shape shows a lot of fuselage torsion, while the strain energy table says that there is none.

4.0 Conclusions

Component strain energy summation has been used to create the capability to automatically name aircraft modes of vibration calculated by using any of the MSC/NASTRAN structural dynamic solutions. The results are displayed in a compact one-page table using Microsoft EXCEL. Though simple in concept, the method is very powerful and very fast and easy to use.

The strain energy method is used in complementary fashion with plots of modal deformation for accurate and fast mode identification. Most of the guess work as well as most of the art (unfortunately) are removed from the mode naming process.

The primary application of the present method as described is for stick and hybrid models of aircraft structures, but this is not an implied limitation to its use for other types of structures.

5.0 References

1. Rose, T., “MSC/NASTRAN Model Checkout”, Presented at the MSC/NASTRAN User’s Conference March 20-21, 1986, Universal City, California.