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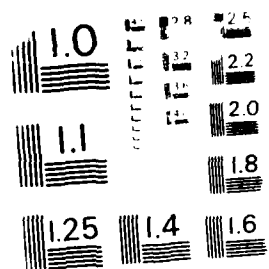
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Aircraft Structures Technical Memorandum 475

PAFEC LEVEL 5.3 APPLICATION PROGRAMS

by
J. PAUL

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PAFEC LEVEL 6.2 APPLICATION PROGRAMS

by

J. Paul

SUMMARY

Finite element programs such as PAFEC often produce vast quantities of data which need to be processed. For analysis purposes only certain information is required and the rest is often discarded. However, the massive amounts of output generated sometimes makes it difficult to locate the relevant information. This report provides a brief outline of a suite of programs which have been developed for use with PAFEC to enable easier processing of the relevant data.



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1. INTRODUCTION

Finite element programs generate vast amounts of numerical data. This set of data has to be processed by the user to obtain the required information about a particular numerical model or process results, e.g. find crack tip nodes or stresses around a crack tip. The purpose of the suite of programs presented in this report is to simplify the processing of this information.

The PAFEC finite element package provides the programmer with a suite of subroutines that allow access to the data held in the PAFEC database. Using these subroutines independent programs can be written to manipulate sections of the database in the required way.

The suite of programs presented in this report are divided into two distinct sections. The first section discusses those programs which enable the user to access and modify the data base. With some programs the modified information can be stored into the database. The second section deals with the post processing of results. In some cases the output from the first section can be used as the input to the post processing programs.

The purpose of this report is to provide a brief outline of each of the application programs currently available. The execution of the programs is simplified by the fact that they are interactive, i.e., the programs prompt the user for the required information. There exists a fairly high degree of error trapping which allows recovery if the incorrect data are entered. However there is always the contingency that the user will have to start from scratch.

2. ACCESSING PAFEC PROGRAMS

Executable versions of the application programs can be accessed by users on the LINC computer at the Aeronautical Research Laboratories (ARL). The path name of the area is as follows:

`/Applications/Fe packages/pafec/pafec`

To access these files aliases are created in the users command directory pointing to the particular file on the PAFEC area. It is envisaged that with future levels of PAFEC this will be changed and will require the user to modify their command search rule to access the PAFEC commands directory. At present a shellfile (i.e., an executable command language file) on the PAFEC area, which is called PAFEC-SET-UP, automatically assigns all the relevant aliases for the user. It also sets up the the users command directory so that they can execute PAFEC.

3. PROGRAM DESCRIPTIONS

3.1 PROGRAMS FOR MODEL MANIPULATION

3.1.1 Program name:	NODEFIND
Description:	The NODEFIND program is used to extract node numbers and their co-ordinates. The menu provided allows the easy selection of a multitude of search patterns. The tolerance on searching the nodal co-ordinates can be changed to adjust for numerical error in the co-ordinate value. Nodes can be read from an external file if the procedure has to be repeated many times.
Output file name:	[Jobname] NODES
Output description:	Papec job name Tolerance used Description of option chosen Node, X, Y, Z, Radius, Theta (relative to input node) Data.

3.1.2	Program name:	PAFGRFIND
	Description:	Element data in a finite element program is made up of group numbers, property numbers and nodal topology. PAFGRFIND is used to extract this set of data. There are two options, one which allows the input of a node number and the other which requires the element number.
	Output file name:	[Jobname].GRFIND
	Output description:	Pafer job name Option description Node, element, group, element type, property numbers Data. or Element, group, property numbers and topology Data.
3.1.3	Program name:	PAFINFO
	Description:	PAFEC stores information about the structure in an array called IBASE. This program displays the information outlined in the output description section and can be very useful in extracting information pertaining to a particular backing store file.
	Output file name:	[Jobname].INFO
	Output description:	Current phase indicator Nodal information. Job tolerance. Element information Number of degrees of freedom Dimension of stiffness matrix Plane stress or plane strain Error and warning count for the current phase
3.1.4	Program name:	PAFTRIM
	Description:	This program allows the extraction of elements with their corresponding nodes from a PAFEC backing store. The nodes extracted can be renumbered from 1 if required. PAFTRIM can be used to extract a substructure from a much larger model. It can also be used to check if elements have collapsed. The output file is written as a PAFEC data file with only nodal and elemental data.
	Output file name:	[Jobname].TRIM
	Output description:	Pafer phase 1 control module Nodes module header Data Elements module header Data. END OF DATA card

- | | | |
|-------|--------------------|--|
| 3.1.5 | Program name | PAICENTROID |
| | Description | <p>This program calculates the centroid of all elements in the structure and with the provided back information it outputs the element numbers found. This is then used in conjunction with PAIGRSET (see 3.1.6) to set the group number of the element to a group number not currently used. Then, when using PEGS (Pafec Integrated Graphics system), the selected group can be drawn, thereby allowing slices of the structure to be drawn.</p> |
| | Output file name | [Jobname].CENT |
| | Output description | <p>Element, X, Y, Z centroid coordinates, Radius, Theta
Data
List of elements for PAIGRSET input
Data</p> |
-
- | | | |
|-------|--------------------|--|
| 3.1.6 | Program name | PAIGRSET |
| | Description | <p>This program changes the group number of the elements listed in an input file to the required group number. The elements that are to have their group numbers changed must exist in column 4 of the file so that the program can access them. PAIGRSET can be used to change element group numbers in the back information and the job can be restarted with the same modified group scheme used in conjunction with an existing PAIEC input model. This is useful if the numerical model was previously generated.</p> |
| | Output file name | [Jobname].BS (MODIFIED) |
| | Output description | <p>None</p> <p>WARNING</p> <p>It should be noted that this program modifies the back information file and might, in some instances, not allow the successful restart of a problem. Therefore great care must be taken when using this program.</p> |
-
- | | | |
|-------|--------------------|---|
| 3.1.7 | Program name | ENQIBASE |
| | Description | <p>When writing PAIEC code it is very useful to know the values of certain PAIEC control and structural constants. This program allows the programmer to examine the value of any IBASE number. IBASE is the PAIEC array that holds the control and structural constants.</p> |
| | Output file name | None (Output is to the terminal) |
| | Output description | IBASE number and value |
-
- | | | |
|-------|--------------|--|
| 3.1.8 | Program name | GAPPS |
| | Description | <p>Locating the GAPPS and CRACK-IP modules are useful for unusual problems or to input difficult and time consuming FE. GAPPS program will automatically generate a crack model, the crack tip node and two nodes on either side of the crack. The crack front length is variable but the crack tip is always defined if reported. The GAPPS program is used to solve both two dimensional problems.</p> |

Output file names	[Jobname] GAPS [Jobname] GAPINFO
Output description	
[Jobname] GAPS	Gaps module header Data Crack tip module header Data
[Jobname] GAPINFO	Paired gap nodes NODE, X, Y, Z coordinates, Bndry, Thctg Data
3.4.9 Program name	SCAL
Description	In some problems, especially with composite materials, where the aspect ratio of elements is sometimes very large, viewing the structure in PIGS is difficult. SCAL allows the user to scale up or down the X, Y or Z coordinates by a factor thereby providing a clearer view of the structure.
Output file name	[Jobname] BS (MODIFIED)
Output description	None
	WARNING: It should be noted that this program modifies the backing store file and might not allow a successful restart of a problem. SCAL can be used in reverse to return the backing store coordinates to their original values, but cannot be taken.
3.4.10 Program name	DELAMINATION
Description	This program will create a new complete PALEO file and, with a hole and a circular delamination at the specified layer in the composite. The output file has a complete list and description of all the parameters used. The program will need to be recompiled if these parameters are changed. DELAMINATION can create a structural model with or without the delamination and with or without a patch on the top surface.
Output file name	Requested at run time
Output description	See related output file for full description of parameters and the PALEO modules involved in it.
3.4.11 Program name	NGDEQIV
Description	<i>Sometimes two data files with the same structure, but different meshed, need to be compared. The same scheme of the structure often can be called into different meshes. NGDEQIV compares the elements of the two data files, finding out that an equivalent element exists in both files. Then the corresponding from columns files containing the parameters are created.</i>
Output file name	[Jobname] EQIV and [Jobname] EQIV.DAT
Output description	For [Jobname] EQIV, [Jobname] X, Y, Z coordinates Data

3.2 POST PROCESSING PROGRAMS

3.2.1	Program name	PAI STRESS
	Description	For large finite element problems, a certain amount of stress output can be generated. PAI STRESS reads and processes this output to a manageable quantity. The program provides the ability to extract nodal or elemental averaged or maximum stress. The elemental global stresses are displayed when the maximum option is selected and the principal stresses are printed when the averaged option is chosen. Output is the form of a table, but all information is written to the output file. PAI STRESS accesses two files: the first is the backing store and the second is called the SS file. The backing store provides the ability to check the requested node or element number with that in the structure and provide the program with the topology of the requested element. The SS file provides the stress information and is accessed through a slightly modified PAI Check routine of the routine R70000 (see PAI/C Data Preparation User Manual, Level 6.2, section 7.12.5).
	Output file name	[Jobname], STRESS
	Output description	Pafec job name Option description Element, node σ_1, σ_2, σ_3, $\sigma_1 + \sigma_2 + \sigma_3$ or Element, node, σ_1, σ_2, σ_3, σ_1, σ_2, σ_3
	Note 1	There exists in the PAI/C code a program bug which causes the stress records to be written to the SS file. This has finally been corrected in PAI/C level 7. Due to this bug PAI STRESS will sometimes print duplicate information for a particular node.
	Note 2	Initially on some PAI STRESS it is advised that you compare plots to output with the output from PAI STRESS. If a difference occurs then ignore the PAI STRESS output as the SS file may somehow have become corrupt.
	Note 3	PAI STRESS will only produce stresses for the element included in the PAI/C STRESS ELEMENT module.
3.2.2	Program name	DISPL
	Description	The PAI/C phase 7 calculates all the static displacements for the numerical model. DISPL can be used to extract any model displacement required. If more than one load case is present then the program will automatically recognise this and prompt for the load case required. The program can also be used to check the status of gaps/nodes and this comes under the option of model pairs difference.
	Output file name	[Jobname], DISPL
	Output description	Pafec job name Node, Ux, Uy, Uz displacement or Node, Ux, Uy, Uz displacement, U diff, gap, closed

3.2.3 Program name:	PLASDISP
Description:	The displacements for a PAFLC property analysis are calculated for each load increment due to the amount of data required. If the displacements are required at each time step of the load increments then modifications are required to the PAFLC and to the PAFLC code. These modifications are outlined below and result in the displacement being stored in a binary file. After the analysis has been completed, PLASDISP can then be executed to extract the displacements at any load increment from the [jobname].DISP
Output file name:	None
Output description:	Node, Ux, Uy, Uz displacements to terminal
Data file changes:	The following lines should be inserted after the PAFLC statement in the control module <pre> USE PLASJNT ADD PROG CALL R09806(CMLCJROW,IP000) IREC = MLG * 4 OPEN(UNIT = 79,FILE = [JOBNAME].DISP + FORM = 'UNFORMATTED',ACCESS = 'DIRECT' + RECL = IREC,STATUS = 'NEW') END OF ADD PROG </pre>
PAFLC code changes:	Insert the following lines in routine INCHDIS in PLASJNT1 before the return statement <pre> IDCHAN = 79 CALL R00401(IDCHAN,INCT,BASE,IP000,IMC2) </pre>

3.2.4 Program name:	PAFSTRAIN
Description:	The program PAFSTRAIN can be used to extract the strain values for nodes and elements in exactly the same manner as PAFSTRESS (see 3.2.1). The program accesses the ET file in which PAFLC has written the strain records. The ET file is only written if the user has requested a non-linear analysis. This file is usually deleted after completion of the analysis by the PAFLC shell commands. If required by any user then the control module option of SAVE ET FILE should be used in control module
Output file name:	[Jobname].STRAIN
Output description:	Paflc job name Option description Element or node number Load case: Group, Element, Node $u_1, u_2, u_3, u_4, u_5, u_6$ or Load case: Node $u_1, u_2, u_3, u_4, u_5, u_6, u_7, u_8$

3.2.5 Program name:	PAFSTRCAL
Description:	Sometimes it is desirable to calculate the strains at only certain sections of the structure. PAFSTRCAL will calculate the strains using the following formulae: $\epsilon_x = \frac{U_2 - U_1}{\Delta L}$

where U_1, U_2 are the displacements of the two points in the x, y or z direction and M is the distance between the two points in the x, y or z direction. The program requests the direction of the line and then a node on the line. Only the corner nodes that exist on the line are used in the above formula.

Output file name: [Jobname] STREAM

Output description: Title
Node (X, Y or Z coordinate), (X, Y or Z difference) = $(U_1 - U_2)$ or (U_1) , (Y, X or Z difference) = $(U_1 - U_2)$ or (U_1)
Paired data

3.2.6 Program name ENERGY

Description: Failure analysis of composite material involves the calculation of a number of parameters such as the strain energy density, failure fraction ($\sigma_1/\sigma_c, \sigma_2/\sigma_c$) and arc fraction. ENERGY accesses the backup store file and the SS file to retrieve the stresses and strains for orthotropic material elements only. To examine a particular point in the structure the node and element number is required. If the element number is given as zero, the program will provide a list of elements attached to that node number.

Output file name: [Jobname] ENERGY

Output description: Page# job name
Node, Element, $\sigma_1/\sigma_c, \sigma_2/\sigma_c, \sigma_3/\sigma_c, \sigma_1/\sigma_c, \sigma_2/\sigma_c, \sigma_3/\sigma_c$
Data
Total energy
Available energy
DV
DA1
DA2
DA3
Message depicting whether DV, DA1, DV, DA2 or DV, DA3 is the maximum

3.2.7 Program name MODAL

Description: Analysis of viscoelastic material using the PALLC dynamic analysis, involves determining the modal strain energy for each element and for each mode shape. PALLC produces tables of strain energy, but it is convenient to manipulate these tables in terms of the elements defined as viscoelastic. The MODAL program calculates the strain energy for each element and mode and assumes that the viscoelastic elements are defined as group 1 in the numerical model. The loss factor for the viscoelastic elements is assumed to be 1. The table names are MODAL, the elemental output file el's file must not be deleted at the end of the run. To stop the PALLC shell command from determining the file the option SAVEFILE must be included in the command module.

Output file name: [Jobname] MODAL

Output description: Title
Element, Mode 1, Mode 2, ..., Mode 10
Data
Element, Mode 11, Mode 12, ..., Mode 20

Data
 For each Model number the following:
 Model Strain energy of ψ_{vib} (electrostatic)
 Model Strain energy of ψ_{vib} (magnetic)
 Loss Factor for ψ_{vib} (electrostatic)
 Loss Factor for ψ_{vib} (magnetic)

4. DISCUSSION

The suite of programs outlined in this report are useful tools in analyzing PAFC numerical models. The programs allow repetitive work to be carried out with the minimum effort. They do not take away the need for the user to check information and if doubt occurs, then the PAFC output should generally be believed before the output from the particular program. As mentioned earlier, extensive error trapping is performed, but sometimes the path through the program that the user takes may cause a problem to arise.

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