DMAP ALTERS FOR CALCULATING AND SUMMARIZING RESULTANT FORCES FROM THE APPLICATION OF SPC AND AUTOSPC CONSTRAINTS

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ABSTRACT:

MSC/NASTRAN DMAP (Direct Matrix Abstraction Programs) alter programs have been written to identify and summarize all resultant forces from single point constraints (SPC) and AUTOSPC constraints. This capability was developed primarily as an enhancement to previous DMAPs for model checking and identifying grounding problems and constraint checks through the use of strain energy calculations on the stiffness matrix.

Discussion and examples of the use of the DMAPs for model verification are presented.

DMAP ALTERs FOR CALCULATING AND SUMMARIZING RESULTANT FORCES FROM THE APPLICATION OF SPC AND AUTOSPC CONSTRAINTS

INTRODUCTION

Use of the rigid body strain energy calculation has been well documented and applied in many derivatives and formats and is extremely valuable for model checking and verification. However, since the calculation only involves the stiffness matrix and the model's rigid body modes, the effect of applied constraints on a specific loading condition cannot be assessed. In addition, while obvious modeling errors can be quickly located and corrected (improper MPC's, springs to non-coincident grids, etc.), some small grounding effects can be introduced from mathematical formulations such as the stiffness component which may result from constraining canted quad plate elements.

To further address model "quality" with respect to actual load cases, MSC/NASTRAN DMAP (Direct Matrix Abstraction Program) alter programs were created to identify and summarize all resultant forces from single point constraints (SPC) and AUTOSPC constraints. This capability was developed primarily as an enhancement to previous DMAPs for model checking [1 - 4] and identifying grounding problems and constraint checks through the use of strain energy calculations on the stiffness matrix.

DISCUSSION

Decisions on the extent of how much "model clean-up" is necessary can become very time consuming, and discussions as to the "quality" of the model can become very intense between various users of the same model.

It is obvious that improper grounding forces which affect load paths, mode shapes, etc., need correction -- especially in aircraft structures. A recommended "final assessment" on the condition of the model and the effects which any grounding may have on the answers resulting from applying actual loads is the topic of this paper. While SPC forces can be obtained in the output by using a simple output request, most engineers either do not request this information or do not spend time evaluating and understanding the data provided. The DMAP alters provided in this paper differentiate the "User-induced" versus the "AUTOSPC-induced" SPCFORCEs, and provide resultant summary vectors and printouts for each type of reaction force. In addition, the "User-induced" reaction forces may be broken down into those caused by the GRID PS field, and those called out in an SPC set.

The need for the evaluation of actual grounding forces for specific load cases was recognized by Northrop while working on the F/A-18 E/F program for the NAVY as a subcontractor to McDonnell Douglas Aircraft in providing quality finite element models and analyses. This request was presented to MSC who provided a DMAP alter which is included in the "new" /misc/sssalter directory [4] delivered with current releases of MSC/NASTRAN.

In addition, further investigation by MSC provided another DMAP which was developed in one of the Regional offices. The discovery of this independent work occurred during the final writing of the paper and is included as an alternative. Both DMAPs are functionally similar, and both are included in the Appendices for your evaluation. MSC will attempt to provide both DMAP alters in the /misc/sssalter directory [4] delivery for release of MSC/NASTRAN Version 68. Subsequently, the DMAP alters may be condensed into one.

STRAIN ENERGY CALCULATION

The rigid-body strain energy calculation is represented as:

$$T = \{\Phi\}^T[K]\{\Phi\}$$

where:

T = strain energy
Φ = "rigid-body" vectors
K = stiffness matrix

This check is performed on the G-, N-, and A- sized stiffness matrix during the processing of the problem.

When using the strain energy calculation, it is impossible to provide one unique guideline for assessing the acceptability of the constraint or grounding of a free-free model. Past experiences have shown that when using English units (inch-pound-second), diagonal values in the resultant strain energy matrix as high as $1X10^0$ for translational degrees-of-freedom, and $1x10^2$ for rotations may be acceptable[5]. The results of a typical calculation are shown in Figure 1. In this output, it is seen that the model is not over-constrained until after the SPCs are applied. That is the strain energy from checking the 'G' and 'N' sets is small (indicating an unconstrained condition), but the values from the 'F' set are large, indicating a constrained structure. This shows a good model, in that there are no unexpected constraints in the matrices before the application of the SPCs.

One important point is that the "rigid-body" vectors should be calculated about a point at or near, the model C.G. This step will reduce artificial scaling which can occur in the rotational terms. As mentioned earlier, decisions on the extent of "model clean-up" can become very time consuming, and discussions as to the "validity" of the model can become very intense between various users of the same model.

SPCFORCE OUTPUT DMAP ALTERS

The teaming of Northrop and McDonnell Douglas Aircraft Company for the F/A-18 Program requires the exchange of models, loads, constraints, and results. Each Company is responsible for their respective major structural components, exchange of data and combining of structures. This requires that model checking be an important part of the finite element analysis process for structural analysis on the F/A-18 E/F Program. As mentioned, a strain energy calculation (such as the one in Figure 1) can be improved, if necessary, through model clean-up. However, the discussion on "how much" always occurs. The included DMAPS assist in determining SPC forces for specific load conditions. These forces (AUTOSPC) can then assist in determining the necessity for additional model correction.

Two DMAP alters are presented for evaluation, and, as mentioned, may be condensed into one DMAP alter. The first DMAP alter is presented in APPENDIX A and is written for MSCV67.5 Solution 101 only, and is titled "Alter To Calculate The Resultant Of The SPC Forces Due To The DOF Constrained By AUTOSPC" (In the /misc/sssalter directory for V68, this alter is contained in the "checka.v68" alter). The output consists of USERSPC, AUTOSPC, and total SPCFORCE resultants.

The second DMAP alter is presented in APPENDIX B for MSCV67.5 Solution 101, and in APPENDIX C for MSCV67.5 Solution 24, and is titled "RFALTER to Display Separate SPCFORCE Output For Modeled-In SPC and

AUTOSPC Reactions." This alter organizes the calculated SPCFORCES by the type of constraint placed upon each DOF; e.g. was it a user-induced constraint such as the PS field on the GRID or an SPC card, or was it a DOF constrained by the AUTOSPC function. The user has the further option of breaking the user-induced constraints into those DOF constrained by the GRID PS field and those on an SPC set. Answers may be independently filtered to remove smaller SPCFORCES from the printouts. Resultant vectors for SPCFORCE contributions are also calculated.

User interface requirements are specified on the introductory comment cards of the DMAPS.

SAMPLE OUTPUT

Examples of the output from these alters are shown in APPENDIX D for the second DMAP Alter (APPENDIX B, i.e. MSC/NASTRAN V67.5, Solution 101). For all load cases, the USERSPC (PS + SPC) Resultant and the SPCFORCE Resultant are nearly identical which is verified by the AUTOSPC Resultant which is essentially zero. Therefore, for this model with the applied loads, there are no large SPC forces causing grounding to the FEM due to modeling errors.

CONCLUSION

To assist the analyst in verifying the FEM, two DMAP alters have been presented for MSCV67.5 Solutions 101 and 24. These DMAPS organize and quantify the calculated SPC forces by type of constraint placed upon a DOF as to user-induced constraint such as the PS field on the GRID or an SPC card, or a DOF constrained by the AUTOSPC function. This information is essential in determining if the model is grounded through improper modeling practices.

The intent of these DMAPs are to provide additional tools for model checking and verifying the integrity of the analysis results.

REFERENCES

[1] J. J. Brown and G .R . Parker, "DMAP Alters for Performing Basic Constraint Checks on Structural Models", MSC/NASTRAN Users Conference Proceedings, March, 1985, MSC/NASTRAN European Users Conference Proceedings, April, 1985.

[2] G. R. Parker and J. J. Brown, "Kinetic Energy DMAP for Mode Identification", MSC/NASTRAN Users Conference Proceedings, March , 1982.

[3] Ted L. Rose, "Using Superelements to Identify the Dynamic Properties of a Structure", MSC/NASTRAN Users Conference Proceedings, March , 1988.

[4] The MacNeal-Schwendler Corporation, MSC/NASTRAN Release Notes for Version 67.5, Appendix D.

[5] Jet Propulsion Lab, Applied Dynamics and Structures Technology Group, "MSC/NASTRAN Model Checkout", MSC/NASTRAN Users Conference Proceedings, March, 1986.

Figure 1, Sample Output Of "Rigid-Body: Strain Energy

```
 MATRIX KRBG   (GINO NAME 101 ) IS A DB  PREC      6 COLUMN X      6 ROW SQUARE  MATRIX.
COLUMN    1    ROWS    1 THRU    6    -----------------------------------
 ROW
  1)  -4.8685D-07 -8.0277D-06  5.2048D-08  9.4184D-04 -5.9314D-05 -9.5774D-05
COLUMN    2    ROWS    1 THRU    6    -----------------------------------
 ROW
  1)  -6.2349D-06  1.6186D-05  1.6442D-08 -3.1286D-03 -7.0926D-04  3.2773D-03
COLUMN    3    ROWS    1 THRU    6    -----------------------------------
 ROW
  1)  -6.5434D-10  1.7033D-08 -1.0000D-06 -5.9427D-04  4.1930D-05  1.7408D-05
COLUMN    4    ROWS    1 THRU    6    -----------------------------------
 ROW
  1)   1.8815D-03  2.6595D-03 -2.2525D-03 -1.6531D+00  3.0683D-01 -8.5042D-01
COLUMN    5    ROWS    1 THRU    6    -----------------------------------
 ROW
  1)   7.6824D-05 -1.1515D-03  4.8678D-05  1.5825D-01  7.2696D-03 -9.0790D-02
COLUMN    6    ROWS    1 THRU    6    -----------------------------------
 ROW
  1)  -3.4110D-04  1.9843D-03 -1.5963D-04 -3.3098D-01 -3.2747D-02  3.6986D-01
THE NUMBER OF NON-ZERO TERMS IN THE DENSEST COLUMN =     6
THE DENSITY OF THIS MATRIX IS 100.00 PERCENT.

 MATRIX KRBN   (GINO NAME 101 ) IS A DB  PREC      6 COLUMN X      6 ROW SQUARE  MATRIX.
COLUMN    1    ROWS    1 THRU    6    -----------------------------------
 ROW
  1)  -4.8685D-07 -8.0277D-06  5.2048D-08  9.4184D-04 -5.9314D-05 -9.5774D-05
COLUMN    2    ROWS    1 THRU    6    -----------------------------------
 ROW
  1)  -6.2349D-06  1.6186D-05  1.6442D-08 -3.1286D-03 -7.0926D-04  3.2773D-03
COLUMN    3    ROWS    1 THRU    6    -----------------------------------
 ROW
  1)  -6.5434D-10  1.7033D-08 -1.0000D-06 -5.9427D-04  4.1930D-05  1.7408D-05
COLUMN    4    ROWS    1 THRU    6    -----------------------------------
 ROW
  1)   1.8815D-03  2.6595D-03 -2.2525D-03 -1.6531D+00  3.0683D-01 -8.5042D-01
COLUMN    5    ROWS    1 THRU    6    -----------------------------------
 ROW
  1)   7.6824D-05 -1.1515D-03  4.8678D-05  1.5825D-01  7.2696D-03 -9.0790D-02
COLUMN    6    ROWS    1 THRU    6    -----------------------------------
 ROW
  1)  -3.4110D-04  1.9843D-03 -1.5963D-04 -3.3098D-01 -3.2747D-02  3.6986D-01
THE NUMBER OF NON-ZERO TERMS IN THE DENSEST COLUMN =     6
THE DENSITY OF THIS MATRIX IS 100.00 PERCENT.

 MATRIX KRBF   (GINO NAME 101 ) IS A DB  PREC      6 COLUMN X      6 ROW SQUARE  MATRIX.
COLUMN    1    ROWS    1 THRU    6    -----------------------------------
 ROW
  1)  -4.8685D-07 -8.0277D-06  5.2048D-08  9.4183D-04 -5.9319D-05 -9.5774D-05
COLUMN    2    ROWS    1 THRU    6    -----------------------------------
 ROW
  1)  -6.2349D-06  1.6186D-05  1.6442D-08 -3.1286D-03 -7.0933D-04  3.2773D-03
COLUMN    3    ROWS    1 THRU    6    -----------------------------------
 ROW
  1)  -6.5388D-10  1.7033D-08 -1.0000D-06 -5.9427D-04  4.1930D-05  1.7408D-05
COLUMN    4    ROWS    1 THRU    6    -----------------------------------
 ROW
  1)   1.8814D-03  2.6603D-03 -2.2482D-03  1.6328D+06  3.0664D-01 -8.5036D-01
COLUMN    5    ROWS    1 THRU    6    -----------------------------------
 ROW
  1)   8.3328D-05 -1.1733D-03  4.9014D-05  1.6103D-01  2.2985D+07 -9.5267D-02
COLUMN    6    ROWS    1 THRU    6    -----------------------------------
 ROW
  1)  -3.5363D-04  1.9834D-03 -1.5929D-04 -3.3065D-01 -3.4000D-02  1.0037D+05
THE NUMBER OF NON-ZERO TERMS IN THE DENSEST COLUMN =     6
```

THE DENSITY OF THIS MATRIX IS 100.00 PERCENT.

APPENDIX A - ALTER for SOL 101

```
$
$ alter to calculate the resultant of the spc forces due to
$  the dof constrained by autospc - 7/26/1993 - TLR
$
$ controlled by PARAM,SPCSUM,x
$     where:
$          x<=-1 then no the alter is not used
$          x>-1 then the alter will calculate the summation of all
$              spcforces due to user specified spcs and AUTOSPC
$
compile sekr, souin=mscsou, nolist, noref
alter 47
type parm,,i,y,spcsum=1, dummyt $
$ *****> 7-26-1993
vec usetb/spcbefor/'G'/'S'/'COMP' $
alter 49
vec uset/spcafter/'G'/'S'/'COMP' $
add spcbefor,spcafter/spcauto/(-1.,0.) $
call dbstore spcauto,,,,//seid/0/'DBALL'/s,dummyt $ store in database
$ <***** 7-26-1993
$
compile super3, souin=mscsou, list, noref
alter 6
type parm,,i,y,spcsum=1, dummyt $
alter 174
if (spcsum>-1) then $
  message //'DMAP alter information message ' $
  message //'the following spcforce summary is the summation of'/
         ' all forces resulting from the application of'/
         ' autospc' $
  call dbfetch /spcauto,,,,/SEID/0/0/0/S,dummyt   $
  partn qg,,spcauto/userspc,autspc,,/1 $
  merge userspc,,,,,spcauto/userspcg/1 $
  merge ,,autspc,,,,spcauto/autspcg/1 $
$
$ calculate totals for user-specified SPCs and AUTOSPC
$
VECPLOT  userspcg,BGPDTS,EQEXINS,CSTMS,CASEDR,/QGSUM1/GRDPNT/0/1/
      'USERSPC' $
VECPLOT  autspcg,BGPDTS,EQEXINS,CSTMS,CASEDR,/QGSUM2/GRDPNT/0/1/
      'AUTOSPC' $
endif $
```

APPENDIX B - Alternate ALTER for SOL 101

```
$
$-------+-------+-------+-------+-------+-------+-------+-------+------
$
$ Alter SPC4C101.V675 - RFALTER to display separate SPCFORCE output
$                 for modelled-in SPC (those on GRID/PS and SPC
$                 sets) and AUTOSPC reactions.
$
$ SOL: 101 (only)
$
$ Description:
$ This alter organizes the calculated SPCForces by the type of
$ constraint placed upon a DOF; e.g. was it a user-induced constraint
$ such as the PS field on the GRID or an SPC card, or was it a DOF
$ constrained by the AUTOSPC function. User has further option of
$ breaking the user-induced constraints into those DOF constrained by
$ the GRID PS field and those on an SPC set. Answers may be
$ independently filtered to remove smaller SPCForces from the
$ printouts. Resultant vectors for SPCForce contributions are also
$ calculated.
$
$ User Interface:
$  1) Include this alter in sol 101
$  2) Ask for SPCFORCEs in the case control
$  3) Bulk Data PARAMS: (optional)
$      -SPCLEVEL: Default = 0 (integer). Default will separate
$             SPCForce output into AUTOSPC'd DOFs and modelled-in
$             (GRID/PS plus SPC set) DOFs. Setting SPCLEVEL
$             to 1 will divide SPCForce output into three
$             separate groups: AUTOSPC, GRID/PS, and SPC sets.
$      -TINYAUTO: Default = 0.0. Acts as a filter on printed
$             SPCForces for those DOF constrained by AUTOSPC.
$             Any SPCForce smaller in magnitude than TINYAUTO
$             will NOT be printed.
$      -TINYSPC: Default = 0.0. Acts as a filter on printed
$             SPCForces for those DOF constrained by either
$             GRID/PS or SPC set cards. Any SPCForce smaller
$             than TINYSPC will NOT be printed.
$      -GRDPNT: Default = 0 (integer). Allows user to have
$             SPCForce Resultants summed about this grid point in
$             a coordinate system parallel to the BASIC system.
$
$-------+-------+-------+-------+-------+-------+-------+-------+------
$
$
$
COMPILE SEKR SOUIN=MSCSOU NOLIST NOREF
ALTER 13      $ At the end of the TYPE statements
TYPE DB, USETB $ Needed later in subdmap SEDRCVR
$
COMPILE SEDRCVR SOUIN=MSCSOU NOLIST NOREF
```

```
$
$ Replace with alter in SEDRCVR just after printed output
ALTER 200 $
$
$
IF (APP1 = 'STATICS') THEN $ THE FOLLOWING APPLIES ONLY TO STATICS RUNS
$
$ Matrix QGS is G-rows by #Loads-cols of SPC (all types) Reaction Forces.
$
$ Partition out & re-expand back to G-set sized those SPCForces that are:
$  1) Called out on SPC set (prior to AUTOSPC) via usetB table from
$     GP4, otherwise known as the SB set
$  2) Called out via the PS field (Field 8) on GRID/GRDSET cards,
$     otherwise known as the SG set
$
  TYPE DB, USETB,PVTS         $ Retrieve from database
  TYPE,PARM,NDDL,I,N,SPC      $ Get SPC set ID
  TYPE,PARM,,RS,Y,TINYAUTO=0. $ Declare, set default on user PARAMs
  TYPE,PARM,,RS,Y,TINYSPC =0. $
  TYPE,PARM,, I,Y,SPCLEVEL=0  $
  PVT  PVTS,/                 $ Update PARAMs
$
$ Act based on value of user input PARAM SPCLEVEL.  At the default
$ value of 0, just separate SPCFORCEs into AUTOSPC-type SPCFORCEs
$ and ALL user input (GRID/PS and SPC set) SPCFORCES
$
  IF (SPCLEVEL = 0) THEN  $ Split into AUTOSPC/PS+SPC
    UPARTN USETB,QGS      /QSPSNSPC,,,/'G'/'S'/'M'/1 $ PS+SPC, pre-AUTOSPC
    UMERGE USETB,QSPSNSPC,/QGPSNSPC  /'G'/'S'/'M'  $ Re-Expand to G-size
    ADD5  QGS,QGPSNSPC,,,/QGAUTSPC/+1./-1.        $ Auto=All-(PS+SPC)
$
  ELSE $ If SPCLEVEL <> 0 then do the following:
$
    UPARTN USETB,QGS      /QSPS,,, /'G'/'SG'/'M'/1 $ PS, pre-AUTOSPC
    UMERGE USETB,QSPS     ,/QGPS   /'G'/'SG'/'M'  $
    UPARTN USETB,QGS      /QSSPC,,,/'G'/'SB'/'M'/1 $ SPC, pre-AUTOSPC
    UMERGE USETB,QSSPC    ,/QGSPC  /'G'/'SB'/'M'  $
    ADD5  QGS,QGPS,QGSPC,,/QGAUTSPC/+1./-1./-1.   $ Auto=All-PS-SPC
$
  ENDIF $ Ends processing on SPCLEVEL
$
  PARAML QGAUTSPC//'PRESENCE'////S,N,ISAUTSPC $ Check for existence of:
  PARAML QGPSNSPC//'PRESENCE'////S,N,ISPSNSPC $
  PARAML QGPS    //'PRESENCE'////S,N,ISPS    $
  PARAML QGSPC   //'PRESENCE'////S,N,ISSPC   $
$
  IF(ISAUTSPC = 0) THEN
    VECPLOT QGAUTSPC,BGPDTS,EQEXINS,CSTMS,CASEDR,/XGAUTSPC/
        GRDPNT/0/1/'AUTOSPC' $
    MESSAGE //'  ' $
    MESSAGE //' THE ABOVE RESULTANT TABLE IS FOR ALL DOFS '/
          'CONSTRAINED BY THE AUTOSPC FEATURE.' $
    MESSAGE //' RESULTANT VECTORS ARE PARALLEL TO BASIC SYSTEM,'/
          ' SUMMED ABOUT GRID POINT:'/GRDPNT
```

```
    MESSAGE //' ' $
    IF(TINYAUTO > 0.) THEN
      MATMOD  QGAUTSPC,,,,,/QFAUTSPC,/2////TINYAUTO $ Filter out terms
    ELSE   $ Dont bother with matmod operation if filter term is zero
      EQUIVX  QGAUTSPC/QFAUTSPC/ALWAYS $
    ENDIF
    MESSAGE //' THE FOLLOWING OUTPUT TABLE, LABELLED "FORCES OF'/
           ' SINGLE-POINT CONSTRAINT", CONTAIN REACTION FORCES'
    MESSAGE //' FOR THOSE DOF CONSTRAINED BY THE AUTOSPC FEATURE '/
           'WITH SPCFORCE TERMS GREATER THAN: '/TINYAUTO
    MESSAGE //' '
    SDR2   CASEDR,CSTMS,MPTS,DIT,EQEXINS,,ETT,OLB1,BGPDTS,,QFAUTSPC,
         UGVS,EST,XYCDB/,OQAUTSPC,,,,/'STATICS' $
    OFP    OQAUTSPC//S,N,CARDNO $ Printout...
$
  ENDIF
$
  IF(ISPSNSPC = 0) THEN
    VECPLOT QGPSNSPC,BGPDTS,EQEXINS,CSTMS,CASEDR,/XGPSNSPC/
         GRDPNT/USRCOORD/1/'PS + SPC' $
    MESSAGE //' ' $
    MESSAGE //' THE ABOVE RESULTANT TABLE IS FOR ALL DOFS '/
           'CONSTRAINED BY THE PS FIELD ON THE GRID' $
    MESSAGE //' CARDS AND ON SPC SETS CALLED OUT IN THE CASE CONTOL'
    MESSAGE //' RESULTANT VECTORS ARE PARALLEL TO BASIC SYSTEM,'/
           ' SUMMED ABOUT GRID POINT:'/GRDPNT
    MESSAGE //' '
    IF(TINYSPC > 0.) THEN
      MATMOD  QGPSNSPC,,,,,/QFPSNSPC,/2////TINYSPC $ Filter out terms
    ELSE     $ Dont bother with matmod operation if filter term is zero
      EQUIVX QGPSNSPC/QFPSNSPC/ALWAYS $
    ENDIF
    MESSAGE //' THE FOLLOWING OUTPUT TABLE, LABELLED "FORCES OF'/
           ' SINGLE-POINT CONSTRAINT", CONTAIN REACTION FORCES' $
    MESSAGE //' FOR THOSE DOF CONSTRAINED BY GRID PS ENTRIES AND '/
           'SPC SETS CALLED OUT IN THE CASE CONTROL,'
    MESSAGE //' WITH TERMS GREATER THAN '/TINYSPC $
    SDR2   CASEDR,CSTMS,MPTS,DIT,EQEXINS,,ETT,OLB1,BGPDTS,,QFPSNSPC,
         UGVS,EST,XYCDB/,OQPSNSPC,,,,/'STATICS' $
    OFP    OQPSNSPC//S,N,CARDNO $
$
  ELSE $ Do below iff PS and SPCs broken out separately
$
    IF(ISPS    = 0) THEN
      VECPLOT QGPS    ,BGPDTS,EQEXINS,CSTMS,CASEDR,/XGPS/
           GRDPNT/USRCOORD/1/'GRID PS ' $
      MESSAGE //' ' $
      MESSAGE //' THE ABOVE RESULTANT TABLE IS FOR ALL DOFS'/
             ' CONSTRAINED BY THE PS FIELD ON THE GRID CARDS'
      MESSAGE //' RESULTANT VECTORS ARE PARALLEL TO BASIC SYSTEM,'/
             ' SUMMED ABOUT GRID POINT:'/GRDPNT
      MESSAGE //' '
      IF(TINYSPC > 0.) THEN
        MATMOD  QGPS    ,,,,,/QFPS    ,/2////TINYSPC $ Filter out terms
```

```
      ELSE      $ Dont bother with matmod operation if filter term is zero
        EQUIVX  QGPS    /QFPS    /ALWAYS $
      ENDIF
      MESSAGE //' THE FOLLOWING OUTPUT TABLE, LABELLED "FORCES OF'/
              ' SINGLE-POINT CONSTRAINT", CONTAIN REACTION'/
              ' FORCES FOR THOSE DOF'  $
      MESSAGE //' CONSTRAINED BY THE PS FIELD ON THE GRID CARDS, '/
              'WITH TERMS GREATER THAN:'/TINYSPC $
      SDR2    CASEDR,CSTMS,MPTS,DIT,EQEXINS,,ETT,OLB1,BGPDTS,,QFPS,
           UGVS,EST,XYCDB/,OQPS    ,,,,/'STATICS' $
      OFP     OQPS    //S,N,CARDNO $
$
    ENDIF
    IF(ISSPC    = 0) THEN
      VECPLOT QGSPC    ,BGPDTS,EQEXINS,CSTMS,CASEDR,/XGSPC/
           GRDPNT/USRCOORD/1/'SPC SET ' $
      MESSAGE //'  ' $
      MESSAGE //' THE ABOVE RESULTANT TABLE IS FOR ALL DOFS '/
              ' CONSTRAINED BY SPC SETS CALLED OUT IN THE CASE'
      MESSAGE //' CONTROL.  RESULTANT VECTORS ARE PARALLEL TO BASIC'/
              ' SYSTEM, SUMMED ABOUT GRID POINT:'/GRDPNT
      MESSAGE //'  '
      IF(TINYSPC > 0.) THEN
        MATMOD  QGSPC    ,,,,,/QFSPC    ,/2////TINYSPC $ Filter out terms
      ELSE      $ Dont bother with matmod operation if filter term is zero
        EQUIVX  QGSPC   /QFSPC   /ALWAYS $
      ENDIF
      MESSAGE //' THE FOLLOWING OUTPUT TABLE, LABELLED "FORCES OF'/
              ' SINGLE-POINT CONSTRAINT", CONTAIN REACTION '/
              ' FORCES FOR THOSE DOF'  $
      MESSAGE //' CONSTRAINED BY SPC SETS CALLED OUT IN '/
              'THE CASE CONTROL, WITH TERMS GREATER THAN:'/TINYSPC
      SDR2    CASEDR,CSTMS,MPTS,DIT,EQEXINS,,ETT,OLB1,BGPDTS,,QFSPC,
           UGVS,EST,XYCDB/,OQSPC    ,,,,/'STATICS' $
      OFP     OQSPC    //S,N,CARDNO $
$
    ENDIF
$
  ENDIF $ Above executed iff PS and SPC sets broken out separately
$
ENDIF $ Above executed iff APP1 = 'STATICS'
$
$-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
$======================================= End of SPC4C101.V675 =====
$-------+-------+-------+-------+-------+-------+-------+-------+------
```

APPENDIX C - DMAP ALTER for SOL 24

```
$
$-------+-------+-------+-------+-------+-------+-------+-------+-------+
$
$ Alter SPC4C_24.V675 - RFALTER to display separate SPCFORCE output
$                for modelled-in SPC (those on GRID/PS and SPC
$                sets) and AUTOSPC reaction forces.
$
$
$ SOL: 24 (only)
$
$ Description:
$ This alter organizes the calculated SPCForces by the type of
$ constraint placed upon a DOF; e.g. was it a user-induced constraint
$ such as the PS field on the GRID or an SPC card, or was it a DOF
$ constrained by the AUTOSPC function. User has further option of
$ breaking the user-induced constraints into those DOF constrained by
$ the GRID PS field and those on an SPC set. Answers may be
$ independently filtered to remove smaller SPCForces from the
$ printouts. Resultant vectors for SPCForce contributions are also
$ calculated. Alter will properly handle changes in boundary
$ conditions (i.e. SPC set changes) between subcases for sol 24.
$
$
$ User Interface:
$  1) Include this alter in sol 24
$  2) Ask for SPCFORCEs in the case control
$  3) Bulk Data PARAMS: (optional)
$      -SPCLEVEL: Default = 0 (integer). Default will separate
$              SPCForce output into AUTOSPC'd DOFs and modelled-in
$              (GRID/PS plus SPC set) DOFs. Setting SPCLEVEL
$              to 1 will divide SPCForce output into three
$              separate groups: AUTOSPC, GRID/PS, and SPC sets.
$      -TINYAUTO: Default = 0.0. Acts as a filter on printed
$              SPCForces for those DOF constrained by AUTOSPC.
$              Any SPCForce smaller in magnitude than TINYAUTO
$              will NOT be printed.
$      -TINYSPC: Default = 0.0. Acts as a filter on printed
$              SPCForces for those DOF constrained by either
$              GRID/PS or SPC set cards. Any SPCForce smaller
$              than TINYSPC will NOT be printed.
$      -GRDPNT: Default = 0 (integer). Allows user to have
$              SPCForce Resultants summed about this grid point in
$              a coordinate system parallel to the BASIC system.
$
$-------+-------+-------+-------+-------+-------+-------+-------+-------+
$
$
ALTER 4
FILE QZAUTSPC=APPEND/QZPSNSPC=APPEND/QZPS=APPEND/QZSPC=APPEND
$
```

```
TYPE PARM,,RS,Y,TINYAUTO=0. $ Declare, set defaults
TYPE PARM,,RS,Y,TINYSPC=0. $
TYPE PARM,,I,Y,SPCLEVEL=0  $
$
ALTER 160,160 $ Remove SDR1, replace with:
SDR1   USET,PG,ULV,UOOV,YS,GO,GM,PS,KFS,KSS,QR/UGV,PGG,QGTEMP/
     V,N,NSKIP/'STATICS' $
IF(NSKIP = 1) THEN
 EQUIVX QGTEMP/QG/ALWAYS  $ Initial Creation
ELSE
 APPEND  QGTEMP,/QG/2     $ APPEND
ENDIF
IF (SPCLEVEL = 0) THEN  $ Split into AUTOSPC/(PS+SPC) groups
  UPARTN USETB,QGTEMP   /QSPSNSPC,,,/'G'/'S'/'M'/1 $ PS+SPC, pre-AUTOSPC
  UMERGE USETB,QSPSNSPC,/QGPSNSPC  /'G'/'S'/'M'  $ Re-Expand to G-size
  ADD5   QGTEMP,QGPSNSPC,,,/QGAUTSPC/+1./-1.      $ Auto=All-(PS+SPC)
$
ELSE $ If SPCLEVEL <> 0 then do the following:
$
  UPARTN USETB,QGTEMP   /QSPS,,, /'G'/'SG'/'M'/1 $ PS, pre-AUTOSPC
  UMERGE USETB,QSPS    ,/QGPS    /'G'/'SG'/'M'  $
  UPARTN USETB,QGTEMP   /QSSPC,,,/'G'/'SB'/'M'/1 $ SPC, pre-AUTOSPC
  UMERGE USETB,QSSPC   ,/QGSPC   /'G'/'SB'/'M'  $
  ADD5   QGTEMP,QGPS,QGSPC,,/QGAUTSPC/+1./-1./-1.$ Auto=All-PS-SPC
ENDIF $
$ Do create/update on QG, create/update series of QZ... matrices.  These
$ are created to feed to SDR2 and OFP later (outside of loop)
IF(NSKIP = 1) THEN
 EQUIVX  QGTEMP /QG     /ALWAYS  $ Initial Creations
 EQUIVX  QGAUTSPC/QZAUTSPC/ALWAYS  $
 EQUIVX  QGPSNSPC/QZPSNSPC/ALWAYS  $
 EQUIVX  QGPS    /QZPS    /ALWAYS $
 EQUIVX  QGSPC   /QZSPC   /ALWAYS  $
ELSE
 APPEND  QGTEMP  ,/QG     /2     $ Appends...
 APPEND  QGAUTSPC,/QZAUTSPC/2      $
 APPEND  QGPSNSPC,/QZPSNSPC/2      $
 APPEND  QGPS    ,/QZPS   /2      $
 APPEND  QGSPC   ,/QZSPC  /2      $
ENDIF
$
ALTER 185 $ After OFP on usual SPCFORCES:
$
PARAML QZAUTSPC//'PRESENCE'////S,N,ISAUTSPC $ Check for existence of:
PARAML QZPSNSPC//'PRESENCE'////S,N,ISPSNSPC $
PARAML QZPS    //'PRESENCE'////S,N,ISPS    $
PARAML QZSPC   //'PRESENCE'////S,N,ISSPC   $
$
IF(ISAUTSPC = 0) THEN
  VECPLOT QZAUTSPC,BGPDT,EQEXIN,CSTM,CASECC,/XGAUTSPC/
       GRDPNT/0/1/'AUTOSPC' $
  MESSAGE //' THE ABOVE RESULTANT TABLE IS FOR ALL DOFS CONSTRAINED '/
         'BY THE AUTOSPC FEATURE,' $
  MESSAGE //' RESULTANT VECTORS ARE PARALLEL TO BASIC SYSTEM,'/
```

```
        ' SUMMED ABOUT GRID POINT:'/GRDPNT
  MESSAGE //' ' $
  IF(TINYAUTO > 0.) THEN
   MATMOD  QZAUTSPC,,,,,/QFAUTSPC,/2////TINYAUTO $ Filter out terms
  ELSE   $ Dont bother with matmod operation if filter term is zero
   EQUIVX  QZAUTSPC/QFAUTSPC/ALWAYS $
  ENDIF
  MESSAGE //' THE FOLLOWING OUTPUT TABLE, LABELLED "FORCES OF'/
        ' CONSTRAINT", CONTAIN REACTION FORCES'
  MESSAGE //' FOR THOSE DOF CONSTRAINED BY THE AUTOSPC FEATURE WITH '/
        'SPCFORCE TERMS GREATER THAN: '/TINYAUTO
  MESSAGE //' '
  SDR2   CASECC,CSTM,MPT,DIT,EQEXIN,,ETT,EDT,BGPDT,,QFAUTSPC,
       UGV,EST,XYCDB/,OQAUTSPC,,,,/'STATICS' $
  OFP    OQAUTSPC//S,N,CARDNO $ Printout...
$
ENDIF
$
IF(ISPSNSPC = 0) THEN
  VECPLOT QZPSNSPC,BGPDT,EQEXIN,CSTM,CASECC,/XGPSNSPC/
       GRDPNT/USRCOORD/1/'PS + SPC' $
  MESSAGE //' THE ABOVE RESULTANT TABLE IS FOR ALL DOFS CONSTRAINED '/
        'BY THE PS FIELD ON THE GRID' $
  MESSAGE //' CARDS AND ON SPC SETS CALLED OUT IN THE CASE CONTOL'
  MESSAGE //' RESULTANT VECTORS ARE PARALLEL TO BASIC SYSTEM,'/
        ' SUMMED ABOUT GRID POINT:'/GRDPNT
  MESSAGE //' '
  IF(TINYSPC > 0.) THEN
   MATMOD  QZPSNSPC,,,,,/QFPSNSPC,/2////TINYSPC $ Filter out terms
  ELSE    $ Dont bother with matmod operation if filter term is zero
   EQUIVX QZPSNSPC/QFPSNSPC/ALWAYS $
  ENDIF
  MESSAGE //' THE FOLLOWING OUTPUT TABLE, LABELLED "FORCES OF'/
        ' CONSTRAINT", CONTAIN REACTION FORCES' $
  MESSAGE //' FOR THOSE DOF CONSTRAINED BY GRID PS AND SPC SETS '/
        'CALLED OUT IN THE CASE CONTROL,'
  MESSAGE //' WITH TERMS GREATER THAN '/TINYSPC $
  SDR2   CASECC,CSTM,MPT,DIT,EQEXIN,,ETT,EDT,BGPDT,,QFPSNSPC,
       UGV,EST,XYCDB/,OQPSNSPC,,,,/'STATICS' $
  OFP    OQPSNSPC//S,N,CARDNO $
$
ELSE $ Do below iff PS and SPCs broken out separately
$
  IF(ISPS    = 0) THEN
   VECPLOT QZPS    ,BGPDT,EQEXIN,CSTM,CASECC,/XGPS/
        GRDPNT/USRCOORD/1/'GRID PS ' $
   MESSAGE //' THE ABOVE RESULTANT TABLE IS FOR ALL DOFS CONSTRAINED'/
         ' BY THE PS FIELD ON THE GRID CARDS'
   MESSAGE //' RESULTANT VECTORS ARE PARALLEL TO BASIC SYSTEM,'/
         ' SUMMED ABOUT GRID POINT:'/GRDPNT
   MESSAGE //' '
   IF(TINYSPC > 0.) THEN
    MATMOD  QZPS    ,,,,,/QFPS    ,/2////TINYSPC $ Filter out terms
   ELSE    $ Dont bother with matmod operation if filter term is zero
```

```
    EQUIVX QZPS   /QFPS   /ALWAYS $
   ENDIF
   MESSAGE //' THE FOLLOWING OUTPUT TABLE, LABELLED "FORCES OF'/
         ' CONSTRAINT", CONTAIN REACTION FORCES FOR THOSE DOF' $
   MESSAGE //' CONSTRAINED BY THE PS FIELD ON THE GRID CARDS, WITH'/
          'TERMS GREATER THAN:'/TINYSPC $
   SDR2   CASECC,CSTM,MPT,DIT,EQEXIN,,ETT,EDT,BGPDT,,QFPS,
        UGV,EST,XYCDB/,OQPS   ,,,,/'STATICS' $
   OFP    OQPS   //S,N,CARDNO $
$
  ENDIF
$
  IF(ISSPC   = 0) THEN
   VECPLOT QZSPC   ,BGPDT,EQEXIN,CSTM,CASECC,/XGSPC/
        GRDPNT/USRCOORD/1/'SPC SET ' $
   MESSAGE //' THE ABOVE RESULTANT TABLE IS FOR ALL DOFS CONSTRAINED'/
         ' BY SPC SETS CALLED OUT IN THE CASE CONTROL'
   MESSAGE //' RESULTANT VECTORS ARE PARALLEL TO BASIC SYSTEM,'/
         ' SUMMED ABOUT GRID POINT:'/GRDPNT
   MESSAGE //' '
   IF(TINYSPC > 0.) THEN
    MATMOD  QZSPC   ,,,,,/QFSPC   ,/2////TINYSPC $ Filter out terms
   ELSE     $ Dont bother with matmod operation if filter term is zero
    EQUIVX QZSPC   /QFSPC   /ALWAYS $
   ENDIF
   MESSAGE //' THE FOLLOWING OUTPUT TABLE, LABELLED "FORCES OF'/
         ' CONSTRAINT", CONTAIN REACTION FORCES FOR THOSE DOF' $
   MESSAGE //' CONSTRAINED BY SPC SETS CALLED OUT IN '/
         'THE CASE CONTROL, WITH TERMS GREATER THAN:'/TINYSPC
   SDR2   CASECC,CSTM,MPT,DIT,EQEXIN,,ETT,EDT,BGPDT,,QFSPC,
        UGV,EST,XYCDB/,OQSPC   ,,,,/'STATICS' $
   OFP    OQSPC  //S,N,CARDNO $
$
  ENDIF
$
ENDIF
$
$-------+-------+-------+-------+-------+-------+-------+-------+-------+
$======================================================= End of SPC4C_24.V675 =====+
$-------+-------+-------+-------+-------+-------+-------+-------+-------+
```

APPENDIX D EXAMPLE OUTPUT

SPCFORCE RESULTANT

	T1	T2	T3	R1	R2	R3
1	-5.3094539E+04	-5.6678233E+00	-4.2590885E+00	1.8558428E+03	1.9379950E+07	-3.8846500E+06
2	-3.8253148E+04	-1.1421434E+01	-8.5429153E+00	7.8288989E+03	1.2567767E+07	-1.1924351E+06
3	-4.4318867E+04	-2.1361561E-01	7.2898865E-03	-3.4464753E+03	-3.8978958E+06	-3.6859128E+06
4	-4.9858578E+04	-5.4187140E+00	-3.8214779E+00	2.6198481E+03	-4.2544230E+06	7.7404359E+04
5	-8.2496281E+04	-8.5461378E+00	-6.1301880E+00	9.9734268E+03	2.2972434E+07	-4.5533010E+06
6	-8.5226711E+04	-6.5802979E-01	-1.1565228E+00	1.4491796E+03	-8.0523035E+06	-4.4108215E+06
7	3.1995389E-01	-3.9000019E-01	-2.9007500E-01	-6.2591797E+01	4.4708316E+02	-5.8861450E+03
8	8.5524359E+04	1.9425917E-01	-4.2921066E-01	2.8974602E+03	-2.1218695E+06	8.3160635E+06
9	-8.3971531E+04	-1.6960022E+00	-1.6223297E+00	7.0319390E+03	1.6459194E+07	-7.1391650E+06
10	-3.4690266E+04	-5.4429202E+00	-4.1011276E+00	4.5372495E+03	1.4803904E+07	-2.7162005E+06
11	-5.4511891E+04	-5.4356470E+00	-3.5393429E+00	1.6390709E+03	5.5801565E+06	-4.5560360E+06
12	-4.4150348E+04	-4.0276637E+00	-3.3299866E+00	8.7249727E+03	5.2157590E+06	-3.9717845E+06
13	-8.9244648E+04	-2.7162604E+00	-1.8479919E+00	1.0864472E+04	1.6465801E+07	-6.9134175E+06
14	-8.7278523E+04	-9.1996832E+00	-6.1075134E+00	5.6726997E+03	5.0256230E+06	9.5236000E+05
15	-4.1010855E+04	-1.8893629E+00	-1.9355545E+00	9.4194453E+03	1.2149500E+07	-2.6664093E+06
16	-6.5922477E+04	-1.4172846E+00	-1.3502350E+00	1.3173508E+04	1.5703447E+07	-4.3594065E+06
17	2.8080369E+04	1.6585100E+01	2.7151947E+01	1.1309681E+04	-2.1698308E+06	4.3532570E+06
18	-3.1227791E+03	1.5677708E+00	9.8944092E-01	4.2572310E+03	5.9713856E+05	-1.4630878E+06
19	-6.1295977E+04	1.7967080E+00	1.6950455E+00	4.9081919E+03	2.2973953E+06	6.3943456E+05
20	-1.4023922E+04	1.7246199E+00	1.3860931E+00	6.2019243E+03	6.7152150E+05	-6.1486006E+05
21	-4.0241410E+04	1.3618126E+00	5.2804184E-01	5.0629492E+03	4.3375765E+06	-3.2202193E+06
22	1.0951962E+04	1.8800858E+00	1.2250671E+00	4.5510293E+03	-1.0033521E+06	3.0847469E+05
23	-4.9378442E+03	1.8403000E+00	6.4810181E-01	3.6794412E+03	8.2680763E+05	3.3579247E+05
24	1.3351150E+04	1.1821666E+00	1.1110077E+00	7.4815396E+03	-1.5666721E+06	1.2046765E+06
25	-3.4688332E+04	1.6288296E+00	1.0255356E+00	4.8956558E+03	3.4163548E+06	-2.9906048E+06
26	9.5945361E+03	1.3107891E+00	5.8843231E-01	7.4842153E+03	-1.3811233E+06	9.4532644E+05
27	-2.6164830E+04	1.3603913E+00	1.2044945E+00	4.8052856E+03	2.7926305E+06	-2.0938564E+06
28	-1.6651229E+04	1.2746110E+00	1.0548172E+00	5.5653252E+03	1.4447608E+06	-2.3098105E+06
29	-4.9490002E+02	1.1237439E+00	1.1484566E+00	3.6483784E+03	-5.0481384E+05	2.5591860E+06
30	-5.6915044E+03	1.8198594E+00	5.3662872E-01	5.8158193E+03	6.9065356E+05	-1.4645316E+06
31	3.4247145E+04	2.7529335E-01	1.8230057E-01	3.1447922E+03	-1.4766609E+06	1.2495381E+06

SUBCASE 1

F O R C E S O F S I N G L E - P O I N T C O N S T R A I N T

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
472413	G	4.866229E+03	.0	-2.262444E+01	.0	3.465724E+00	-1.225604E+00
555351	G	3.969421E+03	.0	1.836535E+01	.0	-3.243922E+00	-4.556570E+01
555369	G	-5.339428E+03	.0	.0	.0	-4.599243E-01	3.207265E+00
555905	G	.0	-5.667823E+00	.0	.0	.0	.0

SUBCASE 2

F O R C E S O F S I N G L E - P O I N T C O N S T R A I N T

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
472413	G	4.964439E+03	.0	-9.485786E+01	.0	3.104650E+00	-1.101812E+00
555351	G	3.278851E+03	.0	8.631495E+01	.0	-3.288540E+00	-4.175576E+01
555369	G	-3.914081E+03	.0	.0	.0	3.420404E-01	2.291013E+00
555905	G	.0	-1.142143E+01	.0	.0	.0	.0

SUBCASE 3

F O R C E S O F S I N G L E - P O I N T C O N S T R A I N T

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
472413	G	-2.303651E+03	.0	4.151382E+01	.0	1.449345E+00	1.558243E-01
555351	G	-1.519099E+03	.0	-4.150653E+01	.0	-2.139199E+00	-3.105376E+01
555369	G	1.154248E+03	.0	.0	.0	4.626644E-01	-9.500779E-01
555905	G	.0	-2.136156E-01	.0	.0	.0	.0

SUBCASE 4

F O R C E S O F S I N G L E - P O I N T C O N S T R A I N T

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
472413	G	-8.116472E+02	.0	-3.181768E+01	.0	1.341908E+00	-1.217481E+00
555351	G	-2.429070E+03	.0	2.799620E+01	.0	-3.964212E-02	9.136409E+00
555369	G	2.406931E+03	.0	.0	.0	1.000694E+00	-2.359890E+00
555905	G	.0	-5.418714E+00	.0	.0	.0	.0

SUBCASE 5

FORCES OF SINGLE-POINT CONSTRAINT

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
472413	G	4.341464E+03	.0	-1.205612E+02	.0	4.844231E+00	-2.030365E+00
555351	G	3.819373E+03	.0	1.144310E+02	.0	-4.442404E+00	-6.438616E+01
555369	G	-8.225520E+03	.0	.0	.0	2.889316E+00	2.055418E+00
555905	G	.0	-8.546138E+00	.0	.0	.0	.0

SUBCASE 6

FORCES OF SINGLE-POINT CONSTRAINT

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
472413	G	-2.696756E+03	.0	-1.749075E+01	.0	4.016569E+00	1.800101E-01
555351	G	-2.451159E+03	.0	1.633422E+01	.0	-4.735464E+00	-6.303524E+01
555369	G	1.605637E+03	.0	.0	.0	8.195946E-01	-1.453779E+00
555905	G	.0	-6.580298E-01	.0	.0	.0	.0

SUBCASE 7

FORCES OF SINGLE-POINT CONSTRAINT

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
472413	G	-6.041093E-03	.0	7.358914E-01	.0	-6.300185E-03	4.710572E-03
555351	G	4.480941E+00	.0	-1.025966E+00	.0	-3.085850E-03	-1.461705E-01
555369	G	-1.484240E+01	.0	.0	.0	4.909618E-03	-2.230593E-04
555905	G	.0	-3.900002E-01	.0	.0	.0	.0

SUBCASE 8

FORCES OF SINGLE-POINT CONSTRAINT

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
472413	G	-4.720176E+02	.0	-3.490008E+01	.0	3.316711E-01	-5.340293E-01
555351	G	3.557494E+03	.0	3.447087E+01	.0	6.490574E-01	-1.036984E+01
555369	G	-1.409107E+03	.0	.0	.0	3.160821E+00	2.144722E-01
555905	G	.0	1.942592E-01	.0	.0	.0	.0

AUTOSPC RESULTANT

	T1	T2	T3	R1	R2	R3
1	.0000000E+00	.0000000E+00	-2.1023331E-17	-1.4425441E-15	4.1761806E+01	.0000000E+00
2	.0000000E+00	.0000000E+00	-1.5762282E-17	-1.0815502E-15	2.7934494E+01	.0000000E+00
3	.0000000E+00	.0000000E+00	1.1988167E-17	8.2258424E-16	-1.0527564E+01	.0000000E+00
4	.0000000E+00	.0000000E+00	2.1920165E-17	1.5040817E-15	-1.5113730E+01	.0000000E+00
5	.0000000E+00	.0000000E+00	-2.8322462E-17	-1.9433839E-15	4.6250816E+01	.0000000E+00
6	.0000000E+00	.0000000E+00	3.3343245E-18	2.2878916E-16	-2.2421028E+01	.0000000E+00
7	.0000000E+00	.0000000E+00	4.8868859E-19	3.3532023E-17	-2.3451276E-02	.0000000E+00
8	.0000000E+00	.0000000E+00	-7.9196009E-18	-5.4341404E-16	-4.9662585E+00	.0000000E+00
9	.0000000E+00	.0000000E+00	-1.9034895E-17	-1.3061049E-15	3.3271679E+01	.0000000E+00
10	.0000000E+00	.0000000E+00	-2.4000272E-17	-1.6468110E-15	3.1754875E+01	.0000000E+00
11	.0000000E+00	.0000000E+00	3.8986296E-18	2.6750971E-16	8.9160757E+00	.0000000E+00
12	.0000000E+00	.0000000E+00	-8.7463199E-18	-6.0014052E-16	5.0301170E+00	.0000000E+00
13	.0000000E+00	.0000000E+00	-3.0583987E-17	-2.0985616E-15	3.2701260E+01	.0000000E+00
14	.0000000E+00	.0000000E+00	-8.3342831E-18	-5.7186805E-16	7.2786708E+00	.0000000E+00
15	.0000000E+00	.0000000E+00	-2.4613302E-17	-1.6888749E-15	2.4965048E+01	.0000000E+00
16	.0000000E+00	.0000000E+00	-2.6164803E-17	-1.7953333E-15	3.0953314E+01	.0000000E+00
17	.0000000E+00	.0000000E+00	-1.9756303E-18	-1.3556053E-16	-4.9311243E-02	.0000000E+00
18	.0000000E+00	.0000000E+00	-1.1139870E-17	-7.6437720E-16	2.4292817E+00	.0000000E+00
19	.0000000E+00	.0000000E+00	-4.3670190E-18	-2.9964886E-16	2.4972811E+00	.0000000E+00
20	.0000000E+00	.0000000E+00	-1.0587866E-17	-7.2650064E-16	1.6923410E+00	.0000000E+00
21	.0000000E+00	.0000000E+00	-4.9170916E-18	-3.3739286E-16	8.1061583E+00	.0000000E+00
22	.0000000E+00	.0000000E+00	-2.3220330E-17	-1.5932942E-15	2.6439977E+00	.0000000E+00
23	.0000000E+00	.0000000E+00	-3.9849451E-18	-2.7343237E-16	1.1067033E+00	.0000000E+00
24	.0000000E+00	.0000000E+00	-2.3265590E-17	-1.5963998E-15	1.4020729E+00	.0000000E+00
25	.0000000E+00	.0000000E+00	-1.1389620E-17	-7.8151410E-16	6.2358441E+00	.0000000E+00
26	.0000000E+00	.0000000E+00	-2.2431911E-17	-1.5391957E-15	1.4780768E+00	.0000000E+00
27	.0000000E+00	.0000000E+00	-9.3619028E-18	-6.4237957E-16	5.2740841E+00	.0000000E+00
28	.0000000E+00	.0000000E+00	-1.1647595E-17	-7.9921540E-16	3.3235557E+00	.0000000E+00
29	.0000000E+00	.0000000E+00	-7.0195364E-19	-4.8165493E-17	-8.2764155E-01	.0000000E+00
30	.0000000E+00	.0000000E+00	-6.7614823E-18	-4.6394821E-16	2.5371282E+00	.0000000E+00
31	.0000000E+00	.0000000E+00	-1.0308652E-17	-7.0734207E-16	-4.1954737E+00	.0000000E+00

^^^

^^^ THE ABOVE RESULTANT TABLE IS FOR ALL DOFS CONSTRAINED BY THE AUTOSPC FEATURE.
^^^ RESULTANT VECTORS ARE PARALLEL TO BASIC SYSTEM, SUMMED ABOUT GRID POINT: 555901
^^^

^^^ THE FOLLOWING OUTPUT TABLE, LABELLED "FORCES OF SINGLE-POINT CONSTRAINT", CONTAIN REACTION FORCES
^^^ FOR THOSE DOF CONSTRAINED BY THE AUTOSPC FEATURE WITH SPCFORCE TERMS GREATER THAN: .000000E+00
^^^

PS + SPC RESULTANT

	T1	T2	T3	R1	R2	R3
1	-5.3094539E+04	-5.6678233E+00	-4.2590885E+00	1.8558428E+03	1.9379908E+07	-3.8846500E+06
2	-3.8253148E+04	-1.1421434E+01	-8.5429153E+00	7.8288989E+03	1.2567739E+07	-1.1924351E+06
3	-4.4318867E+04	-2.1361561E-01	7.2898865E-03	-3.4464753E+03	-3.8978853E+06	-3.6859128E+06
4	-4.9858578E+04	-5.4187140E+00	-3.8214779E+00	2.6198481E+03	-4.2544080E+06	7.7404359E+04
5	-8.2496281E+04	-8.5461378E+00	-6.1301880E+00	9.9734268E+03	2.2972388E+07	-4.5533010E+06
6	-8.5226711E+04	-6.5802979E-01	-1.1565228E+00	1.4491796E+03	-8.0522810E+06	-4.4108215E+06
7	3.1995389E-01	-3.9000019E-01	-2.9007500E-01	-6.2591797E+01	4.4710660E+02	-5.8861450E+03
8	8.5524359E+04	1.9425917E-01	-4.2921066E-01	2.8974602E+03	-2.1218645E+06	8.3160635E+06
9	-8.3971531E+04	-1.6960022E+00	-1.6223297E+00	7.0319390E+03	1.6459161E+07	-7.1391650E+06
10	-3.4690266E+04	-5.4429202E+00	-4.1011276E+00	4.5372495E+03	1.4803872E+07	-2.7162005E+06
11	-5.4511891E+04	-5.4356470E+00	-3.5393429E+00	1.6390709E+03	5.5801475E+06	-4.5560360E+06
12	-4.4150348E+04	-4.0276637E+00	-3.3299866E+00	8.7249727E+03	5.2157540E+06	-3.9717845E+06
13	-8.9244648E+04	-2.7162604E+00	-1.8479919E+00	1.0864472E+04	1.6465768E+07	-6.9134175E+06
14	-8.7278523E+04	-9.1996832E+00	-6.1075134E+00	5.6726997E+03	5.0256155E+06	9.5236000E+05
15	-4.1010855E+04	-1.8893629E+00	-1.9355545E+00	9.4194453E+03	1.2149475E+07	-2.6664093E+06
16	-6.5922477E+04	-1.4172846E+00	-1.3502350E+00	1.3173508E+04	1.5703416E+07	-4.3594065E+06
17	2.8080369E+04	1.6585100E+01	2.7151947E+01	1.1309681E+04	-2.1698308E+06	4.3532570E+06
18	-3.1227791E+03	1.5677708E+00	9.8944092E-01	4.2572310E+03	5.9713613E+05	-1.4630878E+06
19	-6.1295977E+04	1.7967080E+00	1.6950455E+00	4.9081919E+03	2.2973928E+06	6.3943456E+05
20	-1.4023922E+04	1.7246199E+00	1.3860931E+00	6.2019243E+03	6.7151981E+05	-6.1486006E+05
21	-4.0241410E+04	1.3618126E+00	5.2804184E-01	5.0629492E+03	4.3375685E+06	-3.2202193E+06
22	1.0951962E+04	1.8800858E+00	1.2250671E+00	4.5510293E+03	-1.0033547E+06	3.0847469E+05
23	-4.9378442E+03	1.8403000E+00	6.4810181E-01	3.6794412E+03	8.2680656E+05	3.3579247E+05
24	1.3351150E+04	1.1821666E+00	1.1110077E+00	7.4815396E+03	-1.5666735E+06	1.2046765E+06
25	-3.4688332E+04	1.6288296E+00	1.0255356E+00	4.8956558E+03	3.4163485E+06	-2.9906048E+06
26	9.5945361E+03	1.3107891E+00	5.8843231E-01	7.4842153E+03	-1.3811248E+06	9.4532644E+05
27	-2.6164830E+04	1.3603913E+00	1.2044945E+00	4.8052856E+03	2.7926253E+06	-2.0938564E+06
28	-1.6651229E+04	1.2746110E+00	1.0548172E+00	5.5653252E+03	1.4447574E+06	-2.3098105E+06
29	-4.9490002E+02	1.1237439E+00	1.1484566E+00	3.6483784E+03	-5.0481303E+05	2.5591860E+06
30	-5.6915044E+03	1.8198594E+00	5.3662872E-01	5.8158193E+03	6.9065100E+05	-1.4645316E+06
31	3.4247145E+04	2.7529335E-01	1.8230057E-01	3.1447922E+03	-1.4766568E+06	1.2495381E+06

^^^ THE ABOVE RESULTANT TABLE IS FOR ALL DOFS CONSTRAINED BY THE PS FIELD ON THE GRID
^^^ CARDS AND ON SPC SETS CALLED OUT IN THE CASE CONTOL
^^^ RESULTANT VECTORS ARE PARALLEL TO BASIC SYSTEM, SUMMED ABOUT GRID POINT: 555901
^^^

^^^ THE FOLLOWING OUTPUT TABLE, LABELLED "FORCES OF SINGLE-POINT CONSTRAINT", CONTAIN REACTION FORCES
^^^ FOR THOSE DOF CONSTRAINED BY GRID PS ENTRIES AND SPC SETS CALLED OUT IN THE CASE CONTROL,
^^^ WITH TERMS GREATER THAN .000000E+00

SUBCASE 1

F O R C E S   O F   S I N G L E - P O I N T   C O N S T R A I N T

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
472413	G	4.866229E+03	.0	-2.262444E+01	.0	3.465724E+00	-1.225604E+00
555351	G	3.969421E+03	.0	1.836535E+01	.0	-3.243922E+00	-4.556570E+01
555369	G	-5.339428E+03	.0	.0	.0	-4.599243E-01	3.207265E+00
555905	G	.0	-5.667823E+00	.0	.0	.0	.0

SUBCASE 2

F O R C E S   O F   S I N G L E - P O I N T   C O N S T R A I N T

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
472413	G	4.964439E+03	.0	-9.485786E+01	.0	3.104650E+00	-1.101812E+00
555351	G	3.278851E+03	.0	8.631495E+01	.0	-3.288540E+00	-4.175576E+01
555369	G	-3.914081E+03	.0	.0	.0	3.420404E-01	2.291013E+00
555905	G	.0	-1.142143E+01	.0	.0	.0	.0

SUBCASE 3

F O R C E S   O F   S I N G L E - P O I N T   C O N S T R A I N T

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
472413	G	-2.303651E+03	.0	4.151382E+01	.0	1.449345E+00	1.558243E-01
555351	G	-1.519099E+03	.0	-4.150653E+01	.0	-2.139199E+00	-3.105376E+01
555369	G	1.154248E+03	.0	.0	.0	4.626644E-01	-9.500779E-01
555905	G	.0	-2.136156E-01	.0	.0	.0-	.0

SUBCASE 4

F O R C E S   O F   S I N G L E - P O I N T   C O N S T R A I N T

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
472413	G	-8.116472E+02	.0	-3.181768E+01	.0	1.341908E+00	-1.217481E+00
555351	G	-2.429070E+03	.0	2.799620E+01	.0	-3.964212E-02	9.136409E+00
555369	G	2.406931E+03	.0	.0	.0	1.000694E+00	-2.359890E+00
555905	G	.0	-5.418714E+00	.0	.0	.0	.0

SUBCASE 5

FORCES OF SINGLE-POINT CONSTRAINT

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
472413	G	4.341464E+03	.0	-1.205612E+02	.0	4.844231E+00	-2.030365E+00
555351	G	3.819373E+03	.0	1.144310E+02	.0	-4.442404E+00	-6.438616E+01
555369	G	-8.225520E+03	.0	.0	.0	2.889316E+00	2.055418E+00
555905	G	.0	-8.546138E+00	.0	.0	.0	.0

SUBCASE 6

FORCES OF SINGLE-POINT CONSTRAINT

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
472413	G	-2.696756E+03	.0	-1.749075E+01	.0	4.016569E+00	1.800101E-01
555351	G	-2.451159E+03	.0	1.633422E+01	.0	-4.735464E+00	-6.303524E+01
555369	G	1.605637E+03	.0	.0	.0	8.195946E-01	-1.453779E+00
555905	G	.0	-6.580298E-01	.0	.0	.0	.0

SUBCASE 7

FORCES OF SINGLE-POINT CONSTRAINT

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
472413	G	-6.041093E-03	.0	7.358914E-01	.0	-6.300185E-03	4.710572E-03
555351	G	4.480941E+00	.0	-1.025966E+00	.0	-3.085850E-03	-1.461705E-01
555369	G	-1.484240E+01	.0	.0	.0	4.909618E-03	-2.230593E-04
555905	G	.0	-3.900002E-01	.0	.0	.0	.0

FORCES OF SINGLE-POINT CONSTRAINT

SUBCASE 8

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
472413	G	-4.720176E+02	.0	-3.490008E+01	.0	3.316711E-01	-5.340293E-01
555351	G	3.557494E+03	.0	3.447087E+01	.0	6.490574E-01	-1.036984E+01
555369	G	-1.409107E+03	.0	.0	.0	3.160821E+00	2.144722E-01
555905	G	.0	1.942592E-01	.0	.0	.0	.0