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Element Load Data Processor (ELDAP) User's Manual

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Summary

Often, the shear and tensile forces and moments are extracted from finite element analyses to be used in off-line calculations for evaluating the integrity of structural connections involving bolts, rivets, and welds. Usually the maximum forces and moments are desired for use in the calculations. In situations where there are numerous structural connections of interest for numerous load cases, the effort in finding the true maximum force and/or moment combinations among all fasteners and welds and load cases becomes difficult. The Element Load Data Processor (ELDAP) software described herein makes this effort manageable. This software eliminates the possibility of overlooking the worst-case forces and moments that could result in erroneous positive margins of safety and/or selecting inconsistent combinations of forces and moments resulting in false negative margins of safety. In addition to forces and moments, any scalar quantity output in a PATRAN (MSC Sofware Corporation) report file may be evaluated with this software.

This software was originally written to fill an urgent need during the structural analysis of the Ares I–X Interstage segment. As such, this software was coded in a straightforward manner with no effort made to optimize or minimize code or to develop a graphical user interface.

Symbols

A	percent yield at maximum preload for yield strength interaction; (percent of F_{t_y})$/F_{t_u}$ for ultimate strength interaction. See Equations (19) to (21).
A_t	fastener tensile area
B	$n\phi SF/F_{t_y}A_t$ for yield strength interaction; $n\phi SF/F_{t_u}A_t$ for ultimate strength interaction. See Appendix A.
C	$SF/0.577F_{t_y}A_t$ for yield strength interaction; $SF/0.577F_{t_u}A_t$ for ultimate strength interaction. See Appendix A
F_r	resultant force
F_{t_y}	fastener material tensile yield stress
F_{t_u}	fastener material ultimate tensile stress
$F_{x,y,z}$	force components
$[IM]$	matrix of stress ratios
M_r	resultant momentum
$M_{x,y,z}$	moment components
n	loading plane factor (Ref. 1)
$R_{a,b,s}$	stress ratios due to axial, bending, and shear loads, respectively

*NASA Glenn Research Center's Lewis' Educational and Research Collaborative Internship Project (LERCIP).

$R_{x,y,z}$	stress ratio components
SF	yield factor of safety for yield strength interaction; ultimate factor of safety for ultimate strength interaction (Ref. 1)
[Shear]	matrix of shear values
$V_{x,y,z}$	shear force components
x, y, z	force coordinates
ϕ	load factor (Ref. 1)

Introduction

Bolts are frequently modeled in NASTRAN (MSC Sofware Corporation) as rigid, beam, or spring finite elements for the purpose of extracting forces and moments to be used in subsequent off-line bolted-joint calculations; and also in the case of beam and spring elements, to model the bolt or bolted joint stiffness. Typically, the grid point (GP) force or multipoint constraint (MPC) force components are extracted at each GP associated with the rigid finite element representing the fastener. Element forces may be extracted from the beam and spring elements if they are used. Typically, the square root of the sum of the squares (i.e., the root-sum-square (RSS)) of two of the force components is computed to arrive at the shear force on the fastener. The third force component is usually the fastener axial force. Similar approaches may be used to evaluate welded and riveted connections.

To obtain fastener forces, especially for multiple load cases, it is convenient to generate a report file using PATRAN (MSC Software Corporation), listing the GP or MPC forces as shown in Figure 1. For each load case, the report file can be made to list the x,y,z-coordinates of the GPs, as well as the GP x, y, and z force components. PATRAN automatically lists the GP number (denoted in the PATRAN report file as “Entity ID”). Concluding the report file is a summary of the maximum force components correlated with their corresponding GP and load case. The x, y, and z force components may be output with respect to any coordinate system within PATRAN.

The Element Load Data Processor (ELDAP) was originally intended for use solely on GPs and consequently is limited to reading seven different data quantities, which were envisioned to cover GP identification number “ID,” three coordinates, and three forces or moments as previously mentioned. However, ELDAP can accommodate element forces as well. When element forces are requested in the PATRAN report file, PATRAN automatically outputs an element position ID along with the element ID, consequently taking up two data quantities and leaving five remaining data quantities choices. For example, when working with element forces the PATRAN report file could be specified to list any two of its coordinates (x, y, z), and its three x, y, and z force components. The element (Entity) ID and position ID are automatically generated, resulting in seven data quantities.

Generally, the maximum force components do not result from the same load case or GP (fastener) location. This is shown in Figure 1, where load cases 17, 5, and 19 produce the maximum x, y, and z force components, respectively, at GPs 94467, 102339, and 136846, respectively. It is straightforward to use the maximum force components listed in the report summary to calculate the fastener shear force, even if the forces did not originate from the same load case and/or GP. Doing this results in what is known as a maximum-on-maximum load, often referred to as a “max-on-max load,” giving the largest shear force. This approach, being straightforward and convenient, will yield conservative bolted-joint margins of safety. However, this may result in the unnecessary selection of higher strength fasteners and possible false negative margins.

```
                    MSC.Patran 13.1.116 Wed Jul 13 16:35:27 PDT 2005 - Analysis Code: MSC.Nastran
                                        Load Case: LC2_CLL_112, A1:Static Subcase
                                Result Grid Point Forces, MPC Forces - Layer (NON-LAYERED)
                                                    Entity: Node Vector
-Entity ID---X Location----Y Location----Z Location---X Component---Y Component---Z Component--
    6152      105.377495     91.499001    -23.078138    -19.547529    386.995941   1281.157471
    6890      105.388878     91.499001    -23.077343     19.559011   -386.995361  -1281.157471
   10325      105.193832     87.284004    -23.901379    -42.651321    807.220459   -443.229462
   10328      105.205399     87.284004    -23.900581     42.676682   -807.219177    443.229462
                                                            .
                                                            .
                                                            .
   157649    -105.377495     91.499001     23.078138      7.378895    591.447510   2317.700928
                                                            .
                                                            .
                                                            .
                    MSC.Patran 13.1.116 Wed Jul 13 16:35:27 PDT 2005 - Analysis Code: MSC.Nastran
                                        Load Case: LC2_CLL_180, A1:Static Subcase
                                Result Grid Point Forces, MPC Forces - Layer (NON-LAYERED)
                                                    Entity: Node Vector
-Entity ID---X Location----Y Location----Z Location---X Component---Y Component---Z Component--
                                                            .
                                                            .
                                                            .
  102339     -105.193832     55.751999    -23.901379    189.988785  -2116.347900     -9.334555
                                                            .
                                                            .
                                                            .
  104272     -105.205215     55.751999    -23.900572   -189.914902   2116.354492      9.334555
                                                            .
                                                            .
                                                            .
```

Figure 1.—PATRAN (MSC Software Corporation) report file.

```
                    MSC.Patran 13.1.116 Wed Jul 13 16:35:27 PDT 2005 - Analysis Code: MSC.Nastran

                                          Load Case: LC2_CLL_150b, A1:Static Subcase

                               Result Grid Point Forces, MPC Forces - Layer (NON-LAYERED)

                                                         Entity: Node Vector

-Entity ID---X Location----Y Location----Z Location---X Component---Y Component---Z Component--
                                                              .
                                                              .
                                                              .
   94463     -105.193832     51.248001    -23.901379    235.726196  -1539.571045   -114.715668
   94467     -105.205315     51.248001    -23.900595   -235.672455   1539.579224    114.715668
                                                              .
                                                              .
                                                              .
                    MSC.Patran 13.1.116 Wed Jul 13 16:35:27 PDT 2005 - Analysis Code: MSC.Nastran

                                          Load Case: LC2_CLL_180b, A1:Static Subcase

                               Result Grid Point Forces, MPC Forces - Layer (NON-LAYERED)

                                                         Entity: Node Vector

-Entity ID---X Location----Y Location----Z Location---X Component---Y Component---Z Component--
                                                              .
                                                              .
                                                              .
  136846     -107.743629     98.284004     -5.585488    -56.072708   -700.699341  -9804.161133
  138341     -107.730316     98.284004     -5.585574     56.072708    700.699341   9804.161133
                                                              .
                                                              .
                                                              .
```

Figure 1.—Continued.

```
                    SUMMARY INFORMATION
                    ___________________

                      Min/Max Values

     -Source ID--Entity ID--X Component--
Min:     17       94467      -235.672455
Max:     17       94463       235.726196
     -Source ID--Entity ID--Y Component--
Min:      5      102339     -2116.347900
Max:      5      104272      2116.354492
     -Source ID--Entity ID--Z Component--
Min:     19      136846     -9804.161133
Max:     19      138341      9804.161133

                                                  Result Sources
-Source Id---Loadcase Name---------Subcase Name---------Layer Name----
     1       LC2_CLL_112           A1:Static Subcase    (NON-LAYERED)
     2       LC2_CLL_135           A1:Static Subcase    (NON-LAYERED)
     3       LC2_CLL_150           A1:Static Subcase    (NON-LAYERED)
     4       LC2_CLL_165           A1:Static Subcase    (NON-LAYERED)
     5       LC2_CLL_180           A1:Static Subcase    (NON-LAYERED)
                                          .
                                          .
                                          .
    17       LC2_CLL_150b          A1:Static Subcase    (NON-LAYERED)
    18       LC2_CLL_165b          A1:Static Subcase    (NON-LAYERED)
    19       LC2_CLL_180b          A1:Static Subcase    (NON-LAYERED)
```

Figure 1.—Concluded.

A list of the load cases containing one of the maximum force components is provided in the PATRAN report summary. One should not usually RSS the two force components from a load case listed in the PATRAN report summary, as this generally will not yield the maximum shear force. As an example, consider the hypothetical load case summary as shown in Figure 2. Here, the load cases that contain one of the maximum force components are listed. There are four load cases total, meaning one load case is not listed because it does not have a maximum force component. Here the maximum forces (fastener loads) in the x-, y-, and z-directions occur in load cases 2, 3, and 1, respectively. Assume the

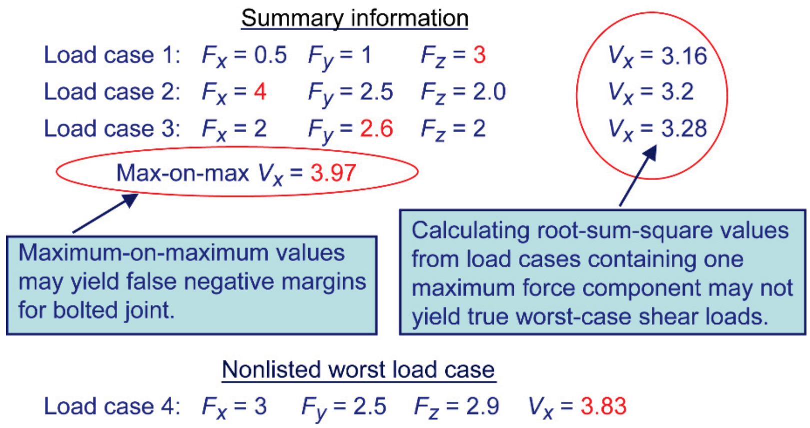

Figure 2.—Hypothetical load summary where $F_{x,y,z}$ are force components and V_x is shear force in y,z-plane.

analyst wants to calculate the shear force in the y,z-plane. If the analyst performs an RSS of the *y* and *z* force components from the same load case, the resultant shear force from load cases 1, 2, and 3 would be 3.16, 3.2, and 3.28 lbf, respectively. However, these load cases do not produce the largest shear force. This occurs in load case 4 where the shear force is 3.83 lbf. Load case 4 was not listed in the summary because its force components were not a maximum. Therefore, it is also possible to use loads that are too low resulting in false positive margins of safety. Note that the examples in this report use English units (lbf, in.) though metric units apply (N, m) and could be used as well.

Element Load Data Processor (ELDAP) is a program based on MATLAB (The Mathworks, Inc.) that was developed to directly address these problems. The purpose of the program is to provide a tool that will enable the analyst to determine the maximum shear load and corresponding axial load from among multiple load cases and grid points using the PATRAN-generated report file. Specific GPs (fasteners) may be selected, shear forces in different planes and their corresponding axial forces may be obtained, and GP (fastener) loads and positions may be plotted. This program will enable the analyst to compute more-accurate bolted-joint margins by avoiding possible false negative margins as a result of using max-on-max loads, and by avoiding missing the true maximum bolt loads arising out of the use of the summary load cases containing one maximum force component.

Equations

Originally the program was developed to calculate fastener shear forces (by use of an RSS of two scalar forces) and also provide the third consistent scalar quantity, fastener axial load, associated with the two RSS components; consequently this report will focus on these aspects as the primary example. However, the program can calculate the RSS of any two or three scalar quantities that PATRAN provides as output.

This section will present the equations used in this program to calculate the forces and moments from the ELDAP input file (PATRAN report file). As previously mentioned, fastener shear forces will be the focus of the example. However, as shown below, the equations are applicable to moments as well as forces. ELDAP first reads the PATRAN report file and converts its data into matrix form to be used in subsequent calculations as shown in Equations (3) to (13). Equations (3) to (5) are used to calculate the shear forces $V_{x,y,z}$ from the three force components F_x, F_y, and F_z. Subscripts on V refer to the axis normal to the plane of shear (refer to Fig. 3). Equation (6) calculates the resultant of all three force components. By replacing F_x, F_y, and F_z with M_x, M_y, and M_z, respectively, the moment components may be RSS'd as shown in Equations (7) to (10).

Up to this point, fastener axial and shear loads have been treated separately and not in combination. The interaction equation in Reference 1 combines stress ratios R due to axial, bending, and shear loads:

$$\left(R_a + R_b\right)^2 + R_s^3 \le 1 \tag{1}$$

ELDAP can determine the worst-case fastener loads based on a combination of both axial and shear loads, also represented by an interaction equation. The interaction Equations (11) to (13) are derived in Appendix A and are based on the equations in Reference 1. The interaction equations of Reference 1 include the effects of bolt bending; however, the interaction Equations (11) to (13) used in the present work omit the bolt bending term for simplicity.

$$R_a^2 + R_s^2 \le 1 \tag{2}$$

In accordance with Reference 1 it is desired that the quantities R_x, R_y, and R_z be less than or equal to 1 for fastener shanks parallel to the x-, y-, or z-directions, respectively.

The constants A, B, and C are functions of the material properties and geometry of both the fastener and the joint and are defined in the Nomenclature section of this report and derived in Appendix A. These three constants are input into ELDAP if the calculation of the interaction equations is desired.

$$V_x = \sqrt{F_y^2 + F_z^2} \tag{3}$$

$$V_y = \sqrt{F_x^2 + F_z^2} \tag{4}$$

$$V_z = \sqrt{F_x^2 + F_y^2} \tag{5}$$

$$F_r = \sqrt{F_x^2 + F_y^2 + F_z^2} \tag{6}$$

$$M_{yz} = \sqrt{M_y^2 + M_z^2} \tag{7}$$

$$M_{xz} = \sqrt{M_x^2 + M_z^2} \tag{8}$$

$$M_{xy} = \sqrt{M_x^2 + M_y^2} \tag{9}$$

$$M_r = \sqrt{M_x^2 + M_y^2 + M_z^2} \tag{10}$$

$$R_x = \left(A + BF_x\right)^2 + \left(C\sqrt{F_y^2 + F_z^2}\right)^3 \tag{11}$$

$$R_y = \left(A + BF_y\right)^2 + \left(C\sqrt{F_x^2 + F_z^2}\right)^3 \tag{12}$$

$$R_z = \left(A + BF_z\right)^2 + \left(C\sqrt{F_x^2 + F_y^2}\right)^3 \tag{13}$$

The quantities calculated in Equations (3) to (6) and (7) to (10) are shown in Figures 3 and 4, respectively. Equations (3) to (6) are used to form four individual vectors in ELDAP: V_x, V_y, V_z, and F_r, which are subsequently arranged in columns to form the matrix of shear values: [Shear] = [V_x V_y V_z F_r], as shown in Figure 5. If moment quantities were generated in the PATRAN report file, this matrix would consist of four column vectors of moments [M_{yz} M_{xz} M_{xy} M_r].

ELDAP determines the maximum value of Equations (3) to (13) and reports them in 11 output files, 1 each for the 11 calculated quantities. The files are described in the section "Output Files."

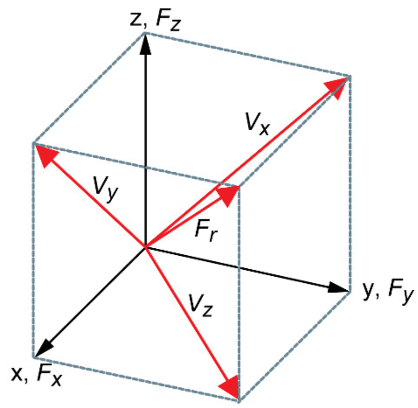

Figure 3.—Shear forces $V_{x,y,z}$ and resultant force F_r with respect to force components $F_{x,y,z}$.

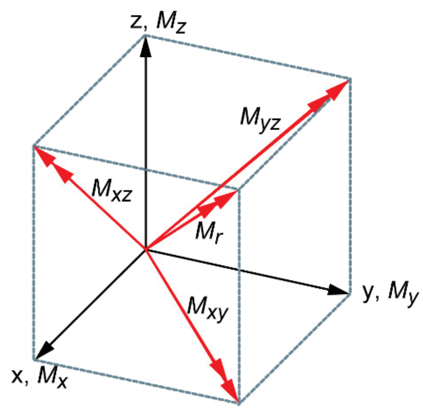

Figure 4.—Moments $M_{xy,xz,yz}$ and M_r with respect to moment components $M_{x,y,z}$.

These are the calculations made from the last three
columns of each load case (matrix M)

Vx	Vy	Vz	Fr
1336.910700	1279.983308	386.949527	1337.052248
1336.910532	1279.983483	386.949524	1337.052247
921.978301	449.532650	807.199307	922.955663
921.977126	449.535043	807.199298	922.955655
2996.716673	2993.515464	138.565387	2996.718707
2996.716677	2993.515460	138.565387	2996.718707
1569.413657	1274.295747	918.530960	1570.125473
1569.414514	1274.294678	918.530940	1570.125462
4438.840459	4379.917682	720.894669	4438.844030
4438.840479	4379.917661	720.894666	4438.844030
1565.275950	1357.112018	790.693334	1567.966482
852.244167	769.407175	455.491546	873.435764
1605.490155	1426.171544	756.400025	1609.923120
1138.256118	1057.540873	495.348334	1153.123944
1422.372006	1304.158113	613.808841	1431.909879
1472.718112	1321.714669	679.184347	1479.378194
5145.043366	5040.770290	1030.597532	5145.044589
668.093756	548.199774	467.235436	694.687416
668.097576	548.195122	467.235441	694.687419
1565.277390	1357.110349	790.693320	1567.966475
852.247083	769.403948	455.491551	873.435767
1605.491887	1426.169579	756.399998	1609.923108
1138.258460	1057.538351	495.348330	1153.123942
1422.374163	1304.155762	613.808843	1431.909880
1472.720095	1321.712455	679.184339	1479.378190
5145.043342	5040.770303	1030.597470	5145.044576
5566.308307	5457.745959	1094.117333	5566.321580
5566.308355	5457.745930	1094.117430	5566.321599
5573.879569	5479.005194	1024.956806	5573.964829
5298.053740	5296.683299	120.642423	5298.055398
520.352369	379.036501	434.412771	549.158316
5573.879614	5479.005153	1024.956830	5573.964833
5745.425428	5739.797243	254.394740	5745.428723
5298.053742	5296.683297	120.642421	5298.055398
520.356588	379.030721	434.412781	549.158324
5745.425433	5739.797239	254.394743	5745.428723
5288.944781	5230.297284	787.965145	5289.132048
3841.968194	3839.214855	161.176558	3842.282407
5904.629305	5903.688393	123.762789	5904.807410
5288.944799	5230.297268	787.965162	5289.132050
3841.968245	3839.214804	161.176554	3842.282407
5904.629315	5903.688382	123.762793	5904.807410
5198.865162	5166.131962	586.105688	5199.069065
457.163287	324.429306	401.946911	487.757094
5766.569289	5766.506567	43.066152	5766.618335
5198.865148	5166.131974	586.105675	5199.069064
2174.805757	2157.782563	271.924309	2174.827407
457.167542	324.423308	401.946909	487.757092
5766.569288	5766.506568	43.066150	5766.618335

Figure 5.— ELDAP output file of matrix of shear values, [Shear].

User's Section

ELDAP is an interactive program running in MATLAB. It requires a PATRAN report file and optionally a text file of GPs arranged in one row and delimited by commas. This section will present the steps necessary to generate the ELDAP input files. The program input prompts and graphing options will be discussed. An example of the required input file as well as the output files will be shown. In this report "node" will be synonymous with "grid point."

Generating the PATRAN Results (ELDAP Input) File

The analyst must request the appropriate output quantities (GP forces, MPC forces, or element forces) in the NASTRAN bulk data file to be able to capture them in a PATRAN report file. This section will demonstrate the on-screen process for calculating fastener forces using GP forces and MPC forces. Note that terms in brackets ⟨ ⟩ are buttons, bold terms are categories, and italic terms are options to select.

Place the desired GPs and finite elements representing the fasteners in the PATRAN display window. This may be accomplished by creating a group within PATRAN consisting solely of the finite elements and their GPs representing the fasteners. If GP or MPC forces were requested as output quantities in NASTRAN, all that is needed in the PATRAN group are the GPs. Shown in Figure 6 is an example of GPs representing a pattern of bolts. In PATRAN, select the ⟨Results⟩ button and choose **Action:** *Create*, **Object:** *Report*, and **Method:** *Overwrite File* as shown in Figure 7. Continuing to refer to Figure 7, select the desired result cases in the **Select Result Cases(s)** list box. Select the desired output quantities: *Grid Point Forces*, *MPC Forces* from the **Select Report Result** list box. Select the quantities: *X Location*, *Y Location*, *Z Location*, *X Component*, *Y Component*, and *Z Component* from the **Select Quantities** list box.

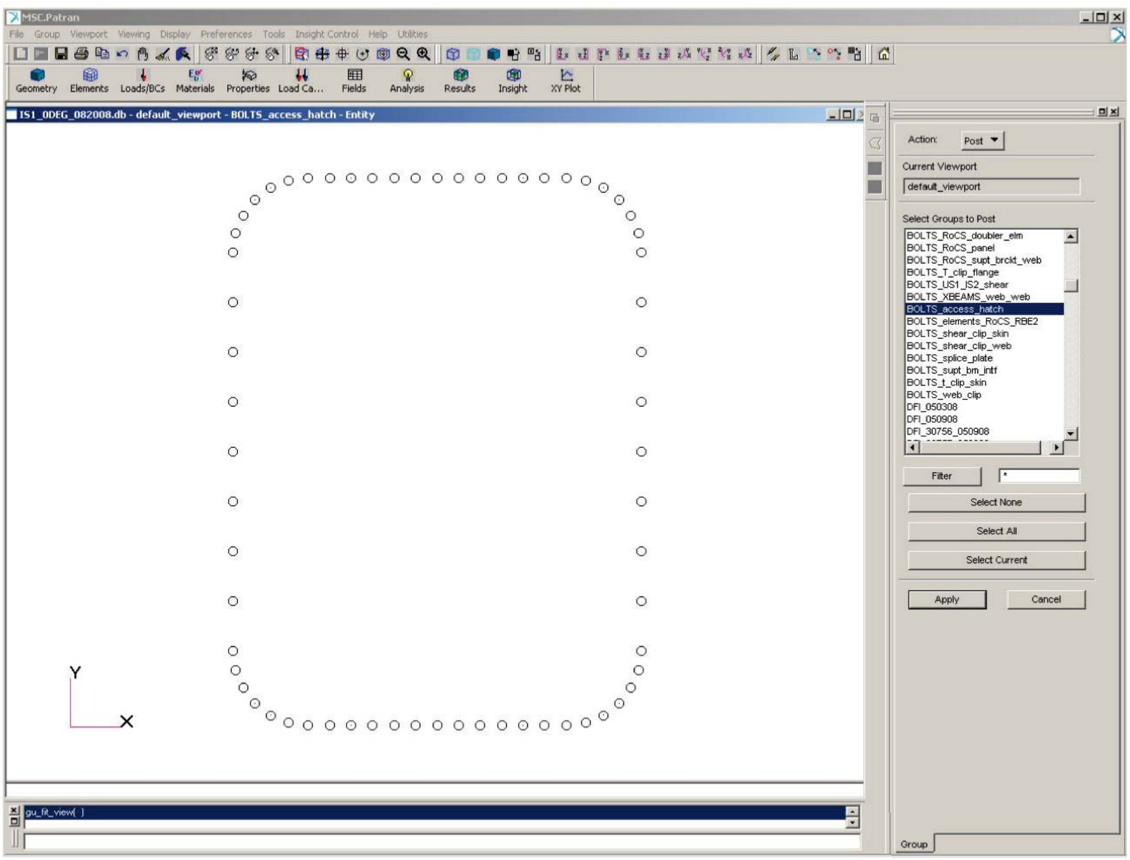

Figure 6.—PATRAN (MSC Software Corporation) viewport showing rigid (RBE2) elements used to model fasteners.

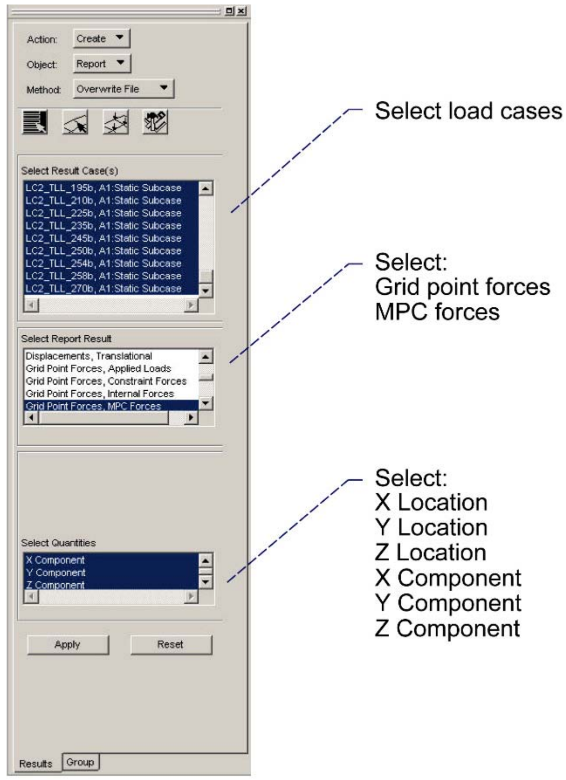

Figure 7.—Processing PATRAN (MSC Software Corporation) results to generate ELDAP input file. Selecting case(s), report result, and quantities.

As shown in Figure 8, select the ⟨Target Entities⟩ icon and select *Current Viewport* from the drop-down box. Under **Addtl. Display Control**, select *Nodes* from the drop-down box.

Referring to Figure 9, select the ⟨Display Attributes⟩ button and choose ⟨File…⟩. If necessary, create the folder where the report file will reside and type in the desired name of the report file. For **Report Type**, select *Full* from the drop-down box, which will generate all of the GP/MPC forces for all of the GPs residing in the viewport window or current group for the selected load cases. Select ⟨Apply⟩ to generate the report file. Note that the forces will be generated for all GPs in the active group even if the analyst has zoomed in and the GPs are not all showing in the viewport window.

Figure 1 is an excerpt from a PATRAN-generated results file, which is the ELDAP input file. Most of the file has been eliminated for clarity. The first several lines of data for selected load cases are shown, followed by the Summary Information section containing the maximum force components and their corresponding load case. Lastly, an index correlating load case number with load case name is presented, most of which has also been eliminated for clarity.

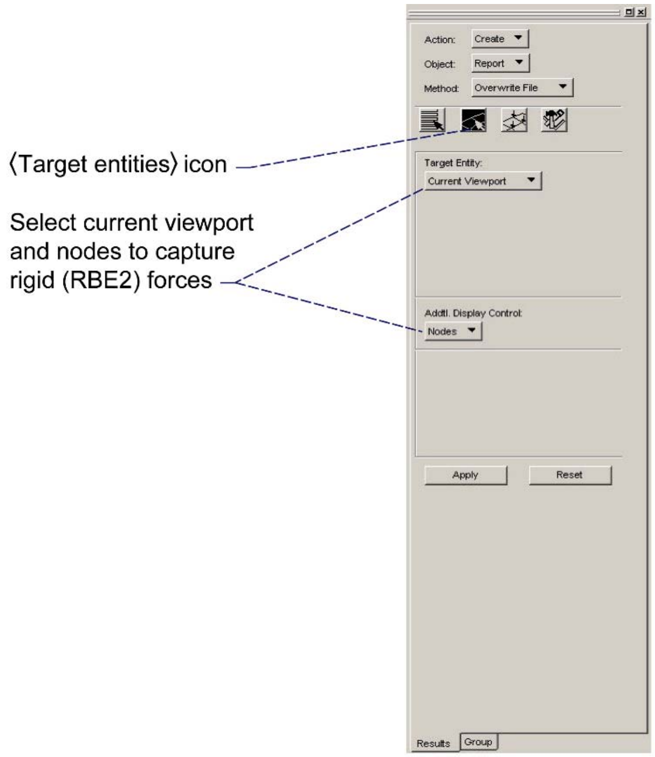

Figure 8.—Processing PATRAN (MSC Software Corporation) results to generate ELDAP input file. Selecting target entities.

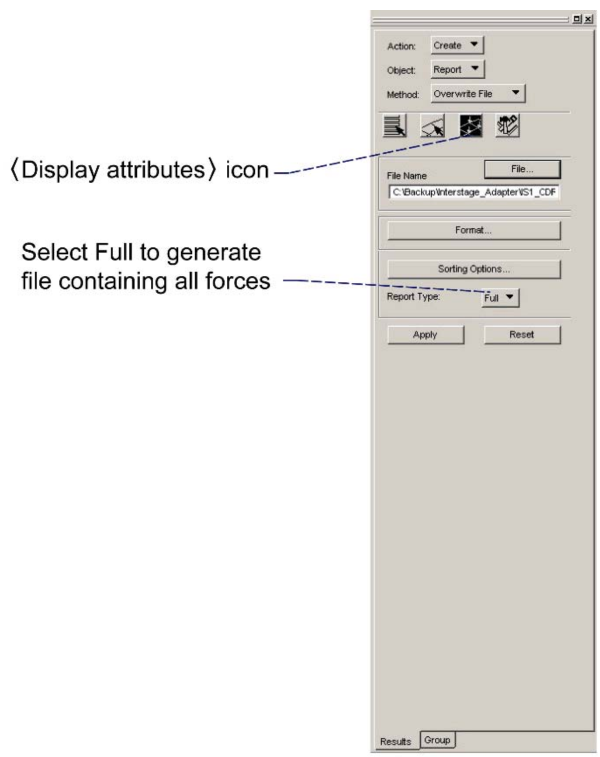

Figure 9.—Processing PATRAN (MSC Software Corporation) results to generate ELDAP input file. Selecting report type.

Prompts

This section is a brief overview of the input prompts that appear on the MATLAB window when ELDAP is run. As previously mentioned, this discussion will focus on extracting and calculating fastener loads, but the program may be used for any other available PATRAN output quantity (whether or not it makes sense). Figure 10 shows the MATLAB command line prompts and entries for this program. The first of the prompts will ask the user to enter the name of the file that contains the PATRAN report containing the GP, MPC, or element force data, followed by prompts for the number of load cases, and the number of nodes (GPs). The next prompt will ask the user if it is desired to calculate the fastener shear and tension interaction equation for each fastener. If so, the user is next prompted for the parameters A, B, and C as defined in the Symbols list at the beginning of this report. The user can enter the values of A, B, and C based on either yield or ultimate strengths (even though the prompt for A refers to yield). ELDAP is capable of processing any number of load cases and nodes (fasteners), subject to the limitations of NASTRAN, PATRAN, and MATLAB. As presented in the section "Output Files," ELDAP determines the maximum values of V_x, V_y, V_z, F_r (or M_{yz}, M_{xz}, M_{xy}, M_r), R_x, R_y, and R_z from among all load cases and GPs using Equations (3) to (13) and reports them along with their other corresponding consistent forces or moments in output files, one each for the calculated quantities. Additionally, ELDAP outputs the matrix of shear values, [Shear] = [V_x V_y V_z F_r], and the matrix of stress ratios, [IM] = [R_x R_y R_z]. If moments are being evaluated, the matrix of shear values contains the moments, [Shear] = [M_{xy} M_{xz} M_{yz} M_r]. The subsequent prompts give the user the option of adding a standard prefix to the default file names (the default file names would then be a suffix) and asks the user to enter the desired prefix or hit return to accept the default file name listed on the screen. The default file names are Vcalc.out, Vx.out, Vy.out, Vz.out, Fr.out, Fx.out, Fy.out, Fz.out, Rcalc.out, Rx.out, Ry.out, and Rz.out. The user also has the option of changing the default name of each separate output file to a chosen name (e.g., Myname.out). If the *prefix* option is chosen, it will be used either for the default names (e.g., *prefix*Vx.out) or the chosen names (e.g., *prefix*Myname.out).

The subsequent prompts ask the user to enter the name of a file containing a list of specific GPs to be evaluated and if there is not one, to hit return. If a file name is entered, ELDAP makes calculations only on the GPs contained in that file. To use this option, the analyst must first construct a text file by creating a list of the desired GPs, making sure to delimit the list with commas and limit the list to one row of text.

Next, ELDAP prints to the screen the maximum values and corresponding load cases for V_x, V_y, V_z, F_r, R_x, R_y, R_z, F_x, F_y, and F_z.

The remaining prompts allow the analyst to make three types of plots of the processed data. The first of these prompts enables the analyst to make a three-dimensional (3D) plot of the original and processed data. To do this the analyst is asked to enter the load case from which to plot the data and also to enter the specific quantities to plot on the x-, y-, and z-axes. The user can refer to the data just printed to the screen to help choose which load case is of most interest. When entering the quantities to be plotted, the analyst needs to be aware of the orientation of the model to be sure to plot what is desired. ELDAP gives the analyst the option of making up to 15 consecutive plots. The second plot request will produce a graph of the location of the GPs along with their corresponding GP number. The third plot request will provide a graph of any one of the calculated quantities from Equations (3) to (13) for a particular GP (fastener) for each load case.

The last ELDAP request will provide the opportunity to print all of the output files to the screen in concatenated form.

```
Please input the name of the file from Patran to be opened (extension required)    ELDAPInput.rpt

Input the number of load cases      56

Input the number of grid points     128


Do you want to Calculate the following interaction equation for each fastener?
(A+B*Pext)^2+(C*V)^3 (y/n)        y

Input A ( Percent of fastener yield strength at maximum preload)      0.65
Input B (n*phi*SF/(Ft*At))     0.0000175
Input C (1/0.577*Ft*At)        0.000249

The results from the shear calculations that are performed on the filename
entered above are stored in the Shear matrix. This matrix along with
the shear calculations and maximum values for vectors: Vx  Vy  Vz  Fr, and the
force vectors: Fx Fy Fz are printed to output files.  The following prompts provide
different options for naming these output files. Type in a name of your choosing,
or hit return to accept the default name listed
Example: (filename.out)


Would you like to add a pre-fix to the beginning of each
output file name? (y/n)    y

Enter pre-fix      Mon_10_27_14_

Enter a name for the file containing the Shear matrix.
Default  (Mon_10_27_14_VCalc.out)     ⟨Enter⟩


Enter a name for the file containing the Interaction Equation Matrix.
Default  (Mon_10_27_14_RCalc.out)     ⟨Enter⟩


Enter a name for the file containing calculations for Vx.
Default  (Mon_10_27_14_Vx.out)      ⟨Enter⟩
```

Figure 10.— MATLAB (The Mathworks, Inc.) screen capture of ELDAP input prompts. Note that entries typed in by user are in italic font, and ⟨*Enter*⟩ indicates user pressed “Enter” button (this is “Return” on some computers) to select default entry.

```
Enter a name for the file containing calculations for Vy.
Default  (Mon_10_27_14_Vy.out)     ⟨Enter⟩

Enter a name for the file containing calculations for Vz.
Default  (Mon_10_27_14_Vz.out)     ⟨Enter⟩

Enter a name for the file containing calculations for Fr.
Default   (Mon_10_27_14_Fr.out)     ⟨Enter⟩

Enter a name for the file containing calculations for Rx.
Default  (Mon_10_27_14_Rx.out)     ⟨Enter⟩

Enter a name for the file containing calculations for Ry.
Default  (Mon_10_27_14_Ry.out)     ⟨Enter⟩

Enter a name for the file containing calculations for Rz.
Default  (Mon_10_27_14_Rz.out)     ⟨Enter⟩
    Enter a name for the file containing calculations for Fx.
Default  (Mon_10_27_14_Fx.out)     ⟨Enter⟩

Enter a name for the file containing calculations for Fy.
Default   (Mon_10_27_14_Fy.out)     ⟨Enter⟩

Enter a name for the file containing calculations for Fz.
Default  (Mon_10_27_14_Fz.out)     ⟨Enter⟩

If you have a file listing specific grid points that you would like evaluated
Enter the file name. Otherwise hit return.     ⟨Enter⟩

------------Please wait while ELDAP makes Calculations----------------

Load Case for the max of Vx
27.000000
The max value for Vx
```

Figure 10.—Continued.

```
780.118104
Load Case for the max of Vy
53.000000
The max value for Vy
609.403763
Load Case for the max of Vz
27.000000
The max value for Vz
777.448122
Load Case for the max of Fr
27.000000
The max value for Fr
780.118106
Load Case for the max of Rx
27.000000
The max value for Rx
0.429828
Load Case for the max of Ry
27.000000
The max value for Ry
0.440376
Load Case for the max of Rz
53.000000
The max value for Rz
0.436478
Load Case for the max of Fx
28.000000
The max value for Fx
36.669701
Load Case for the max of Fy
27.000000
The max value for Fy
777.448120
Load Case for the max of Fz
53.000000
The max value for Fz
609.403748
Would you like to make a 3D plot of the calculated results?(y/n)    y
```

Figure 10.—Continued.

```
Enter the load case number
from which you wish to graph the results      27

Enter the three vectors that you would like to graph.
They can be one of the following coordinates: x y z
or one of the ten quantities:
 vx vy vz fr fx fy fz rx ry rz.
Enter all inputs in lower case letters

Input the vector to be plotted on the x axis      x

Input the vector to be plotted on the y axis      y

Input the vector to be plotted on the z axis      vz

Would you like to make another 3D plot of the calculated results?(y/n)   n

Would you like make a 3D plot showing the location of the grid
points?(y/n)   y

Would you like to plot fx,fy,fz,vx,vy,vz,fr,rx,ry,or rz on a particular
 grid point as a function of the load cases?(y/n)   y

Enter the grid point number
to be plotted.  130255

Enter one of the entities, fx,fy,fz,vx,vy,vz,fr,rx,ry,or rz
to be plotted.  vz

Would you like to make another plot of fx,fy,fz,vx,vy,vz,fr,rx,ry,or rz on a
 particular grid point as a function of the load cases?(y/n)   n

Would you like to print the .out files to the screen (y/n)   n
```

Figure 10.—Concluded.

Output files

ELDAP determines the maximum values of V_x, V_y, V_z, F_r (or M_{yz}, M_{xz}, M_{xy}, M_r), R_x, R_y, and R_z from among all load cases and GPs using Equations (3) to (13) and reports them along with their other corresponding consistent forces (or moments) in output files one each for the calculated quantities. The corresponding default file names are Vx.out, Vy.out, Vz.out, Fr.out, Fx.out, Fy.out, Fz.out, Rx.out, Ry.out, and Rz.out. If moments instead of forces are being evaluated, the output files Vx.out, Vy.out, Vz.out, and Fr.out contain moments instead of forces. The first output file that ELDAP generates has the default name of

Vcalc.out and contains the matrix of shear values: [Shear] = [V_x V_y V_z F_r]. This four-column matrix consists of the shear forces V_x, V_y, and V_z in the y,z-, x,z-, and x,y-planes, respectively, as well as F_r, which is an RSS of the three force components, as shown in Equations (3) to (6). If moments are being evaluated, this matrix contains the moments as calculated in Equations (7) to (10). Figure 5 is an example output file containing the matrix of shear values. The file has been shortened to fit on the page. ELDAP also calculates the interaction equation stress ratios R_x, R_y, and R_z as shown in Equations (11) to (13). These stress ratios are stored in the three-column matrix [IM] = [R_x R_y R_z]. This matrix is also printed to an output file with a default file name of Rcalc.out and in the same format as the matrix of shear values. The user has the option of naming these output files (e.g., MyName.out) or can accept the default name (e.g., Vx.out) given by the program. As previously mentioned, the user may also specify a prefix to the chosen or default file name. The default file names are included in the prompts as shown in Figure 10.

Figure 11 is an example output file for V_x, the shear force in the y,z-plane. Output files for V_y, V_z, F_r, F_x, F_y, F_z, R_y, and R_z have identical formats. In the upper left of Figure 11 is the PATRAN report file load case number and row number for the data in this load case corresponding to the maximum shear force V_x. Below that is the maximum shear force value. The NASTRAN load case that produced the maximum V_x is provided next in the center of the figure. After that is a reprint of the specific row of data from the PATRAN report file (containing the maximum V_x shear force) along with the RSS values of the combinations of the x-force (XComponent), y-force (YComponent), and z-force (ZComponent) components, denoted as V_x, V_y, V_z, and F_r per Equations (3) to (6). If moment results were used instead, the output file would have the moments about the x-, y-, and z-axes replacing the force components, and moment RSS values per Equations (7) to (10) replacing the RSS of the forces. Figure 11 presents the entire output file.

Similarly, an output file for F_x, the maximum axial force on the fastener, is also to be generated. The file also includes the same type of data and has the same format as that shown in Figure 11. The specific row of data from the PATRAN report file containing the maximum force F_x, along with the RSS values of the three combinations of the x-force (XComponent), y-force (YComponent), and z-force (ZComponent) components denoted as V_x, V_y, and V_z is also provided, where the shear force V_x corresponds to and is consistent with the axial force F_x. In this way both types of output files, one for V_x and one for F_x, provide fastener maximum shear and correlated axial load and maximum axial load and correlated shear loads, respectively.

Graphs

ELDAP provides the analyst several plotting options. The first of these options is to make a 3D graph of any combination of the 10 data quantities (x, y, z, V_x, V_y, V_z, F_r, F_x, F_y, and F_z) from a particular load case previously generated. Figure 12 is an example 3D plot showing fastener (GP) shear forces (vertical axis) at each fastener location (horizontal axes).

Figure 13 is an example of the second plotting option. This option plots the location of each GP and displays the GP number beside its corresponding location on the graph. When the GP numbers displayed on the plot overlap, the analyst can select (click) and drag the numbers apart.

The last plot option is shown in Figure 14. Here the analyst can choose to plot any of the 10 data quantities (x, y, z, V_x, V_y, V_z, F_r, F_x, F_y, and F_z) for any one node (GP) as a function of all of the load cases. In this example, the GP is listed at the top of the graph, the load is indicated on the ordinate, and load case number on the abscissa.

```
Load Case for the max of Vx
1.000000
Row Number of Load Case for max Vx
1.000000
The max value for Vx
1336.910700
The Load Case Title
                                           Load Case: LC2_CLL_112, A1:Static Subcase



Row Data Containing the max value of Vx
Entity--ID        XLocation      YLocation      ZLocation      XComponent     YComponent     ZComponent        Vx
Vy               Vz             Vr
6152.000000       105.377495      91.499001     -23.078138     -19.454901     386.460144    1279.835449    1336.910700
1279.983308     386.949527    1337.052248
```

Figure 11.—Example of ELDAP output file Vx.out, for shear force in y,z-plane, V_x.

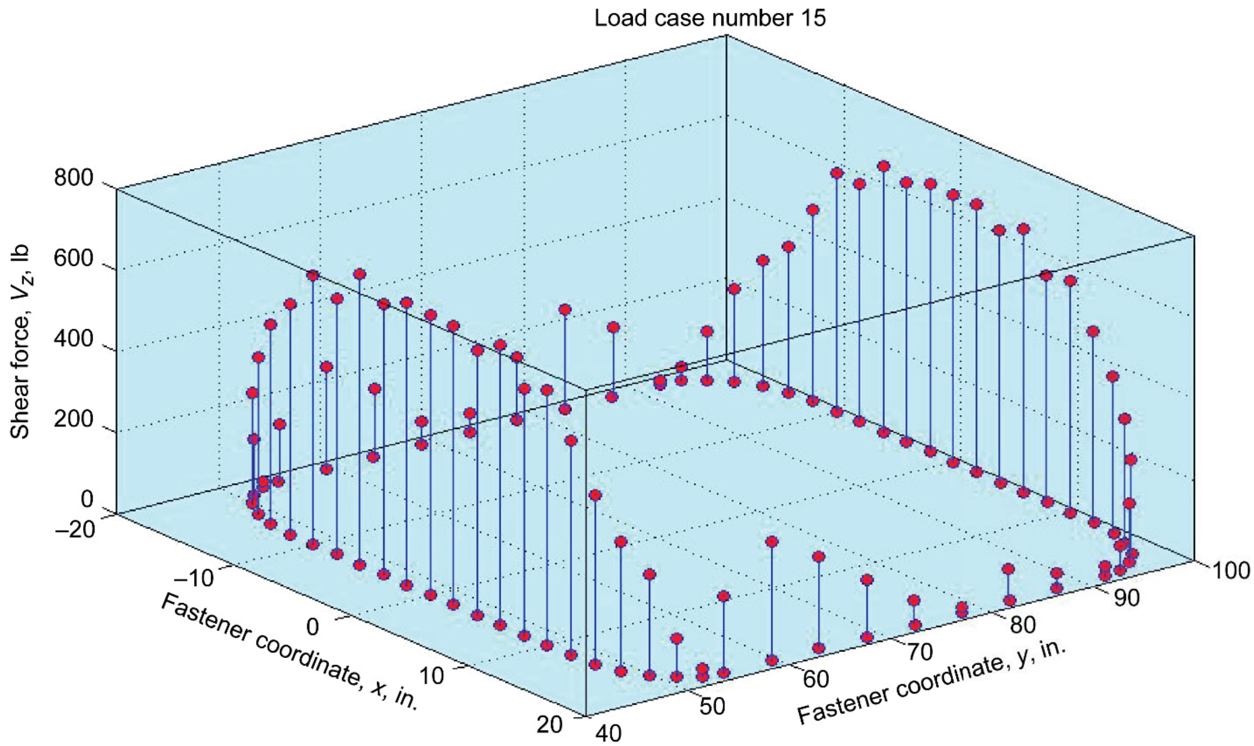

Figure 12.—ELDAP three-dimensional plot showing fastener shear force V_x at each fastener location.

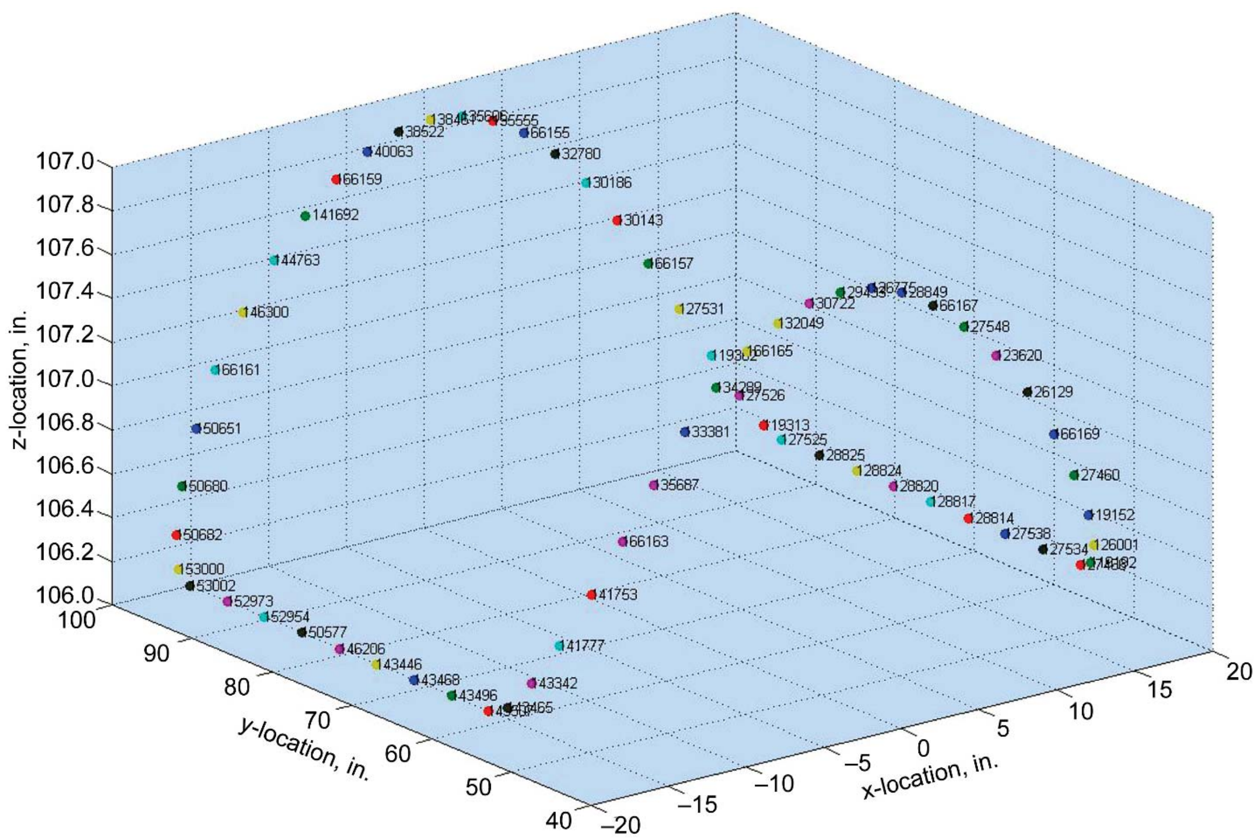

Figure 13.—ELDAP three-dimensional plot showing each fastener location. Grid point numbers are provided.

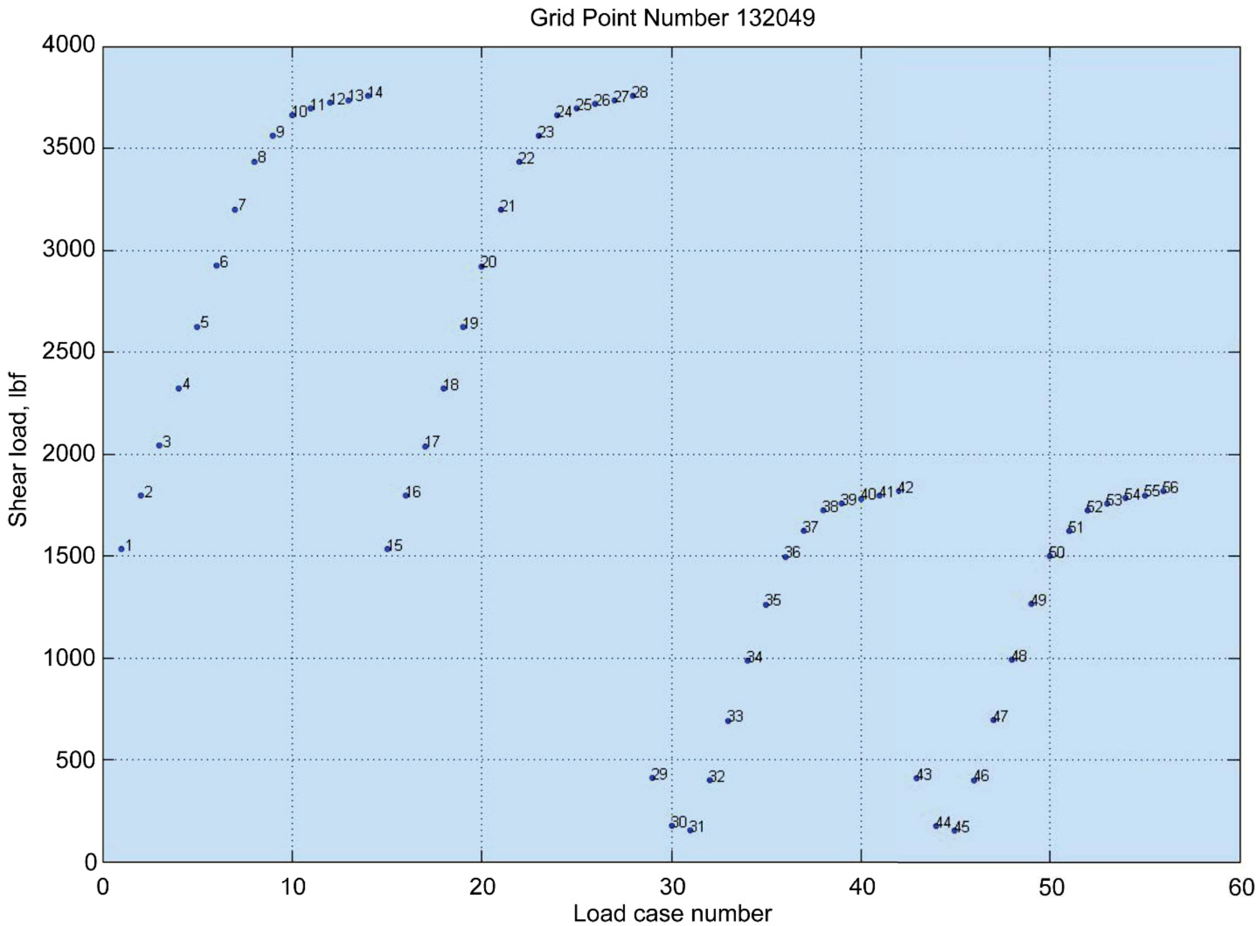

Figure 14.—ELDAP shear load (lbf) for node (grid point) 132049 as function of all load cases.

Conclusion

A MATLAB (The Mathworks, Inc.) computer program has been developed to facilitate the determination of the maximum NASTRAN (MSC Software Corporation) grid point (GP) forces and moments from among numerous GPs and numerous loads cases. This software denoted as ELDAP (Element Load Data Processor) determines the correlated shear and tension forces for each GP. The maximum shear force and corresponding tensile force or the maximum tensile force and the corresponding shear force for each GP are determined. This eliminates the possibility of recovering overly conservative loads as would be the case when only retrieving and combining the maximum force and moment components irrespective of the associated GP and load cases. It also eliminates the possibility of false positive margins that result from overlooking the root-sum-square (RSS) of less than maximum force components where the RSS would result in maximum forces. As such, this software eliminates erroneous margins of safety resulting from the use of inappropriate forces and moments. This software may also be used to evaluate any scalar quantity output from NASTRAN and PATRAN (MSC Software Corporation), in addition to the GP forces and moments.

Appendix A.—Derivation of Interaction Equations Based on Fastener Properties

When a fastener experiences multiple loads simultaneously, such as axial, bending, and shear loads, the combined effect of all of the loads on the fastener integrity can be determined using an interaction equation. A typical interaction equation for axial and shear loads, omitting bending for simplicity, is considered in this work and is shown in Equation (2):

$$R_a^2 + R_s^3 \leq 1 \tag{2}$$

Here, R_a is the ratio of the bolt axial load to the allowable axial load, and R_s is the ratio of the bolt shear load to the allowable bolt shear load. The stress ratios can be written in terms of either yield or ultimate strength. The following derivation will be based on yield strength. Similar equations may be derived based on ultimate strength by replacing F_{t_y} with F_{t_u} (except that $PLD_{\max}$ remains in terms of F_{t_y}) and by replacing the yield factor of safety with the ultimate factor of safety. The allowable axial yield load is the product of the bolt allowable yield stress F_{t_y}, and the bolt tensile area A_t.

The ratio of the bolt load to the bolt allowable yield load may be expressed as

$$R_a = \frac{P_b}{F_{t_y} A_t} \tag{14}$$

where P_b is the bolt axial load due to both the maximum preload $PLD_{\max}$, and external load P,

$$P_b = PLD_{\max} + n\phi(SF \times P) \tag{15}$$

and where n, ϕ, and SF are the loading-plane factor, load factor, and yield factor of safety, respectively, which are defined in Reference 1. Substituting Equation (15) into (14),

$$R_a = \frac{PLD_{\max}}{F_{t_y} A_t} + \frac{n\phi(SF \times P)}{F_{t_y} A_t} \tag{16}$$

Assuming the bolt shank is aligned with the z-axis, the external axial bolt load may be expressed as

$$P = F_z \tag{17}$$

The maximum bolt preload is often given as a percentage of allowable material yield stress:

$$PLD_{\max} = (\text{percent of } F_{t_y})A_t \tag{18}$$

Substituting Equations (17) and (18) into Equation (16), the axial stress ratio becomes

$$R_a = \frac{\text{percent of } F_{t_y} A_t}{F_{t_y} A_t} + \frac{n\phi(SF \times F_z)}{F_{t_y} A_t} \tag{19}$$

Recognizing the constant terms, Equation (19) can be simplified as

$$R_a = A + B \times F_z \tag{20}$$

where the constant coefficients are

$$A = \text{percent of fastener yield strength at maximum preload} \tag{21a}$$

$$B = \frac{n\phi(SF)}{F_{t_y} A_t} \tag{21b}$$

The ratio of external shear force to the allowable shear force may be expressed as

$$R_s = \frac{SF \times V}{0.577 F_{t_y} A_t} \tag{22}$$

where V is the external fastener shear force and $0.577 F_{t_y} A_t$ is the allowable shear force, where the allowable shear stress is given as $0.577\, F_{t_y}$. The factor 0.577 is an average of the allowable shear stress for alloy and carbon steels $\left(0.6 F_{t_y}\right)$ and stainless steels $\left(0.55 F_{t_y}\right)$ as given in Reference 2. Since the fastener shank is aligned with the z-axis as previously mentioned, the fastener shear force may be computed as the root-sum-square of the two force components in the x,y-plane as shown in Equation (23):

$$V = \sqrt{F_x^2 + F_y^2} \tag{23}$$

Substituting Equation (23) into (22),

$$R_s = \frac{SF \sqrt{F_x^2 + F_y^2}}{0.577 F_{t_y} A_t} \tag{24}$$

Recognizing the constant terms and simplifying, Equation (24) becomes

$$R_s = C \sqrt{F_x^2 + F_y^2} \tag{25}$$

where

$$C = \frac{SF}{0.577 F_{t_y} A_t} \tag{26}$$

Substituting Equations (20) and (25) into Equation (2), the axial and shear interaction equation for a fastener with its shank parallel to the z-axis may be expressed as

$$R_z = \left(A + B \times F_z\right)^2 + \left(C \sqrt{F_x^2 + F_y^2}\right)^3 \tag{27}$$

Similar equations may be developed for fasteners with shanks parallel to the other two orthogonal directions as shown in Equations (11) and (12) of this report.

Appendix B.—ELDAP Program Source Code

This appendix provides the source code for the Element Load Data Processor (ELDAP). This source code is written in the MATLAB programming language and was originally written to fill an urgent need during the structural analysis of the Ares I–X interstage segment. As such, this software is coded in a straightforward manner with no effort made to optimize or minimize code or to develop a graphical user interface.

```
%
%%                                    ~ELDAP~
%                           Element Load Data Processor
%
%
%%                                 NOMENCLATURE
%
%
%                                  -Variables-
%  Line#
%  (681)   A           = assigned to the function reading the input file from Patran, load case by load
%                        case
%  (1036)  AA          = variable representing load cases when making IM a matrix of all zeros when R calcs
%                        are not chosen to be calculated
%  (1036)  CC          = variable representing rows when making IM a matrix of all zeros when R calcs
%                        are not chosen to be calculated
%  (658)   dummy       = assigned to the function reading lines that aren't the load case title
%  (310)   FNF         = assigned to the number of nodes in each load case
%  (646)   file1       = assigned to the function opening the input file from Patran (Source)
%  (719)   file2       = assigned to the function opening the output file for the shear calculations
%  (800)   file3       = assigned to the function opening the output file to print the max calculations
%                        for (Vx)
%  (822)   file4       = assigned to the function opening the output file to print the max calculations
%                        for (Vy)
%  (844)   file5       = assigned to the function opening the output file to print the max calculations
%                        for (Vz)
%  (866)   file6       = assigned to the function opening the output file to print the max calculations
%                        for (Fr)
%  (1421)  file7       = assigned to the function opening the output file to print the max calculations
%                        for (Fx)
%  (1523)  file8       = assigned to the function opening the output file to print the max calculations
%                        for (Fy)
%  (1465)  file9       = assigned to the function opening the output file to print the max calculations
%                        for (Fz)
%  (947)   file12      = assigned to the function opening the output file to print the max calculations
%                        for Rx)
%  (969)   file13      = assigned to the function opening the output file to print the max calculations
%                        for (Ry)
%  (991)   file14      = assigned to the function opening the output file to print the max calculations
%                        for (Rz)
%  (902)   file15      = assigned to the function opening the output file to print the IM Matrix
```

```
%  (739)   FN1          = represents either (F*NF) or (GN) in the loop that
%                         prints (Shear) to an output file
%  (752)   FN2          = represents either (F*NF) or (GN) in the loop that
%                         prints the max calculations to an output file
%  (428)   FRMCAL       = user input to name the output file that contains
%                         the shear calculations and maximum data for (Fr)
%  (792)   Fr           = sqrt((Matrix(:,5,1:L)).^2+(Matrix(:,6,1:L)).^2+...
%                         (Matrix(:,7,1:L)).^2)
%  (583)   FXMCAL       = assigned to the user input to name the output file that contains
%                         the shear calculations and maximum data for (Fx)
%  (475)   FXPRE2       = assigned to the user chosen pre-fix to make a default
%                         output file name for Fx
%  (590)   FYMCAL       = assigned to the user input to name the output file that contains
%                         the shear calculations and maximum data for (Fy)
%  (486)   FYPRE2       = assigned to the user chosen pre-fix to make a default
%                         output file name for Fy
%  (597)   FZMCAL       = assigned to the user input to name the output file that contains
%                         the shear calculations and maximum data for (Fz)
%  (497)   FZPRE2       = assigned to the user chosen pre-fix to make a default
%  (1044)  fr           = used to define the (Fr) vector for plotting inputs
%  (1045)  fx           = assigned to the Fx force from M matrix to be
%                         plotted in the 3D plot option
%  (1046)  fy           = assigned to the Fy force from M matrix to be
%                         plotted in the 3D plot option
%  (1047)  fz           = assigned to the Fz force from M matrix to be
%                         plotted in the 3D plot option
%  (1022)  G            = assigned to the user input stating whether or not
%                         they would like to plot a 3D graph
%  (1263)  GL           = assigned to the input that asks the user if a plot
%                         of a specific fastener across all of the load cases
%                         is desired
%  (1284)  GL1          = the grid point number of the fastener to be plotted
%                         from the GL prompt
%  (629)   GN           = the number of grid points per load case to be
%                         calculated
%  (1217)  GPC          = assigned to the grid point column pulled out of the M matrix
%  (1218)  GPCCON       = assigned to the conversion of the GPC matrix from
%                         a number to a string for use in the 3D plot
%  (630)   GPL          = matrix containing specific grid points to be
%                         calculated
%  (611)GridPointSource= the name of the file containing specific grid
```

```
%                           points to be calculated
%  (1280)  Hby            = converting Kbi2 from a number to a string
%  (306)   L              = number of load cases
%  (857)   Label          = assigned to the row of labels from the original file
%                           from Patran
%  (859)   Labe2          = as the row of labels from the original file
%                           from Patran for R calcs
%  (1031)  LC             = assigned to the user input stating the Load Case from which they
%                           would like to plot
%  (1388)  LoadMaxFx      = the number of the Load Case containing the max
%                           value of (Fx)
%  (1398)  LoadMaxFy      = the number of the Load Case containing the max
%                           value of (Fy)
%  (1408)  LoadMaxFz      = the number of the Load Case containing the max
%                           value of (Fz)
%  (756)   LoadMaxVx      = the number of the Load Case containing the max
%                           value of (Vx)
%  (766)   LoadMaxVy      = the number of the Load Case containing the max
%                           value of (Vy)
%  (776)   LoadMaxVz      = the number of the Load Case containing the max
%                           value of (Vz)
%  (786)   LoadMaxFr      = the number of the Load Case containing the max
%                           value of (Fr)
%  (922)   LoadMaxRx      = the number of the Load Case containing the max
%                           value of (Rx)
%  (932)   LoadMaxRy      = the number of the Load Case containing the max
%                           value of (Ry)
%  (940)   LoadMaxRz      = the number of the Load Case containing the max
%                           value of (Rz)
%  (682)   M              = the matrix containing the file read in from Patran
%  (708)   Matrix         = Used to represent either (M) or (GRID) in the shear
%                           calculations
%  (1387)  MaxFx          = the row number in matrix (M) that contains the
%                           maximum value for (Fx)
%  (1397)  MaxFy          = the row number in matrix (M) that contains the
%                           maximum value for (Fy)
%  (1407)  MaxFz          = the row number in matrix (M) that contains the
%                           maximum value for (Fz)
%  (756)   MaxVx          = the row number in matrix (M) that contains the
%                           maximum value for (Vx)
%  (766)   MaxVy          = the row number in matrix (M) that contains the
```

```
%                          maximum value for (Vy)
%  (776)   MaxVz         = the row number in matrix (M) that contains the
%                          maximum value for (Vz)
%  (786)   MaxFr         = the row number in matrix (M) that contains the
%                          maximum value for (Fr)
%  (921)   MaxRx         = the row number in matrix (M) that contains the
%                          maximum value for (Rx)
%  (931)   MaxRy         = the row number in matrix (M) that contains the
%                          maximum value for (Ry)
%  (939)   MaxRz         = the row number in matrix (M) that contains the
%                          maximum value for (Rz)
%  (711)   MN1           = represents either (M) or (Q) in defining the
%                          vectors that can be plotted
%  (369)   MSC           = user input to name the matrix that contains the shear
%                          calculations performed on the (M) matrix or (Q) matrix
%  (648)   ncases        = assigned to number of load cases (L)
%  (320)   NEW           = User input for interaction equation question
%  (323)   NEW4          = User input for variable A of interaction equation
%  (324)   NEW2          = User input for variable b of interaction equation
%  (325)   NEW3          = User input for variable c of interaction equation
%  (358)   PRE           = the option to add a pre-fix to the out put files
%  (361)   PRE2          = the assigned prefix for the output files
%  (698)   Q             = the matrix containing the lines from (M) that are
%                          specified by (GPL)
%  (660)   r             = the matrix containing a list of the load case
%                          titles
%  (1215)  RB2           = assigned to the prompt asking user if a 3D plot of the RBE2
%                          elements is desired
%  (375)   RCalcPRE2     = assigned to the user chosen pre-fix to make a default
%                          output file name for the file containing the IM
%                          matrix that holds the R calcs
%  (381)   RMAT          = user input to name the output file that contains
%                          the IM Matrix
%  (439)   RXPRE2        = assigned to the user chosen pre-fix to make a default
%                          output file name for Rx
%  (451)   RYPRE2        = assigned to the using the user chosen pre-fix to make a default
%                          output file name for Ry
%  (463)   RZPRE2        = assigned to the using the user chosen pre-fix to make a default
%                          output file name for Rz
%  (893)   Rx            = assigned to the interaction equation for Rx
%  (895)   Ry            = assigned to the interaction equation for Ry
```

```
% (897)   Rz         = assigned to the interaction equation for Rz
% (379)   RXR        = assigned to the input prompt for the user chosen
%                      output filename for the IM matrix
% (445)   RXMCAL     = assigned to the user input to name the output file that contains
%                      the calculations and maximum data for (Rx)
% (457)   RYMCAL     = assigned to the user input to name the output file that contains
%                      the calculations and maximum data for (Ry)
% (468)   RZMCAL     = assigned to the user input to name the output file that contains
%                      the calculations and maximum data for (Rz)
% (732)   Shear      = the matrix containing the shear calculations
%                      for each load case
% (302)   Source     = the name of the input file to be opened from Patran
% (757)   Temp2      = temporarily assigned to the current max calculation
%                      for (Vx) with every cycle of the loop
% (767)   Temp3      = temporarily assigned to the current max calculation
%                      for (Vy) with every cycle of the loop
% (777)   Temp4      = temporarily assigned to the current max calculation
%                      for (Vz) with every cycle of the loop
% (787)   Temp5      = temporarily assigned to the current max calculation
%                      for (Fr) with every cycle of the loop
% (1389)  Temp6      = temporarily assigned to the current max calculation
%                      for (Fx) with every cycle of the loop
% (1399)  Temp7      = temporarily assigned to the current max calculation
%                      for (Fy) with every cycle of the loop
% (1409)  Temp8      = temporarily assigned to the current max calculation
%                      for (Fz) with every cycle of the loop
% (923)   Temp9      = temporarily assigned to the current max calculation
%                      for (Rx) with every cycle of the loop
% (933)   Temp10     = temporarily assigned to the current max calculation
%                      for (Ry) with every cycle of the loop
% (941)   Temp11     = temporarily assigned to the current max calculation
%                      for (Rz) with every cycle of the loop
% (1388)  TempFx     = the maximum value currently calculated for (Fx)
% (1397)  TempFy     = the maximum value currently calculated for (Fy)
% (1407)  TempFz     = the maximum value currently calculated for (Fz)
% (755)   TempVx     = the maximum value currently calculated for (Vx)
% (765)   TempVy     = the maximum value currently calculated for (Vy)
% (775)   TempVz     = the maximum value currently calculated for (Vz)
% (785)   TempFr     = the maximum value currently calculated for (Fr)
% (922)   TempRx     = the maximum value currently calculated for (Rx)
% (931)   TempRy     = the maximum value currently calculated for (Ry)
```

```
% (939)   TempRz     = the maximum value currently calculated for (Rz)
% (1041)  vx         = used to define the (Vx) vector for plotting inputs
% (1042)  vy         = used to define the (Vy) vector for plotting inputs
% (1043)  vz         = used to define the (Vz) vector for plotting inputs
% (785)   Vx         = sqrt((Matrix(:,6,1:L)).^2+(Matrix(:,7,1:L)).^2)
% (788)   Vy         = sqrt((Matrix(:,5,1:L)).^2+(Matrix(:,7,1:L)).^2)
% (790)   Vz         = sqrt((Matrix(:,5,1:L)).^2+(Matrix(:,6,1:L)).^2)
%                      output file name for Fz
% (363)   VCalcPRE2  = assigned to the user chosen pre-fix to make a default out
%                      put file name for the Shear Matrix
% (390)   VXPRE2     = assigned to the user chosen pre-fix to make a default out
%                      put file name for Vx
% (402)   VYPRE2     = assigned to the user chosen pre-fix to make a default out
%                      put file name for Vy
% (414)   VZPRE2     = assigned to the user chosen pre-fix to make a default out
%                      put file name for Vz
% (425)   FRPRE2     = using the user chosen pre-fix to make a default out
%                      put file name for Fr
% (394)   VXMCAL     = user input to name the output file that contains
%                      the shear calculations and maximum data for (Vx)
% (406)   VYMCAL     = user input to name the output file that contains
%                      the shear calculations and maximum data for (Vy)
% (417)   VZMCAL     = user input to name the output file that contains
%                      the shear calculations and maximum data for (Vz)
% (1038)  x          = assigned to the (x) vector while plotting inputs
% (1062)  x1         = user input defining which vector to plot on the x
%                      axis
% (367)   XSM        = assigned to the input prompt for the user chosen
%                      output filename for the Shear Matrix
% (392)   XVX        = assigned to the input prompt for the user chosen
%                      output filename for (Vx)
% (404)   XVY        = assigned to the input prompt for the user chosen
%                      output filename for (Vy)
% (412)   XVZ        = assigned to the input prompt for the user chosen
%                      output filename for (Vz)
% (426)   XFR        = assigned to the input prompt for the user chosen
%                      output filename for (Fr)
% (476)   XFX        = assigned to the input prompt for the user chosen
%                      output filename for (Fx)
% (487)   XFY        = assigned to the input prompt for the user chosen
%                      output filename for (Fy)
```

```
%  (498)   XFZ         = assigned to the input prompt for the user chosen
%                        output filename for (Fz)
%  (441)   XRX         = assigned to the input prompt for the user chosen
%                        output filename for (Rx)
%  (453)   XRY         = assigned to the input prompt for the user chosen
%                        output filename for (Ry)
%  (464)   XRZ         = assigned to the input prompt for the user chosen
%                        output filename for (Rz)
%  (1039)   y          = used to define the (y) vector for plotting inputs
%  (1064)   y1         = user input defining which vector to plot on the y
%                        axis
%  (1040)   z          = used to define the (z) vector for plotting inputs
%  (1066)   z1         = user input defining which vector to plot on the z
%                        axis
%
%%                          Description of the Different Matrices
%
%
%%                                    Matrix-M-Q
%   This is the matrix containing the readout of the rows and columns of
%   data from each load case. The indices for -M- are (R,C,L), where R is the
%   row of the load case, C is the column for the load case, and L specifies
%   which load case the R and C are from. Example: M(:,:,2) is load case 2.
%   This matrix is defined as M if the entire input file is processed or Q
%   if a list of specific grid point numbers is being processed.
%
%%                                    Matrix-r
%   This matrix contains the load case information. Each load case title is
%   saved as a new row in the matrix. The indices for -r- are (R,C) where R
%   corresponds to the number of rows which is determined by the number of
%   load cases. C is always 1 in this matrix. Example: r(3,1) is the title
%   line for load case 3.
%
%%                                  Matrix-Shear
%   This matrix contains the results from the shear calculations from the
%   last three columns of each load case (which are contained in matrix -M-).
%   The four columns of -Shear- are Vx, Vy, Vz, and Fr, where Fr is the Root
%   Sum of the Squares (RSS) of Fx, Fy and Fz.
%
%%                                  Matrix-IM
%   This matrix contains the results from the interaction calculations from the
```

```
%   last three columns of each load case (which are contained in matrix -M-).
%   The three columns of -IM- are Rx, Ry, and Rz
%
%%
%
format('short');
clear all;
clear global;
%
Source=input('Please input the name of the file from Patran to be opened (extension required)      ','s');
%
disp('   ');
%
L=input('Input the number of load cases      '); %input for # of load cases
%
disp('   ');
%
FNF=input('Input the number of grid points          ');   %input for #  of fasteners
%
disp('   ');
%
%NF=input('Input the number of grid points per element (fastener)       ');
%
disp('   ');
%%%%%%%%%%%%%%%%%%%%%%%NEW MATERIAL AS OF 1/2/2010%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
for Inter=1:20;
disp('Do you want to Calculate the following interaction equation for each fastener?');
NEW=input('(A+B*Pext)^2+(C*V)^3 (y/n)        ','s');
if NEW=='y';
    disp('  ');
    NEW4=input('Input A ( Percent of fastener yield strength at maximum preload)      ');
    NEW2=input('Input B (n*phi*SF/(Ft*At))     ');
    NEW3=input('Input C (1/0.577*Ft*At)        ');
    break;
%
%%%%%%%%%%%%%%%%%%%%%%%%%%NEW 8-10-10%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
else if NEW=='n';
        break;
    else    %GL~= 'y'||'n'
      disp('    ');
      disp('    ');
```

```
      disp('The program did not recognize the input.') ;
      disp('Enter y or n in a lowercase letter.');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
end
end
end
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%
disp('   ');
%
disp('The results from the shear calculations that are performed on the filename');
disp('entered above are stored in the Shear matrix. This matrix along with');
disp('the shear calculations and maximum values for vectors: Vx  Vy  Vz  Fr, and the  ');
disp('force vectors: Fx Fy Fz are printed to output files.  The following prompts provide ');
disp('different options for naming these output files. Type in a name of your choosing,');
disp('or hit return to accept the default name listed');
disp('Example: (filename.out)');
disp('   ');
%%
%     Loop for prefixes
%%
for PREFIX=1:20;
disp('   ')
disp('Would you like to add a pre-fix to the beginning of each');
PRE=input('output file name? (y/n)    ','s');
if PRE=='y';
    disp('   ')
    PRE2=input('Enter pre-fix      ','s');
    disp('   ');
    VCalcPRE2=[PRE2,'VCalc.out'];
    disp('Enter a name for the file containing the Shear matrix.');
    disp(['Default  ','(',VCalcPRE2,')']);
    disp('   ');
    XSM=input('     ','s');
if isempty(XSM);
   MSC = [PRE2,'VCalc.out'];
else
    MSC=[PRE2,XSM];
end
disp('   ');
%%%%%%%%%%%%NEW AS OF 8-9-10%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

```
RCalcPRE2=[PRE2,'RCalc.out'];
disp('Enter a name for the file containing the Interaction Equation Matrix.');
disp(['Default  ','(',RCalcPRE2,')']);
disp('   ');
RXR=input('    ','s');
if isempty(RXR);
     RMAT= [PRE2,'RCalc.out'];
else
     RMAT=[PRE2,RXR];
end
disp('   ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%
VXPRE2=[PRE2,'Vx.out'];
disp('Enter a name for the file containing calculations for Vx.');
disp(['Default  ','(',VXPRE2,')']);
disp('   ');
XVX=input('    ','s');
if isempty(XVX);
    VXMCAL = [PRE2,'Vx.out'];
else
    VXMCAL=[PRE2,XVX];
end
disp('   ');
%
VYPRE2=[PRE2,'Vy.out'];
disp('Enter a name for the file containing calculations for Vy.');
disp(['Default  ','(',VYPRE2,')']);
disp('   ');
XVY=input('    ','s');
if isempty(XVY);
    VYMCAL = [PRE2,'Vy.out'];
else
    VYMCAL=[PRE2,XVY];
end
disp('   ');
%
VZPRE2=[PRE2,'Vz.out'];
disp('Enter a name for the file containing calculations for Vz.');
disp(['Default  ','(',VZPRE2,')']);
XVZ=input('    ','s');
```

```
if isempty(XVZ);
    VZMCAL = [PRE2,'Vz.out'];
else
    VZMCAL=[PRE2,XVZ];
end
disp('   ');
%
FRPRE2=[PRE2,'Fr.out'];
disp('Enter a name for the file containing calculations for Fr.');
disp(['Default   ','(',FRPRE2,')']);
XVR=input('    ','s');
if isempty(XVR);
    VRMCAL = [PRE2,'Fr.out'];
else
    VRMCAL=[PRE2,XVR];
end
disp('   ');

%%%%%%%%%%%%%%%%%%%NEW on 7/27/10%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%
disp('   ');
RXPRE2=[PRE2,'Rx.out'];
disp('Enter a name for the file containing calculations for Rx.');
disp(['Default  ','(',RXPRE2,')']);
disp('   ');
XRX=input('    ','s');
if isempty(XRX);
    RXMCAL = [PRE2,'Rx.out'];
else
    RXMCAL=[PRE2,XRX];
end
disp('   ');
%
RYPRE2=[PRE2,'Ry.out'];
disp('Enter a name for the file containing calculations for Ry.');
disp(['Default  ','(',RYPRE2,')']);
disp('   ');
XRY=input('    ','s');
if isempty(XRY);
    RYMCAL = [PRE2,'Ry.out'];
else
```

```
    RYMCAL=[PRE2,XRY];
end
disp('   ');
%
RZPRE2=[PRE2,'Rz.out'];
disp('Enter a name for the file containing calculations for Rz.');
disp(['Default  ','(',RZPRE2,')']);
XRZ=input('    ','s');
if isempty(XRZ);
    RZMCAL = [PRE2,'Rz.out'];
else
    RZMCAL=[PRE2,XRZ];
end
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%
FXPRE2=[PRE2,'Fx.out'];
disp('Enter a name for the file containing calculations for Fx.  ');
disp(['Default  ','(',FXPRE2,')']);
XFX=input('    ','s');
if isempty(XFX);
    FXMCAL = [PRE2, 'Fx.out'];
else
    FXMCAL=[PRE2,XFX];
end
disp('   ');
%
FYPRE2=[PRE2,'Fy.out'];
disp('Enter a name for the file containing calculations for Fy.  ');
disp(['Default   ','(',FYPRE2,')']);
XFY=input('     ','s');
if isempty(XFY);
    FYMCAL = [PRE2,'Fy.out'];
else
    FYMCAL=[PRE2,XFY];
end
disp('   ');
%
FZPRE2=[PRE2,'Fz.out'];
disp('Enter a name for the file containing calculations for Fz.  ');
disp(['Default  ','(',FZPRE2,')']);
```

```
XFZ=input('     ','s');
if isempty(XFZ);
    FZMCAL = [PRE2,'Fz.out'];
else
    FZMCAL=[PRE2,XFZ];
end
break
disp('   ');
disp('   ');
disp('   ');
%
else if PRE =='n';
disp('   ');
disp('   ');
disp('Enter a name for the file containing the Shear matrix.');
MSC=input('Default (VCalc.out)     ','s');
if isempty(MSC);
   MSC = 'VCalc.out';
end
disp('   ');
%%%%%%%%%%%%%%%%%%%%%%%%%NEW AS OF 8-9-10%%%%%%%%%%%%%%%%%%%%%%%%%%%
disp('Enter a name for the file containing the Interaction Equation matrix.');
RMAT=input('Default (RCalc.out)     ','s');
if isempty(RMAT);
   RMAT = 'RCalc.out';
end
disp('   ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%
disp('Enter a name for the file containing calculations for Vx.');
VXMCAL=input('Default (Vx.out)     ','s');
if isempty(VXMCAL);
    VXMCAL = 'Vx.out';
end
disp('   ');
%
disp('Enter a name for the file containing calculations for Vy.');
VYMCAL=input('Default (Vy.out)    ','s');
if isempty(VYMCAL);
    VYMCAL = 'Vy.out';
end
```

```
disp('   ');
%
disp('Enter a name for the file containing calculations for Vz.');
VZMCAL=input('Default (Vz.out)    ','s');
if isempty(VZMCAL);
    VZMCAL = 'Vz.out';
end
disp('   ');
%
disp('Enter a name for the file containing calculations for Fr.');
VRMCAL=input('Default (Fr.out)     ','s');
if isempty(VRMCAL);
    VRMCAL = 'Fr.out';
%%
%%%%%%%%%%%%%%%%NEW on 7/27/10%%%%%%%%%%%%%%%%%%%%%%%%%%
disp('Enter a name for the file containing calculations for Rx.');
RXMCAL=input('Default (Rx.out)     ','s');
if isempty(RXMCAL);
    RXMCAL = 'Rx.out';
end
disp('   ');
%
disp('Enter a name for the file containing calculations for Ry.');
RYMCAL=input('Default (Ry.out)    ','s');
if isempty(RYMCAL);
    RYMCAL = 'Ry.out';
end
disp('   ');
%
disp('Enter a name for the file containing calculations for Rz.');
RZMCAL=input('Default (Rz.out)    ','s');
if isempty(RZMCAL);
    RZMCAL = 'Rz.out';
end
disp('   ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
end
disp('   ');
%
%
%
```

```
disp('Enter a name for the file containing calculations for Fx.  ');
FXMCAL=input('Default (Fx.out)     ','s');
if isempty(FXMCAL);
    FXMCAL = 'Fx.out';
end
disp('   ');
%
disp('Enter a name for the file containing calculations for Fy.  ');
FYMCAL=input('Default (Fy.out)     ','s');
if isempty(FYMCAL);
    FYMCAL = 'Fy.out';
end
disp('   ');
%
disp('Enter a name for the file containing calculations for Fz.  ');
FZMCAL=input('Default (Fz.out)     ','s');
if isempty(FZMCAL);
    FZMCAL = 'Fz.out';
end
break
else
   disp('    ');
   disp('    ');
   disp('The program did not recognize the input.') ;
   disp('Enter y or n in a lowercase letter.');
    end
 end
end
disp('   ');
%
disp('If you have a file listing specific grid points that you would like evaluated ');
GridPointSource=input('Enter the file name. Otherwise hit return.  ','s');
disp('   ');
disp('   ');
%
if isempty(GridPointSource);
    GridPointSource = 'n';
    disp('');
    disp('');
    disp('');
    disp('');
```

```
    disp('------------Please wait while ELDAP makes Calculations--------------- ');
    disp('');
    disp('');
    disp('');
    disp('');

else
    GN=input('Enter the number of grid points in this file         ');
    GPL=dlmread(GridPointSource);    % GPL=the Grid Point List that was read in
    GridPointSource= 'y';
    disp('');
    disp('');
    disp('');
    disp('');

    disp('------------Please wait while ELDAP makes Calculations--------------- ');
    disp('');
    disp('');
    disp('');
    disp('');

end
%
%
file1=fopen(Source,'r');
frewind(file1);
ncases=L;
%This loop reads out the load case line from the
%beginning of each matrix and puts them in a matrix (r)
for j=1:ncases;    %loop for load case
%
%   read the first load case description
%
   if j==1;           % j=number of load case
        for i=1:14;     % i=number of spaces to read until beginning of fastener loads
         if i~=8;
        dummy=fgets(file1);  % reading out all lines that aren't the load case
         else  i==8;
             r{j,:}=fgets(file1);    % b= first load case, changed () to {} for r everywhere 1/13/09
         end;
```

```
          end;
     end;
%
%   reading the load case descriptions after the first
%
    if j~=1;
      for ii=1:9;
         if (ii~=3);
           dummy=fgets(file1);
         else  (ii==3);
            r{j,:}=fgets(file1);   % read load case j
         end;
      end;
    end;
%
Dummy=fgets(file1);
%
%   reading the lines of numerical data in each load case
%
A=fscanf(file1,'%8f %16f %14f %14f %14f %14f %14f',[7 ((FNF)+1)]);
M(:,:,j)=A';     %M=the data output matrix
%
end;
%
M;
%
r ;
%
%%   Section comparing the read in matrix (GPL) from the grid point file to the M  matrix
%
if GridPointSource == 'y';
 for LCL=1:L;   % load case loop
     for NGP=1:GN;    % number of grid points per load case loop
      for FL=1:(FNF);   % fastener loop
        for CN=1:7;
         if M(FL,1,LCL)==GPL(1,NGP);
               Q(NGP,CN,LCL)=M(FL,CN,LCL);
         end
        end
      end
     end
```

```
 end
end
%
%%
if GridPointSource =='n';
    Matrix=M;
    FN1=(FNF);
    FN2=(FNF);
    MN1=(M);
else
    Matrix=Q;
    FN1=GN;
    FN2=GN;
    MN1=Q;
end
%
file2=fopen(MSC,'wt');
%
     % Vx=sqrt(B^2+C^2)
Vx=sqrt((Matrix(:,6,1:L)).^2+(Matrix(:,7,1:L)).^2);
%fprintf(file2,'%f\n',Vx)
     % Vy=sqrt(A^2+C^2)
Vy=sqrt((Matrix(:,5,1:L)).^2+(Matrix(:,7,1:L)).^2);
     % Vz=sqrt(A^2+B^2)
Vz=sqrt((Matrix(:,5,1:L)).^2+(Matrix(:,6,1:L)).^2);
     % Fr=sqrt(A^2+B^2+C^2)
Fr=sqrt((Matrix(:,5,1:L)).^2+(Matrix(:,6,1:L)).^2+(Matrix(:,7,1:L)).^2);
%
%
Shear=[ Vx   Vy    Vz    Fr];[CC,BB,AA]=size(Shear);IM=zeros(CC,3,AA);
%
fprintf(file2,'These are the calculations made from the last three ');
fprintf(file2,'\ncolumns of each load  case (matrix M)');
fprintf(file2,'\n        Vx                 Vy                 Vz                 Fr');
%
 for k=1:L;
   for e=1:(FN1);
    fprintf(file2,'\n%14f    %14f    %14f    %14f',Shear(e,:,k));
   end
 end
%
```

```
%%

%
Temp2=0;
Temp3=0;
Temp4=0;
Temp5=0;
for n=1:L;
for h=1:(FN2);
    TempVx=max(Shear(1:h,1,n));
    if TempVx>Temp2;
        MaxVx=h;
        LoadMaxVx=n;
        Temp2=TempVx;
    end
end
%
%
for p=1:(FN2);
    TempVy=max(Shear(1:p,2,n));
    if TempVy>Temp3;
        MaxVy=p;
        LoadMaxVy=n;
        Temp3=TempVy;
    end
end
%
%
for q=1:(FN2);
    TempVz=max(Shear(1:q,3,n));
    if TempVz>Temp4;
        MaxVz=q;
        LoadMaxVz=n;
        Temp4=TempVz;
    end
end
%
%
for t=1:(FN2);
    TempFr=max(Shear(1:t,4,n));
    if TempFr>Temp5;
```

```
        MaxFr=t;
        LoadMaxFr=n;
        Temp5=TempFr;
    end
end
end
%% Max values for Vx,Vy,Vz,Fr and recording their position in matrix M/Q.
%
%%
Label=('Entity--ID        XLocation      YLocation      ZLocation      XComponent     YComponent
ZComponent        Vx              Vy              Vz              Fr');
%
Labe2=('Entity--ID        XLocation      YLocation      ZLocation      XComponent     YComponent
ZComponent        Rx              Ry              Rz');
%
%%        Calculations for Vx
%
file3=fopen(VXMCAL,'wt');
fprintf(file3,'Load Case for the max of Vx');
fprintf(file3,'\n%f',LoadMaxVx);
fprintf('\nLoad Case for the max of Vx');
fprintf('\n%f',LoadMaxVx);
%
fprintf(file3,'\nRow Number of Load Case for max Vx');
fprintf(file3,'\n%f',MaxVx);
%
fprintf(file3,'\nThe max value for Vx');
fprintf(file3,'\n%f',Shear(MaxVx,1,LoadMaxVx));
fprintf('\nThe max value for Vx');
fprintf('\n%f',Shear(MaxVx,1,LoadMaxVx));
%
fprintf(file3,'\nThe Load Case Title');
fprintf(file3,'\n%s',r{LoadMaxVx,:});
%
fprintf(file3,'\nRow Data Containing the max value of Vx');
fprintf(file3,'\n%s',Label);
fprintf(file3,'\n%8f %16f %14f %14f %14f %14f %14f %14f %14f %14f %14f'...
    ,[Matrix(MaxVx,:,LoadMaxVx) Shear(MaxVx,:,LoadMaxVx)]);
%
fclose(file3);
%
```

```
%%        Calculations for Vy
%
file4=fopen( VYMCAL,'wt');
fprintf(file4,'Load Case for the max of Vy');
fprintf(file4,'\n%f',LoadMaxVy);
fprintf('\nLoad Case for the max of Vy');
fprintf('\n%f',LoadMaxVy);
%
fprintf(file4,'\nRow Number of Load Case for max Vy');
fprintf(file4,'\n%f',MaxVy);
%
fprintf(file4,'\nThe max value for Vy');
fprintf(file4,'\n%f',Shear(MaxVy,2,LoadMaxVy));
fprintf('\nThe max value for Vy');
fprintf('\n%f',Shear(MaxVy,2,LoadMaxVy));
%
fprintf(file4,'\nThe Load Case Title');
fprintf(file4,'\n%s',r{LoadMaxVy,:});
%
fprintf(file4,'\nRow Data Containing the max value of Vy');
fprintf(file4,'\n%s',Label);
fprintf(file4,'\n%8f %16f %14f %14f %14f %14f %14f %14f %14f %14f %14f'...
    ,[Matrix(MaxVy,:,LoadMaxVy) Shear(MaxVy,:,LoadMaxVy)]);
%
fclose(file4);
%
%%          Calculations for Vz
%
file5=fopen(VZMCAL,'wt');
fprintf(file5,'Load Case for the max of Vz');
fprintf(file5,'\n%f',LoadMaxVz);
fprintf('\nLoad Case for the max of Vz');
fprintf('\n%f',LoadMaxVz);
%
fprintf(file5,'\nRow Number of Load Case for max Vz');
fprintf(file5,'\n%f',MaxVz);
%
fprintf(file5,'\nThe max value for Vz');
fprintf(file5,'\n%f',Shear(MaxVz,3,LoadMaxVz));
fprintf('\nThe max value for Vz');
fprintf('\n%f',Shear(MaxVz,3,LoadMaxVz));
```

```
%
fprintf(file5,'\nThe Load Case Title');
fprintf(file5,'\n%s',r{LoadMaxVz,:});
%
fprintf(file5,'\nRow Data Containing the max value of Vz');
fprintf(file5,'\n%s',Label);
fprintf(file5,'\n%8f %16f %14f %14f %14f %14f %14f %14f %14f %14f %14f'...
    ,[Matrix(MaxVz,:,LoadMaxVz) Shear(MaxVz,:,LoadMaxVz)]);
%
fclose(file5);
%
%%         Calculations for Fr
%
file6=fopen(VRMCAL,'wt');
fprintf(file6,'Load Case for the max of Fr');
fprintf(file6,'\n%f',LoadMaxFr);
fprintf('\nLoad Case for the max of Fr');
fprintf('\n%f',LoadMaxFr);
%
fprintf(file6,'\nRow Number of Load Case for max Fr');
fprintf(file6,'\n%f',MaxFr);
%
fprintf(file6,'\nThe max value for Fr');
fprintf(file6,'\n%f',Shear(MaxFr,4,LoadMaxFr));
fprintf('\nThe max value for Fr');
fprintf('\n%f',Shear(MaxFr,4,LoadMaxFr));
%
fprintf(file6,'\nThe Load Case Title');
fprintf(file6,'\n%s',r{LoadMaxFr,:});
%
fprintf(file6,'\nRow Data Containing the max value of Fr');
fprintf(file6,'\n%s',Label);
fprintf(file6,'\n%8f %16f %14f %14f %14f %14f %14f %14f %14f %14f %14f'...
    ,[Matrix(MaxFr,:,LoadMaxFr) Shear(MaxFr,:,LoadMaxFr)]);
%
fclose(file6);
%
%%
if NEW=='y';

% making IM matrix to hold R calcs
```

```
%MSC2=['Rcalc.out'];
%file11=fopen(MSC2,'wt');
%
Rx=((NEW4)+((NEW2).*(Matrix(:,5,1:L)))).^2+(((NEW3).*(sqrt((Matrix(:,6,1:L)).^2+(Matrix(:,7,1:L)).^2))).^3)
;
%
Ry=((NEW4)+((NEW2).*(Matrix(:,6,1:L)))).^2+(((NEW3).*(sqrt((Matrix(:,5,1:L)).^2+(Matrix(:,7,1:L)).^2))).^3)
;
%
Rz=((NEW4)+((NEW2).*(Matrix(:,7,1:L)))).^2+(((NEW3).*(sqrt((Matrix(:,5,1:L)).^2+(Matrix(:,6,1:L)).^2))).^3)
;
%% finding max R values%
%
IM=[Rx,Ry,Rz];
%
file15=fopen(RMAT,'wt');
%
fprintf(file15,'These are the calculations made from the last three ');
fprintf(file15,'\ncolumns of each load  case (matrix M)');
fprintf(file15,'\n        Rx                 Ry                 Rz                 ');
%
 for k=1:L;
   for e=1:(FN1);
    fprintf(file15,'\n%14f    %14f    %14f    ',IM(e,:,k));
   end
 end
%
Temp9=0;
Temp10=0;
Temp11=0;
for n2=1:L;
for h2=1:(FN2);
    TempRx=max(IM(1:h2,1,n2));
    if TempRx>Temp9;
        MaxRx=h2;
        LoadMaxRx=n2;
        Temp9=TempRx;
    end
end
%
%
```

```
for p2=1:(FN2);
    TempRy=max(IM(1:p2,2,n2));
    if TempRy>Temp10;
        MaxRy=p2;
        LoadMaxRy=n2;
        Temp10=TempRy;
    end
end
for q2=1:(FN2);
    TempRz=max(IM(1:q2,3,n2));
    if TempRz>Temp11;
        MaxRz=q2;
        LoadMaxRz=n2;
        Temp11=TempRz;
    end
end
end
%%        Calculations for Rx
%
file12=fopen(RXMCAL,'wt');
fprintf(file12,'Load Case for the max of Rx');
fprintf(file12,'\n%f',LoadMaxRx);
fprintf('\nLoad Case for the max of Rx');
fprintf('\n%f',LoadMaxRx);
%
fprintf(file12,'\nRow Number of Load Case for max Rx');
fprintf(file12,'\n%f',MaxRx);
%
fprintf(file12,'\nThe max value for Rx');
fprintf(file12,'\n%f',IM(MaxRx,1,LoadMaxRx));
fprintf('\nThe max value for Rx');
fprintf('\n%f',IM(MaxRx,1,LoadMaxRx));
%
fprintf(file12,'\nThe Load Case Title');
fprintf(file12,'\n%s',r{LoadMaxRx,:});
%
fprintf(file12,'\nRow Data Containing the max value of Rx');
fprintf(file12,'\n%s',Labe2);
fprintf(file12,'\n%8f %16f %14f %14f %14f %14f %14f %14f %14f %14f'...
    ,[Matrix(MaxRx,:,LoadMaxRx) IM(MaxRx,:,LoadMaxRx)]);
%
```

```
fclose(file12);
%
%%        Calculations for Ry
%
file13=fopen(RYMCAL,'wt');
fprintf(file13,'Load Case for the max of Ry');
fprintf(file13,'\n%f',LoadMaxRy);
fprintf('\nLoad Case for the max of Ry');
fprintf('\n%f',LoadMaxRy);
%
fprintf(file13,'\nRow Number of Load Case for max Ry');
fprintf(file13,'\n%f',MaxRy);
%
fprintf(file13,'\nThe max value for Ry');
fprintf(file13,'\n%f',IM(MaxRy,2,LoadMaxRy));
fprintf('\nThe max value for Ry');
fprintf('\n%f',IM(MaxRy,2,LoadMaxRy));
%
fprintf(file13,'\nThe Load Case Title');
fprintf(file13,'\n%s',r{LoadMaxRy,:});
%
fprintf(file13,'\nRow Data Containing the max value of Ry');
fprintf(file13,'\n%s',Labe2);
fprintf(file13,'\n%8f %16f %14f %14f %14f %14f %14f %14f %14f %14f'...
    ,[Matrix(MaxRy,:,LoadMaxRy) IM(MaxRy,:,LoadMaxRy)]);
%
fclose(file13);
%
%%        Calculations for Rz
%
file14=fopen(RZMCAL,'wt');
fprintf(file14,'Load Case for the max of Rz');
fprintf(file14,'\n%f',LoadMaxRz);
fprintf('\nLoad Case for the max of Rz');
fprintf('\n%f',LoadMaxRz);
%
fprintf(file14,'\nRow Number of Load Case for max Rz');
fprintf(file14,'\n%f',MaxRz);
%
fprintf(file14,'\nThe max value for Rz');
fprintf(file14,'\n%f',IM(MaxRz,3,LoadMaxRz));
```

```
fprintf('\nThe max value for Rz');
fprintf('\n%f',IM(MaxRz,3,LoadMaxRz));
%
fprintf(file14,'\nThe Load Case Title');
fprintf(file14,'\n%s',r{LoadMaxRz,:});
%
fprintf(file14,'\nRow Data Containing the max value of Rz');
fprintf(file14,'\n%s',Labe2);
fprintf(file14,'\n%8f %16f %14f %14f %14f %14f %14f %14f %14f %14f'...
    ,[Matrix(MaxRz,:,LoadMaxRz) IM(MaxRz,:,LoadMaxRz)]);
%
fclose(file14);
else
end
%
%%  Finding and Printing Maximum Values for Fx, Fy, and Fz to output files
%
Temp6=0;
Temp7=0;
Temp8=0;
for cove1=1:L;
for flat1=1:(FN2);
    TempFx=max(Matrix(1:flat1,5,cove1));
    if TempFx>Temp6;
        MaxFx=flat1;
        LoadMaxFx=cove1;
        Temp6=TempFx;
    end
end
%
%
for flat2=1:(FN2);
    TempFy=max(Matrix(1:flat2,6,cove1));
    if TempFy>Temp7;
        MaxFy=flat2;
        LoadMaxFy=cove1;
        Temp7=TempFy;
    end
end
%
%
```

```
for flat3=1:(FN2);
    TempFz=max(Matrix(1:flat3,7,cove1));
    if TempFz>Temp8;
        MaxFz=flat3;
        LoadMaxFz=cove1;
        Temp8=TempFz;
    end
end
end
%
%% Max values for Fx,Fy,Fz and recording their position in Matrix.
%
%%
Label=('Entity--ID        XLocation      YLocation      ZLocation      XComponent     YComponent
ZComponent        Vx             Vy              Vz             Fr');
%
%%        Calculations for Fx
%
file7=fopen(FXMCAL,'wt');
fprintf(file7,'Load Case for the max of Fx');
fprintf(file7,'\n%f',LoadMaxFx);
fprintf('\nLoad Case for the max of Fx');
fprintf('\n%f',LoadMaxFx);
%
fprintf(file7,'\nRow Number of Load Case for max Fx');
fprintf(file7,'\n%f',MaxFx);
%
fprintf(file7,'\nThe max value for Fx');
fprintf(file7,'\n%f',Matrix(MaxFx,5,LoadMaxFx));
fprintf('\nThe max value for Fx');
fprintf('\n%f',Matrix(MaxFx,5,LoadMaxFx));
%
fprintf(file7,'\nThe Load Case Title');
fprintf(file7,'\n%s',r{LoadMaxFx,:});
%
fprintf(file7,'\nRow Data Containing the max value of Fx');
fprintf(file7,'\n%s',Label);
fprintf(file7,'\n%8f %16f %14f %14f %14f %14f %14f %14f %14f %14f %14f'...
    ,[Matrix(MaxFx,:,LoadMaxFx) Shear(MaxFx,:,LoadMaxFx)]);
%
fclose(file7);
```

```
%
%%        Calculations for Fy
%
file8=fopen(FYMCAL,'wt');
fprintf(file8,'Load Case for the max of Fy');
fprintf(file8,'\n%f',LoadMaxFy);
fprintf('\nLoad Case for the max of Fy');
fprintf('\n%f',LoadMaxFy);
%
fprintf(file8,'\nRow Number of Load Case for max Fy');
fprintf(file8,'\n%f',MaxFy) ;
%
fprintf(file8,'\nThe max value for Fy');
fprintf(file8,'\n%f',Matrix(MaxFy,6,LoadMaxFy));
fprintf('\nThe max value for Fy');
fprintf('\n%f',Matrix(MaxFy,6,LoadMaxFy));
%
fprintf(file8,'\nThe Load Case Title');
fprintf(file8,'\n%s',r{LoadMaxFy,:});
%
fprintf(file8,'\nRow Data Containing the max value of Fy');
fprintf(file8,'\n%s',Label);
fprintf(file8,'\n%8f %16f %14f %14f %14f %14f %14f %14f %14f %14f %14f'...
    ,[Matrix(MaxFy,:,LoadMaxFy) Shear(MaxFy,:,LoadMaxFy)]);
%
fclose(file8);
%
%%          Calculations for Fz
%
file9=fopen(FZMCAL,'wt');
fprintf(file9,'Load Case for the max of Fz');
fprintf(file9,'\n%f',LoadMaxFz);
fprintf('\nLoad Case for the max of Fz');
fprintf('\n%f',LoadMaxFz);
%
fprintf(file9,'\nRow Number of Load Case for max Fz');
fprintf(file9,'\n%f',MaxFz);
%
fprintf(file9,'\nThe max value for Fz');
fprintf(file9,'\n%f',Matrix(MaxFz,7,LoadMaxFz));
fprintf('\nThe max value for Fz');
```

```
fprintf('\n%f',Matrix(MaxFz,7,LoadMaxFz));
%
fprintf(file9,'\nThe Load Case Title');
fprintf(file9,'\n%s',r{LoadMaxFz,:});
%
fprintf(file9,'\nRow Data Containing the max value of Fz');
fprintf(file9,'\n%s',Label);
fprintf(file9,'\n%8f %16f %14f %14f %14f %14f %14f %14f %14f %14f %14f'...
    ,[Matrix(MaxFz,:,LoadMaxFz) Shear(MaxFz,:,LoadMaxFz)]);
%
fclose(file9);
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%     Graphing results according to user input
%
%
%%
%
for u=1:15;
disp('    ');
  if u==1
    G=input('Would you like to make a 3D plot of the calculated results?(y/n)   ','s');
     elseif u~=1
    G=input('Would you like to make another 3D plot of the calculated results?(y/n)   ','s');
  end
if G=='y';
    disp('    ');
    disp('    ');
    disp('    ');
    disp('Enter the load case number');
    LC=input('from which you wish to graph the results      ');

%
%       defining the vectors that can be plotted
%
%[CC,BB,AA]=size(Shear);
%IM=zeros(CC,3,AA);
x=MN1(:,2,LC);
y=MN1(:,3,LC);
z=MN1(:,4,LC);
vx=Shear(:,1,LC);
```

```
vy=Shear(:,2,LC);
vz=Shear(:,3,LC);
fr=Shear(:,4,LC);
fx=MN1(:,5,LC);
fy=MN1(:,6,LC);
fz=MN1(:,7,LC);
rx=IM(:,1,LC);
ry=IM(:,2,LC);
rz=IM(:,3,LC);
%
disp('    ');
disp('    ');
    disp('Enter the three vectors that you would like to graph.');
    disp('They can be one of the following coordinates: x y z');
    disp('or one of the ten quantities:');
    disp(' vx vy vz fr fx fy fz rx ry rz.');
    disp('Enter all inputs in lower case letters');
    disp('    ');
    disp('    ');
    disp('    ');
    x1=input('Input the vector to be plotted on the x axis        ');
    disp('    ');
    y1=input('Input the vector to be plotted on the y axis        ');
    disp('    ');
    z1=input('Input the vector to be plotted on the z axis        ');
%
figure;
stem3(x1,y1,z1)    % 3D Plot command
%
% xlabel
%
if x1==vx;
    xlabel('Vx(lbs.)');
    else if x1==vy;
            xlabel('Vy(lbs.)');
        else if x1==vz;
                xlabel('Vz(lbs.)');
            else if x1==fr;
                    xlabel('Fr(lbs.)');
                else if x1==fx;
                        xlabel('Fx(lbs.)');
```

```
                        else if x1==fy;
                                xlabel('Fy(lbs.)');
                            else if x1==fz;
                                    xlabel('Fz(lbs.)');
                               else if x1==rx;
                                       xlabel('Rx');
                                    else if x1==ry;
                                           xlabel('Ry');
                                      else if x1==rz;
                                               xlabel('Rz');
                                       else if x1==x;
                                        xlabel('X(in.)');
                                            else if x1==y;
                                            xlabel('Y(in.)');
                                               else if x1==z;
                                                xlabel('Z(in.)');
                                            end
                                        end
                                     end
                                end
                            end
                    end
                end
            end
                    end
                end
            end
        end
end
%
% ylabel
%
if y1==vx;
    ylabel('Vx(lbs.)');
    else if y1==vy;
            ylabel('Vy(lbs.)');
        else if y1==vz;
                ylabel('Vz(lbs.)');
            else if y1==fr;
                    ylabel('Fr(lbs.)');
                else if y1==fx;
```

```
            ylabel('Fx(lbs.)');
            else if y1==fy;
                ylabel('Fy(lbs.)');
              else if y1==fz;
                  ylabel('Fz(lbs.)');
                else if y1==rx;
                    ylabel('Rx');
                  else if y1==ry;
                      ylabel('Ry');
                   else if y1==rz;
                        ylabel('Rz');
        else if y1==x;
            ylabel('X(in.)');
          else if y1==y;
              ylabel('Y(in.)');
            else if y1==z;
                ylabel('Z(in.)');
              end
            end
          end
              end
            end
          end
                end
              end
          end
        end
      end
    end
end
%
% zlabel
%
if z1==vx;
  zlabel('Vx(lbs.)');
  else if z1==vy;
      zlabel('Vy(lbs.)');
    else if z1==vz;
        zlabel('Vz(lbs.)');
      else if z1==fr;
          zlabel('Fr(lbs.)');
```

```
                     else if z1==fx;
                             zlabel('Fx(lbs.)');
                        else if z1==fy;
                                zlabel('Fy(lbs.)');
                            else if z1==fz;
                                    zlabel('Fz(lbs.)');
                                else if z1==rx;
                                       zlabel('Rx');
                                    else if z1==ry;
                                           zlabel('Ry');
                                      else if z1==rz;
                                               zlabel('Rz');
                 else if z1==x;
                         zlabel('X(in.)');
                     else if z1==y;
                             zlabel('Y(in.)');
                         else if z1==z;
                                 zlabel('Z(in.)');
                             end
                         end
                     end
                             end
                                         end
                                     end
                                 end
                             end
                     end
                 end
             end
         end
end
title({'Load Case Number',num2str(LC)});
%
else if G=='n';
        break;
else
        disp('    ');
        disp('    ');
        disp('The program did not recognize the input.') ;
        disp('Enter y or n in a lowercase letter.');
    end
```

```
end
end
%
%%
%
for threeDL=1:20;
disp('   ');
disp('   ');
disp('Would you like make a 3D plot showing the location of the grid');
RB2=input('points?(y/n)   ','s');
if RB2=='y';
GPC=Matrix(:,1,1);
GPCCON=num2str(GPC);
%
figure;
  for jj=1:(FN1)
      scatter3(Matrix(jj,2,1),Matrix(jj,3,1),Matrix(jj,4,1),'filled')
hold on
  end
%
x=MN1(:,2,:);
y=MN1(:,3,:);
z=MN1(:,4,:);
%
hold on
for ee=1:(FN1)
    for Fx=x(ee);
        for Fy=y(ee);
            for Fz=z(ee);
               text(Fx,Fy,Fz,GPCCON(ee ,:),'fontsize',10)
            end
        end
    end
end
hold on
%
xlabel('x Location (in.)');
ylabel('y Location (in.)');
zlabel('z Location (in.)');
%axis equal ;
break
```

```
else if RB2 =='n';
    break;
else            %RB2~= 'y'||'n'
      disp('    ');
      disp('    ');
      disp('The program did not recognize the input.') ;
      disp('Enter y or n in a lowercase letter.');
    end
  end
end
%%
for LP=1:10;
disp('   ');
disp('   ');
  if LP==1
    disp('Would you like to plot fx,fy,fz,vx,vy,vz,fr,rx,ry,or rz on a particular');
    GL=input(' grid point as a function of the load cases?(y/n)   ','s');
     elseif LP~=1
    disp('Would you like to make another plot of fx,fy,fz,vx,vy,vz,fr,rx,ry,or rz on a');
    GL=input(' particular grid point as a function of the load cases?(y/n)   ','s');
  end
%
if GL=='y';
    disp('   ');
    disp('   ');
    disp('Enter the grid point number');
    GL1=input('to be plotted.  ');
    disp('   ');
    disp('   ');
    disp('Enter one of the entities, fx,fy,fz,vx,vy,vz,fr,rx,ry,or rz ');
    GL2=input('to be plotted.  ','s');
Kbi=1:L;
Kbi2=Kbi';
Hby=num2str(Kbi2);
figure;
for de=1:L;
 for dd=1:(FN1);
     if Matrix(dd,1,de)==GL1;
         if GL2=='vx';
         plot(de,Shear(dd,1,de),'-ob','LineWidth',2,'MarkerSize',3)
         GL3= 'vx (lbs.)';, hold on;
```

```
text((de),(Shear(dd,1,de)+18),Hby(de,:))
grid on;
hold on
else if GL2=='vy';
plot(de,Shear(dd,2,de),'-ob','LineWidth',2,'MarkerSize',3)
GL3= 'vy (lbs.)';, hold on;
text((de),(Shear(dd,2,de)+18),Hby(de,:))
grid on;
hold on
else if GL2=='vz';
plot(de,Shear(dd,3,de),'-ob','LineWidth',2,'MarkerSize',3)
GL3= 'vz (lbs.)';, hold on;
text((de),(Shear(dd,3,de)+18),Hby(de,:))
grid on;
hold on
else if GL2=='fr';
plot(de,Shear(dd,4,de),'-ob','LineWidth',2,'MarkerSize',3)
GL3= 'Fr (lbs.)';, hold on;
text((de),(Shear(dd,4,de)+18),Hby(de,:))
grid on;
hold on
else if GL2=='fx';
plot(de,M(dd,5,de),'-ob','LineWidth',2,'MarkerSize',3)
GL3= 'fx (lbs.)';, hold on;
text((de),(M(dd,5,de)+18),Hby(de,:))
grid on;
hold on
else if GL2=='fy';
plot(de,M(dd,6,de),'-ob','LineWidth',2,'MarkerSize',3)
GL3= 'fy (lbs.)';, hold on;
text((de),(M(dd,6,de)+18),Hby(de,:))
grid on;
hold on
else if GL2=='fz';
plot(de,M(dd,7,de),'-ob','LineWidth',2,'MarkerSize',3)
GL3= 'fz (lbs.)';, hold on;
text((de),(M(dd,7,de)+18),Hby(de,:))
grid on;
hold on
%%%%%%%%%%%%%%%%%NEW AS OF 8-9-10%%%%%%%%%%%%%
else if GL2=='rx';
```

```
            plot(de,IM(dd,1,de),'-ob','LineWidth',2,'MarkerSize',3)
            GL3='rx';, hold on;
            text((de),(IM(dd,1,de)+18),Hby(de,:))
            grid on;
            hold on
            else if GL2=='ry';
            plot(de,IM(dd,2,de),'-ob','LineWidth',2,'MarkerSize',3)
            GL3='ry';, hold on;
            text((de),(IM(dd,2,de)+18),Hby(de,:))
            grid on;
            hold on
            else if GL2=='rz';
            plot(de,IM(dd,3,de),'-ob','LineWidth',2,'MarkerSize',3)
            GL3='rz';, hold on;
            text((de),(IM(dd,3,de)+18),Hby(de,:))
            grid on;
            hold on
            %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
                end
                end
                end
                end
                end
                end
                end
                end
                end
            end
        end
    end
end
hold on
xlabel('Load Case Number');
ylabel([(GL3)]);
title(['Grid Point Number    ',num2str(GL1)]);
hold off
%break;
else if GL =='n';
    break;
else    %GL~= 'y'||'n'
      disp('    ');
```

```
        disp('    ');
        disp('The program did not recognize the input.') ;
        disp('Enter y or n in a lowercase letter.');
end
end
end


%
%%%%%%%%%%%%%%%%%%%%%%%%%%
disp('   ');
disp('   ');
%
Last=input('Would you like to print the .out files to the screen (y/n)   ','s');
if Last=='y'
disp('   ');
disp('   ');
disp('   ');
disp('   ');
fprintf(1,'Load Case for the max of Vx');
fprintf(1,'\n%f',LoadMaxVx);
%
fprintf(1,'\nRow Number of Load Case for max Vx');
fprintf(1,'\n%f',MaxVx);
%
fprintf(1,'\nThe max value for Vx');
fprintf(1,'\n%f',Shear(MaxVx,1,LoadMaxVx));
%
fprintf(1,'\nThe Load Case Title');
fprintf(1,'\n%s',r{LoadMaxVx,:});
%
fprintf(1,'\nRow Data Containing the max value of Vx');
fprintf(1,'\n%s',Label);
fprintf(1,'\n%8f %16f %14f %14f %14f %14f %14f %14f %14f %14f %14f'...
    ,[Matrix(MaxVx,:,LoadMaxVx) Shear(MaxVx,:,LoadMaxVx)]);
%
%%        Calculations for Vy
%
disp('   ');
disp('   ');
disp('   ');
```

```
disp('   ');
file4=fopen( VYMCAL,'wt');
fprintf(1,'Load Case for the max of Vy');
fprintf(1,'\n%f',LoadMaxVy);
%
fprintf(1,'\nRow Number of Load Case for max Vy');
fprintf(1,'\n%f',MaxVy);
%
fprintf(1,'\nThe max value for Vy');
fprintf(1,'\n%f',Shear(MaxVy,2,LoadMaxVy));
%
fprintf(1,'\nThe Load Case Title');
fprintf(1,'\n%s',r{LoadMaxVy,:});
%
fprintf(1,'\nRow Data Containing the max value of Vy');
fprintf(1,'\n%s',Label);
fprintf(1,'\n%8f %16f %14f %14f %14f %14f %14f %14f %14f %14f %14f'...
    ,[Matrix(MaxVy,:,LoadMaxVy) Shear(MaxVy,:,LoadMaxVy)]);
%
%%          Calculations for Vz
%
disp('   ');
disp('   ');
disp('   ');
disp('   ');
fprintf(1,'Load Case for the max of Vz');
fprintf(1,'\n%f',LoadMaxVz);
%
fprintf(1,'\nRow Number of Load Case for max Vz');
fprintf(1,'\n%f',MaxVz);
%
fprintf(1,'\nThe max value for Vz');
fprintf(1,'\n%f',Shear(MaxVz,3,LoadMaxVz));
%
fprintf(1,'\nThe Load Case Title');
fprintf(1,'\n%s',r{LoadMaxVz,:});
%
fprintf(1,'\nRow Data Containing the max value of Vz');
fprintf(1,'\n%s',Label);
fprintf(1,'\n%8f %16f %14f %14f %14f %14f %14f %14f %14f %14f %14f'...
    ,[Matrix(MaxVz,:,LoadMaxVz) Shear(MaxVz,:,LoadMaxVz)]);
```

```
%
%%         Calculations for Fr
%
disp('   ');
disp('   ');
disp('   ');
disp('   ');
fprintf(1,'Load Case for the max of Fr');
fprintf(1,'\n%f',LoadMaxFr);
%
fprintf(1,'\nRow Number of Load Case for max Fr');
fprintf(1,'\n%f',MaxFr);
%
fprintf(1,'\nThe max value for Fr');
fprintf(1,'\n%f',Shear(MaxFr,4,LoadMaxFr));
%
fprintf(1,'\nThe Load Case Title');
fprintf(1,'\n%s',r{LoadMaxFr,:});
%
fprintf(1,'\nRow Data Containing the max value of Fr');
fprintf(1,'\n%s',Label);
fprintf(1,'\n%8f %16f %14f %14f %14f %14f %14f %14f %14f %14f %14f'...
    ,[Matrix(MaxFr,:,LoadMaxFr) Shear(MaxFr,:,LoadMaxFr)]);
%

if NEW=='y'

%%        Calculations for Rx
%
disp('   ');
disp('   ');
disp('   ');
disp('   ');
fprintf(1,'Load Case for the max of Rx');
fprintf(1,'\n%f',LoadMaxRx);
%
fprintf(1,'\nRow Number of Load Case for max Rx');
fprintf(1,'\n%f',MaxRx);
%
fprintf(1,'\nThe max value for Rx');
fprintf(1,'\n%f',IM(MaxRx,1,LoadMaxRx));
```

```
%
fprintf(1,'\nThe Load Case Title');
fprintf(1,'\n%s',r{LoadMaxRx,:});
%
fprintf(1,'\nRow Data Containing the max value of Rx');
fprintf(1,'\n%s',Labe2);
fprintf(1,'\n%8f %16f %14f %14f %14f %14f %14f %14f %14f %14f'...
    ,[Matrix(MaxRx,:,LoadMaxRx) IM(MaxRx,:,LoadMaxRx)]);
%
%%        Calculations for Ry
%
disp('   ');
disp('   ');
disp('   ');
disp('   ');
fprintf(1,'Load Case for the max of Ry');
fprintf(1,'\n%f',LoadMaxRy);
%
fprintf(1,'\nRow Number of Load Case for max Ry');
fprintf(1,'\n%f',MaxRy);
%
fprintf(1,'\nThe max value for Ry');
fprintf(1,'\n%f',IM(MaxRy,2,LoadMaxRy));
%
fprintf(1,'\nThe Load Case Title');
fprintf(1,'\n%s',r{LoadMaxRy,:});
%
fprintf(1,'\nRow Data Containing the max value of Ry');
fprintf(1,'\n%s',Labe2);
fprintf(1,'\n%8f %16f %14f %14f %14f %14f %14f %14f %14f %14f'...
    ,[Matrix(MaxRy,:,LoadMaxRy) IM(MaxRy,:,LoadMaxRy)]);
%
%%        Calculations for Rz
%
disp('   ');
disp('   ');
disp('   ');
disp('   ');
fprintf(1,'Load Case for the max of Rz');
fprintf(1,'\n%f',LoadMaxRz);
%
```

```
fprintf(1,'\nRow Number of Load Case for max Rz');
fprintf(1,'\n%f',MaxRz);
%
fprintf(1,'\nThe max value for Rz');
fprintf(1,'\n%f',IM(MaxRz,3,LoadMaxRz));
%
fprintf(1,'\nThe Load Case Title');
fprintf(1,'\n%s',r{LoadMaxRz,:});
%
fprintf(1,'\nRow Data Containing the max value of Rz');
fprintf(1,'\n%s',Labe2);
fprintf(1,'\n%8f %16f %14f %14f %14f %14f %14f %14f %14f %14f'...
    ,[Matrix(MaxRz,:,LoadMaxRz) IM(MaxRz,:,LoadMaxRz)]);
%
else
end
%%         Calculations for Fx
%
disp('    ');
disp('    ');
disp('    ');
disp('    ');
fprintf(1,'Load Case for the max of Fx');
fprintf(1,'\n%f',LoadMaxFx);
%
fprintf(1,'\nRow Number of Load Case for max Fx');
fprintf(1,'\n%f',MaxFx);
%
fprintf(1,'\nThe max value for Fx');
fprintf(1,'\n%f',Matrix(MaxFx,5,LoadMaxFx));
%
fprintf(1,'\nThe Load Case Title');
fprintf(1,'\n%s',r{LoadMaxFx,:});
%
fprintf(1,'\nRow Data Containing the max value of Fx');
fprintf(1,'\n%s',Label);
fprintf(1,'\n%8f %16f %14f %14f %14f %14f %14f %14f %14f %14f %14f'...
    ,[Matrix(MaxFx,:,LoadMaxFx) Shear(MaxFx,:,LoadMaxFx)]);
%
%%         Calculations for Fy
%
```

```
disp('   ');
disp('   ');
disp('   ');
disp('   ');
fprintf(1,'Load Case for the max of Fy');
fprintf(1,'\n%f',LoadMaxFy);
%
fprintf(1,'\nRow Number of Load Case for max Fy');
fprintf(1,'\n%f',MaxFy) ;
%
fprintf(1,'\nThe max value for Fy');
fprintf(1,'\n%f',Matrix(MaxFy,6,LoadMaxFy));
%
fprintf(1,'\nThe Load Case Title');
fprintf(1,'\n%s',r{LoadMaxFy,:});
%
fprintf(1,'\nRow Data Containing the max value of Fy');
fprintf(1,'\n%s',Label);
fprintf(1,'\n%8f %16f %14f %14f %14f %14f %14f %14f %14f %14f %14f'...
    ,[Matrix(MaxFy,:,LoadMaxFy) Shear(MaxFy,:,LoadMaxFy)]);
%

%%          Calculations for Fz
%
disp('   ');
disp('   ');
disp('   ');
disp('   ');
fprintf(1,'Load Case for the max of Fz');
fprintf(1,'\n%f',LoadMaxFz);
%
fprintf(1,'\nRow Number of Load Case for max Fz');
fprintf(1,'\n%f',MaxFz);
%
fprintf(1,'\nThe max value for Fz');
fprintf(1,'\n%f',Matrix(MaxFz,7,LoadMaxFz));
%
fprintf(1,'\nThe Load Case Title');
fprintf(1,'\n%s',r{LoadMaxFz,:});
%
fprintf(1,'\nRow Data Containing the max value of Fz');
```

```
fprintf(1,'\n%s',Label);
fprintf(1,'\n%8f %16f %14f %14f %14f %14f %14f %14f %14f %14f %14f'...
    ,[Matrix(MaxFz,:,LoadMaxFz) Shear(MaxFz,:,LoadMaxFz)]);
%
else
    break;
end

%
fclose('all');    %added 1/13/09
```

References

1. National Aeronautics and Space Administration: Criteria for Preloaded Bolts. NSTS 08307, Rev. A, 1998.
2. Barrett, Richard T.: Fastener Design Manual. NASA RP–1228, 1990.

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13. SUPPLEMENTARY NOTES

14. ABSTRACT
Often, the shear and tensile forces and moments are extracted from finite element analyses to be used in off-line calculations for evaluating the integrity of structural connections involving bolts, rivets, and welds. Usually the maximum forces and moments are desired for use in the calculations. In situations where there are numerous structural connections of interest for numerous load cases, the effort in finding the true maximum force and/or moment combinations among all fasteners and welds and load cases becomes difficult. The Element Load Data Processor (ELDAP) software described herein makes this effort manageable. This software eliminates the possibility of overlooking the worst-case forces and moments that could result in erroneous positive margins of safety and/or selecting inconsistent combinations of forces and moments resulting in false negative margins of safety. In addition to forces and moments, any scalar quantity output in a PATRAN report file may be evaluated with this software. This software was originally written to fill an urgent need during the structural analysis of the Ares I-X Interstage segment. As such, this software was coded in a straightforward manner with no effort made to optimize or minimize code or to develop a graphical user interface.

15. SUBJECT TERMS
Computer programs; Loads; Fasteners; Finite element method; PATRAN; NASTRAN

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