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SPAR DATA SET CONTENTS

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## CONTENTS

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SUMMARY

The SPAR structural analysis system consists of a collection of processors for performing finite-element analysis. The data generated by each of these processors are stored in a data base library as two-dimensional tables or matrices called data sets. These data sets are identified by four-word names which are listed in the table of contents for the data base library.

This report documents the contents of the SPAR data sets. The creating SPAR processor, number of rows and columns, and definitions of each of the data items are documented for each data set. An example problem is included, with SPAR input and resulting table of contents. This information can be used to create new SPAR processors or to interface SPAR with another system.

INTRODUCTION

The SPAR computer software system is a collection of processors for performing finite-element structural analysis. The data generated by each processor is stored on a data base complex for use by subsequent processors. This data may be read by the user through SPAR data processors (ref. 1) or FORTRAN data handling utilities (ref. 2).

This report documents the contents of many of the SPAR data sets stored in the data base complex. An example problem for creating the data sets documented in this report is included, with the SPAR input and resulting table of contents listed. This data was collected in the course of writing an interface from SPAR to another data base complex, and represents the formalizing of a set of notes passed on by several users. This information can be used (1) to understand more clearly and to use more productively the existing processors in the SPAR system, (2) to develop new SPAR processors, or (3) to interface SPAR with another software system.

SPAR DATA SET CONTENTS

The SPAR software system, created by W. D. Whetstone, is composed of processors for performing finite-element structural analysis. The data from a SPAR run is saved in a data file organized as a "library." Each library file is composed of a number of datasets and a table of contents. These library files have names SPARLA through SPARLZ for Control Data; SPAR-A through SPAR-Z for Univac; or SPLA through SPLZ for PRIME or VAX; corresponding
to SPAR library numbers 1 through 26. The data is automatically put in library 1 by the processors. This file may be renamed to another library name and may still be read using DCU or the data handling utilities.

The data are stored in 2-dimensional tables or matrices dimensioned (NI, NJ) called blocks. Each data set contains one or more blocks with NI rows and NJ columns. Following are lists of the contents of many SPAR data sets. The creating SPAR processor, number of rows and columns, and the definition of each of the data items are listed for each data set.

JDF1 BTAB 1 8

Created from TAB processor START card.

NJ = 1
NI = 18

Contents:
1. Total number of joints.
2. Number of joint degrees of freedom, both translations and rotations, constrained by START card.
3. Number of joint translational degrees of freedom not constrained.
4. 
5. A list of unconstrained joint degrees of freedom, filled in consecutively from position 4; unused values are zero.
6. Example for d.o.f. 1, 2, and 6 unconstrained:
7. 1,2,6,0,0,0
8. 
9. 

10. A list specifying the order of each unconstrained degree of freedom; zero if not active.
11. Example for d.o.f. 1, 2, and 6 unconstrained:
12. 1,2,0,0,0,3
13. 
14. 
15. 
16. 
17. Not used.
18. 

JREF BTAB 2 6

Created from JREF in processor TAB.

NJ = Total number of joints
NI = 1

Contents:
Contains the Joint Reference Frame number for each joint, corresponding to the row number of dataset ALTR BTAB 2 4 which contains the definition of each Joint Reference Frame.
ALTR BTAB 2 4

Created from ALTREF in processor TAB.
NJ = Number of alternate reference frames
NI = 12

Contents of each entry:
1. $a_{11}$
2. $a_{21}$
3. $a_{31}$
4. $a_{12}$
5. $a_{22}$
6. $a_{32}$
7. $a_{13}$
8. $a_{23}$
9. $a_{33}$
10. $X_0$
11. $Y_0$
12. $Z_0$

Components of a coordinate transformation matrix

Location of origin of alternate reference frame given in global coordinates

Formula:

$$
\begin{bmatrix}
X_g \\
Y_g \\
Z_g
\end{bmatrix} =
\begin{bmatrix}
a_{11} & a_{12} & a_{13} \\
a_{21} & a_{22} & a_{23} \\
a_{31} & a_{32} & a_{33}
\end{bmatrix}
\begin{bmatrix}
X_a \\
Y_a \\
Z_a
\end{bmatrix} +
\begin{bmatrix}
X_o \\
Y_o \\
Z_o
\end{bmatrix}
$$

coordinates in global reference frame

coordinates in alternate reference frame

NDAL 0 0

Created from TITLE card in processor TAB.

Contains title in text.

TEXT BTAB 2 2

Created from TEXT card(s) in processor TAB.

Contains data in text.

JLOC BTAB 2 5

Created from JLOC in processor TAB.
NJ = Number of joints
NI = 3
Contents:

\[ J = 1, 2, \ldots \] Number of joints

\[ I = X \]

\[ Y \]

\[ Z \]

Rectangular coordinates of each joint in the global reference frame

---

**MREF BTAB 2 7**

Created from MREF in processor TAB.

NJ = Number of beam orientation entries

NI = 5

Contents of each entry:

(See reference 1 description of MREF input)

Format 1 (Default)

1. Beam axis NB
2. Global axis NG
3. 1 if cosine between NB and NG is positive, -1 if negative
4. Cosine of angle between NB and NG
5. 1. indicating format = 1

Format 2

1. \( X_1 \)
2. \( X_2 \)
3. \( X_3 \)
4. \( \bar{X} \) axis orientation
5. -1. indicating format = 2

---

**MATC BTAB 2 2**

Created from MATC in processor TAB.

NJ = Number of material types

NI = 10

Contents of each entry:

1. E = Modulus of elasticity
2. \( \nu \) = Poisson's Ratio
3. \( G \) = \( E/(2(1+\nu)) \)
4. \( \rho \) = Weight per unit volume
5. \( \alpha_1 \) = Thermal expansion coefficient, direction \( \bar{x} \)
6. \( \alpha_2 \) = Thermal expansion coefficient, direction \( y \)
7. \( \theta^\circ \) = Angle between element reference frame \((x, y)\) and \((\bar{x}, \bar{y})\)
8. 
9. \} Not used
10. 

4
BA BTAB 2 9

Created from E21 section properties in processor TAB.
NJ = Number of entries
NI = 31

Contents of each entry:
(See reference 1 description of DSY input of E21 section properties)
1. Element type indicator 17. Number of points at which stresses are to be calculated
2. ) Not used
3. 
4. \(I_1\)
5. \(a_1\)
6. \(I_2\)
7. \(a_2\)
8. \(a\)
9. \(f\)
10. \(f_1\)
11. \(z_1\)
12. \(z_2\)
13. \(\theta\)
14. \(q_1\)
15. \(q_2\)
16. \(q_3\)

BC BTAB 2 11

Created from E23 section properties in processor TAB.
NJ = Number of entries
NI = 6

Contents of each entry:
1. Cross-sectional area of axial element
2. Cross-sectional area of axial element
3. 
4. ) Not used.
5. 
6. 

SA BTAB 2 13

Created from shell section properties in processor TAB.
NJ = Number of entries
Contents vary according to section type:
For MEMBRANE, PLATE, ISOTROPIC or UNCOUPLED section types
NI = 43
Contents of each entry:
1. Number indicating section type:
   1 = MEMBRANE
   2 = PLATE
   3 = ISOTROPIC or UNCOUPLED
2. Pointer to entry of NMAT containing material constants
3. Structural weight/area
4. $d_{11}$
5. $d_{12}$
6. $d_{22}$
7. $d_{13}$
8. $d_{23}$
9. $d_{23}$
10. $d_{44}$
11. $d_{45}$
12. $d_{45}$
13. $d_{45}$
14. $d_{66}$
15. $d_{66}$

For COUPLED section types:
$N_l = 43$

Naturally:
1. Number indicating section type:
   4 = COUPLED
2. Pointer to entry of NMAT containing material constants
3. Structural weight/area
4. $d_{11}$
5. $d_{12}$
6. $d_{22}$
7. $d_{13}$
8. $d_{23}$
9. $d_{23}$
10. $d_{44}$
11. $d_{45}$
12. $d_{45}$
13. $d_{45}$
14. $d_{66}$
15. $d_{66}$

For COUPLED section types:
$N_l = 43$
For LAMINATE section types:
NI = 25 + (18 times number of layers)

Contents of each entry:
1. Number indicating section type:
   5 = LAMINATE
2. Pointer to entry of NMAT containing material constants
3. Structural weight/area
4. \( d_{11} \)
5. \( d_{12} \)
6. \( d_{22} \)
7. \( d_{13} \)
8. \( d_{23} \)
9. \( d_{33} \)
10. \( d_{14} \)
11. \( d_{24} \)
12. \( d_{34} \)
13. \( d_{44} \)
14. \( d_{15} \)
15. \( d_{25} \)
16. \( d_{35} \)
17. \( d_{45} \)
18. \( d_{55} \)
19. \( d_{16} \)
20. \( d_{26} \)
21. \( d_{36} \)
22. \( d_{46} \)
23. \( d_{56} \)
24. \( d_{66} \)

\( g_{11}, g_{12}, g_{22}, g_{13}, g_{23}, g_{33}, g_{14}, g_{24}, g_{34}, g_{15}, g_{25}, g_{35}, g_{16}, g_{26}, g_{36} \)

\( g^{2}_{11}, g^{2}_{12}, g^{2}_{22}, g^{2}_{13}, g^{2}_{23}, g^{2}_{33}, g^{2}_{14}, g^{2}_{24}, g^{2}_{34}, g^{2}_{15}, g^{2}_{25}, g^{2}_{35}, g^{2}_{16}, g^{2}_{26}, g^{2}_{36} \)

\( g^{3}_{11}, g^{3}_{12}, g^{3}_{22}, g^{3}_{13}, g^{3}_{23}, g^{3}_{33}, g^{3}_{14}, g^{3}_{24}, g^{3}_{34}, g^{3}_{15}, g^{3}_{25}, g^{3}_{35}, g^{3}_{16}, g^{3}_{26}, g^{3}_{36} \)

**Example:**

- ncon = Constraint case
- Created from CON in processor TAB
- NJ = Number of joints
- NI = 1

Contents:
Each entry contains an integer representing the Joint Reference Frame number and constrained components for that joint. The bit pattern of each integer contains a 1 for constrained components, zero otherwise, stored in reverse order (6 to 1) with Joint Reference Frame number leading. For example:

A joint with components 1, 2, 3, and 5 zeroed out and JREF = 11 would have the integer 45333 stored:

\[
\text{bit pattern } \rightarrow 0.\ldots01011
\]

\[
\text{JREF number } \rightarrow 00 \ 01 \ 00 \ 01 \ 01 \ 01
\]

\[
\begin{array}{cccccc}
6 & 5 & 4 & 3 & 2 & 1 \\
\text{joint motion components}
\end{array}
\]
Component 1 (constrained) = 1 x 1 = 1
Component 2 (constrained) = 1 x 4 = 4
Component 3 (constrained) = 1 x 16 = 16
Component 4 (unconstrained) = 0 x 64 = 0
Component 5 (constrained) = 1 x 256 = 256
Component 6 (unconstrained) = 0 x 1024 = 0
JREF number = 11 = 11 x 4096 = 45056
Integer stored for this joint = 45333

QJ JT BTAB 29

Created in processor TAB.
NJ = Number of Joints
NI = 9
Contents of each entry:
1. a11
2. a21
3. a31
4. a12
5. a22
6. a32
7. a13
8. a23
9. a33

Formula:
Each entry contains a 3 x 3 matrix to convert Alternate Reference Frame to Global Reference Frame for that joint.

\[
\begin{bmatrix}
X_g \\
Y_g \\
Z_g
\end{bmatrix} =
\begin{bmatrix}
a_{11} & a_{12} & a_{13} \\
a_{21} & a_{22} & a_{23} \\
a_{31} & a_{32} & a_{33}
\end{bmatrix}
\begin{bmatrix}
X_a \\
Y_a \\
Z_a
\end{bmatrix}
\]

coordinates in global reference frame
coordinates in alternate reference frame

DEF Exx y z

Exx = Element name
y = Type number (E21 = 1 through E44 = 12)
z = Number of joints/element
Created from element definitions in processor ELD.
NJ = Number of elements of this type
NI For 2-node elements = 18 columns
3-node elements = 15 columns
4-node elements = 16 columns
Contents of each entry:
1. Element number
2. Group number
3. Element number within group
4. Not used
5. N3 of corresponding dataset xx BTAB N3 N4
6. N4 where xx = BA, BB, SA...
7. Index of MATC containing material constants
8. Index section property dataset containing section properties.
9. Index of non-structural weight dataset (NSW)
10. Index of rigid link offset dataset (BRL)
11. Index of beam orientation dataset (MREF)
12. Not used
13. Joint #1
14. Joint #2
15. Joint #3
16. Joint #4
17. Not used
18. Not used

GD Exx y z

Exx = Element name
y = Type number (E21 = 1 through E44 = 12)
z = Number of joints/element
Created from element definitions in processor ELD.
NJ = Number of groups
NI = 2

Contents of each entry:
1. Total number of elements within group.
2. Cumulative total of last element in each group for more than one group.

GTIT Exx y z

Exx = Element name
y = Type number (E21 = 1 through E44 = 12)
z = Number of joints/element
Created from element definitions in processor ELD.
NJ = Number of groups
NI = 15

Contents of each entry:
15 words of title for each group.
Default is blanks.
DIR Exx y z

Exx = Element name
y = Type number (E21 = 1 through E44 = 12)
z = Number of joints/element
Created in processor ELD.
NJ = 1
NI = 20

Contents:
1. Number of nodes
2. Type number
3. Number of elements of this type
4. N4 in "xx BTAB N3 N4" where xx is BA, BC, SA...
5. Size of Exx EFIL for this element
6-20. Directory information for element data.

NS 0 0

Created in processor ELD.
NJ = Number of element types present
NI = 15

Contents:
Each entry contains directory information for corresponding element data.

ELTS NAME 0 0

Created in processor ELD.
NJ = 1
NI = Number of element types

Contains alphanumeric element name of each element used in the structure.

ELTS NNOD 0 0

Created in processor ELD.
NJ = Number of element types
NI = 1

Contains the number of nodes in each element type.
ELTS ISCT 0 0

Created in processor ELD.
NJ = Number of element types
NI = 1

Contains N4 of "xx BTAB N3 N4" where xx = BA, BC, SA...

KMAP y z

Created in processor TOPO.
This information is stored in blocks with the block length determined by
a RESET control in the TOPO processor. Default block length is 896 words.

Contents:
Used by K, M, and KG to guide assembly of stiffness and mass matrices in the
SPAR standard sparse-matrix format.

AMAP y z

Created in processor TOPO.
This information is stored in blocks with the block length determined by
a RESET control in the TOPO processor. Default block length is 1792 words.

Contents:
Used by INV in factoring system matrices, such as the reduction of the stiffness
matrix.
Exx EFIL y z

Exx = Element name
y = Type number (E 21 = 1 through E 44 = 12)
z = Number of joints/element
Created in processor E.
NJ = Number of elements of this type

Contents:
Each entry contains alphanumeric information packet with the following categories:
1. Integer information, corrected joint numbers, tables
2. Material constants
3. Geometrical details
4. Section properties
5. Intrinsic stiffness matrix
6. Stress recovery influence matrix
7. Internal stress resultants

DEM DIAG 0 0

Created in processor E.
NJ = Number of joints
NI = 6 minus number of joint motion components constrained on START card

Contains system mass matrix in diagonal form.

K SPAR ncon 0

ncon = constraint case
Created in processor K.
This information is stored in blocks with the block length determined by a
RESET control in the K processor. Default block length is 2240 words.

Contains stiffness matrix composed of submatrices, each submatrix corresponding
to the connection of one joint to another.
INV x ncon 0

\begin{align*}
\text{x} & = \text{First word of the name of the input stiffness matrix} \\
ncon & = \text{Constraint case} \\
\end{align*}

Created in processor INV.

This information is stored in blocks with the block length determined by a \texttt{RESET} control in the INV processor. Default block length is 3584 words.

Contains factored system matrix.

______________________________

CEM SPAR ncon 0

\begin{align*}
ncon & = \text{Constraint case} \\
\end{align*}

Created in processor M.

This information is stored in blocks with the block length determined by a \texttt{RESET} control in the M processor. Default block length is 2240 words.

Contains unconstrained system consistent mass matrices considering only the structural and nonstructural distributed mass associated with the elements.

______________________________

CASE TITL iset

\begin{align*}
iset & = \text{Load set} \\
\end{align*}

Created in processor AUS.

Number of blocks = Number of load cases in this load set.

Contents:
Each block contains the title for the corresponding load case in text.

______________________________

APPL FORC iset

\begin{align*}
iset & = \text{Load set} \\
\end{align*}

Created in processor AUS.

\begin{align*}
NJ & = \text{Number of joints} \\
NI & = 6 \text{ minus number of joint motion components constrained on START card} \\
\end{align*}

Number of blocks = Number of load cases in this load set.

Contents:
Each entry contains applied forces and moments on that joint in each active direction.
APPL MOTI iset

iset = Load set
Created in processor AUS.
NJ = Number of joints
NI = 6 minus number of joint motion components constrained on START card.
Number of blocks = Number of load cases in this load set.

Contents:
Each entry contains applied motions on that joint in each active direction.

NODA TEMP iset

iset = Load set
Created in processor AUS part TABLE
NJ = Number of joints
NI = 1
Number of blocks = Number of load cases in this load set.

Contents:
Each block of data contains nodal temperatures for every joint in the structure.
One block corresponds to one load case.

NODA PRES iset

iset = Load set
Created in processor AUS part TABLE
NJ = Number of joints
NI = 1
Number of blocks = Number of load cases in this load set.

Contents:
Each block of data contains nodal pressures for every joint in the structure.
One block corresponds to one load case.

TEMP Exx iset icase

Exx = Element name
iset = Load set
icase = Load case within Load set
Created in processor AUS.
NJ = Number of elements of this type.

For 2-node elements:
Note: Not defined for E25 elements
NI = 3
Contents of each entry:
1. Average temperature of the element
2. Transverse gradient in direction 1
3. Transverse gradient in direction 2

For 3-node elements:
   Note: Not defined for E32 elements
   NI = 3

Contents of each entry:
1. Temperature at joint 1 of element
2. Temperature at joint 2 of element
3. Temperature at joint 3 of element

For 4-node elements:
   Note: Not defined for E42 elements
   NI = 4

Contents of each entry:
1. Temperature at joint 1 of element
2. Temperature at joint 2 of element
3. Temperature at joint 3 of element
4. Temperature at joint 4 of element

Formula:
\[ \text{Total effective temperature at node n} = \text{Element temperature at node n} + \text{Nodal temperature from block icase of dataset "NODA TEMP iset"} \]

DISL Exx iset icase

   Exx = Element name
   iset = Load set
   icase = Load case within load set
   Created in processor AUS
   NJ = Number of elements of this type

For 2-node elements:
   NI = 6

Contents of each entry:
1. Displacement in direction 1
2. Displacement in direction 2
3. Displacement in direction 3
4. Rotation about axis 1
5. Rotation about axis 2
6. Rotation about axis 3
   These displacements and rotations are relative to a reference frame, parallel to the element’s reference frame, and embedded in the terminus.
For E31 elements:
  \( NI = 3 \)

Contents of each entry:
1. Displacement of joint 2 in direction 1
2. Displacement of joint 3 in direction 1
3. Displacement of joint 3 in direction 2

For E32 elements:
  \( NI = 6 \)

Contents of each entry:
1. Displacement of joint 2 in direction 3
2. Rotation of joint 2 about axis 1
3. Rotation of joint 2 about axis 2
4. Displacement of joint 3 in direction 3
5. Rotation of joint 3 about axis 1
6. Rotation of joint 3 about axis 2

For E33 elements:
  \( NI = 9 \)

Contents of each entry:
1. Displacement of joint 2 in direction 1
2. Displacement of joint 3 in direction 1
3. Displacement of joint 3 in direction 2
4. Displacement of joint 2 in direction 3
5. Rotation of joint 2 about axis 1
6. Rotation of joint 2 about axis 2
7. Displacement of joint 3 in direction 3
8. Rotation of joint 3 about axis 1
9. Rotation of joint 3 about axis 2

For E41 elements:
  \( NI = 6 \)

Contents of each entry:
1. Displacement of joint 2 in direction 1
2. Displacement of joint 3 in direction 1
3. Displacement of joint 3 in direction 2
4. Displacement of joint 4 in direction 1
5. Displacement of joint 4 in direction 2
6. Displacement of joint 4 in direction 3

For E42 elements:
  \( NI = 6 \)

Contents of each entry:
1. Displacement of joint 2 in direction 3
2. Rotation of joint 2 about axis 1
3. Rotation of joint 2 about axis 2
4. Displacement of joint 3 in direction 3
5. Rotation of joint 3 about axis 1
6. Rotation of joint 3 about axis 2
7. Displacement of joint 4 in direction 3
8. Rotation of joint 4 about axis 1
9. Rotation of joint 4 about axis 2

For E43 elements:
    NI = 14

Contents of each entry:
1. Displacement of joint 2 in direction 1
2. Displacement of joint 3 in direction 1
3. Displacement of joint 3 in direction 2
4. Displacement of joint 4 in direction 1
5. Displacement of joint 4 in direction 2
6. Displacement of joint 2 in direction 3
7. Rotation of joint 2 about axis 1
8. Rotation of joint 2 about axis 2
9. Displacement of joint 3 in direction 3
10. Rotation of joint 3 about axis 1
11. Rotation of joint 3 about axis 2
12. Displacement of joint 4 in direction 3
13. Rotation of joint 4 about axis 1
14. Rotation of joint 4 about axis 2

For E44 elements:
    NI = 6

Contents of each entry:
1. Displacement of joint 2 in direction 1
2. Displacement of joint 3 in direction 1
3. Displacement of joint 3 in direction 2
4. Displacement of joint 4 in direction 1
5. Displacement of joint 4 in direction 2
6. Displacement of joint 4 in direction 3

PRES Exx iset icase

    Exx   = Element name
    iset   = Load set
    icase  = Load case within Load set
Created in processor AUS
NJ = Number of elements of this type

For 3-node elements:
    Note: Not defined for 2-node elements.
    NI = 3
Contents of each entry:
1. Pressure at joint 1
2. Pressure at joint 2
3. Pressure at joint 3

For 4-node elements:
   NI = 4

Contents of each entry:
1. Pressure at joint 1
2. Pressure at joint 2
3. Pressure at joint 3
4. Pressure at joint 4

STAT DISP iset ncon

iset = Load set
ncon = Constraint case
Created in processor SSOL
NJ = Number of joints
NI = 6 minus number of joint motion components constrained on START card

Contents:
Each entry contains static displacements for that joint in each active direction.

STAT REAC iset ncon

iset = Load set
ncon = Constraint case
Created in processor SSOL
NJ = Number of joints
NI = 6 minus number of joint motion components constrained on START card

Contents:
Each entry contains static reactions for that joint in each active direction.

STRS E21 iset icase

iset = Load set
icase = Load case within set
Created in processor GSF.
NJ = Number of E21 elements
NI = 52
### Contents of each entry:

<table>
<thead>
<tr>
<th>Entry</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Group number</td>
</tr>
<tr>
<td>2.</td>
<td>Element number within group</td>
</tr>
<tr>
<td>3.</td>
<td>Joint #1</td>
</tr>
<tr>
<td>4.</td>
<td>Joint #2</td>
</tr>
<tr>
<td>5.</td>
<td>Max. combined P/A + bending (tension)</td>
</tr>
<tr>
<td>6.</td>
<td>Max. combined P/A + bending (compression)</td>
</tr>
<tr>
<td>7.</td>
<td>P/A</td>
</tr>
<tr>
<td>8.</td>
<td>Transverse shear stress, $S_1$</td>
</tr>
<tr>
<td>9.</td>
<td>Transverse shear stress, $S_2$</td>
</tr>
<tr>
<td>10.</td>
<td>Twist shear</td>
</tr>
<tr>
<td>11.</td>
<td>Shear force, end 1, direction 1</td>
</tr>
<tr>
<td>12.</td>
<td>Shear force, end 1, direction 2</td>
</tr>
<tr>
<td>13.</td>
<td>Axial force, end 1, direction 3</td>
</tr>
<tr>
<td>14.</td>
<td>Moment, end 1, direction 4</td>
</tr>
<tr>
<td>15.</td>
<td>Moment, end 1, direction 5</td>
</tr>
<tr>
<td>16.</td>
<td>Moment, end 1, direction 6</td>
</tr>
<tr>
<td>17.</td>
<td>Shear force, end 2, direction 1</td>
</tr>
<tr>
<td>18.</td>
<td>Shear force, end 2, direction 2</td>
</tr>
<tr>
<td>19.</td>
<td>Axial force, end 2, direction 3</td>
</tr>
<tr>
<td>20.</td>
<td>Moment, end 2, direction 4</td>
</tr>
<tr>
<td>21.</td>
<td>Moment, end 2, direction 5</td>
</tr>
<tr>
<td>22.</td>
<td>Moment, end 2, direction 6</td>
</tr>
<tr>
<td>23.</td>
<td>?</td>
</tr>
<tr>
<td>24.</td>
<td>$I_1$</td>
</tr>
<tr>
<td>25.</td>
<td>$a_1$</td>
</tr>
<tr>
<td>26.</td>
<td>$a_2$</td>
</tr>
<tr>
<td>27.</td>
<td>$I_2$</td>
</tr>
<tr>
<td>28.</td>
<td>$a_2$</td>
</tr>
<tr>
<td>29.</td>
<td>Area</td>
</tr>
<tr>
<td>30.</td>
<td>$f_1$</td>
</tr>
<tr>
<td>31.</td>
<td>$f_2$</td>
</tr>
<tr>
<td>32.</td>
<td>$z_1$</td>
</tr>
<tr>
<td>33.</td>
<td>$z_2$</td>
</tr>
<tr>
<td>34.</td>
<td>$\theta$</td>
</tr>
<tr>
<td>35.</td>
<td>$q_1$</td>
</tr>
<tr>
<td>36.</td>
<td>$q_2$</td>
</tr>
<tr>
<td>37.</td>
<td>$q_3$</td>
</tr>
<tr>
<td>38.</td>
<td>$N_x$ = number of points for stress</td>
</tr>
<tr>
<td>39.</td>
<td>$y_{11}$</td>
</tr>
<tr>
<td>40.</td>
<td>$y_{12}$</td>
</tr>
<tr>
<td>41.</td>
<td>$y_{21}$</td>
</tr>
<tr>
<td>42.</td>
<td>$y_{22}$</td>
</tr>
<tr>
<td>43.</td>
<td>$y_{31}$</td>
</tr>
<tr>
<td>44.</td>
<td>$y_{32}$</td>
</tr>
<tr>
<td>45.</td>
<td>$y_{41}$</td>
</tr>
<tr>
<td>46.</td>
<td>$y_{42}$</td>
</tr>
<tr>
<td>47.</td>
<td>$b_1$</td>
</tr>
<tr>
<td>48.</td>
<td>$t_1$</td>
</tr>
<tr>
<td>49.</td>
<td>$b_2$</td>
</tr>
<tr>
<td>50.</td>
<td>$t_2$</td>
</tr>
<tr>
<td>51.</td>
<td>$b_3$</td>
</tr>
<tr>
<td>52.</td>
<td>$t_3$</td>
</tr>
</tbody>
</table>

---

**STRS E22 iset icase**

iset = Load set
icase = Load case within set

Created in processor GSF
NJ = Number of E22 elements
NI = 16

### Contents of each entry:

<table>
<thead>
<tr>
<th>Entry</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Group number</td>
</tr>
<tr>
<td>2.</td>
<td>Element number within group</td>
</tr>
<tr>
<td>3.</td>
<td>Joint #1</td>
</tr>
<tr>
<td>4.</td>
<td>Joint #2</td>
</tr>
<tr>
<td>5.</td>
<td>Force in direction 1 at joint 1</td>
</tr>
<tr>
<td>6.</td>
<td>Force in direction 2 at joint 1</td>
</tr>
<tr>
<td>7.</td>
<td>Force in direction 3 at joint 1</td>
</tr>
<tr>
<td>8.</td>
<td>Moment about axis 1 at joint 1</td>
</tr>
<tr>
<td>9.</td>
<td>Moment about axis 2 at joint 1</td>
</tr>
<tr>
<td>10.</td>
<td>Moment about axis 3 at joint 1</td>
</tr>
<tr>
<td>11.</td>
<td>Force in direction 1 at joint 2</td>
</tr>
<tr>
<td>12.</td>
<td>Force in direction 2 at joint 2</td>
</tr>
<tr>
<td>13.</td>
<td>Force in direction 3 at joint 2</td>
</tr>
<tr>
<td>14.</td>
<td>Moment about axis 1 at joint 2</td>
</tr>
<tr>
<td>15.</td>
<td>Moment about axis 2 at joint 2</td>
</tr>
<tr>
<td>16.</td>
<td>Moment about axis 3 at joint 2</td>
</tr>
</tbody>
</table>
STRS E23 iset icase

iset = Load set
icase = Load case within set
Created in processor GSF.
NJ = Number of E23 elements
NI = 6

Contents of each entry:
1. Group number
2. Element number within group
3. Joint #1
4. Joint #2
5. Force in element
6. Stress in element

---

STRS E24 iset icase

iset = Load set
icase = Load case within set
Created in processor GSF
NJ = Number of E24 elements
NI = 18

Contents of each entry:
1. Group number
2. Element number within group
3. Joint #1
4. Joint #2
5. Axial force at joint 1
6. Transverse shear at joint 1
7. Moment at joint 1
8. Axial force at joint 2
9. Transverse shear at joint 2
10. Moment at joint 2
11. Axial stress at joint 1
12. Shear stress at joint 1
13. Bending stress on upper surface at joint 1
14. Bending stress on lower surface at joint 1
15. Axial stress at joint 2
16. Shear stress at joint 2
17. Bending stress on upper surface at joint 2
18. Bending stress on lower surface at joint 2
STRS E25 iset icase

iset = Load set
icase = Load case within set
Created in processor GSF.
NJ = Number of E25 elements
NI = 16

Contents of each entry:
1. Group number
2. Element number within group
3. Joint #1
4. Joint #2
5. Force in direction 1 at joint 1
6. Force in direction 2 at joint 1
7. Force in direction 3 at joint 1
8. Moment about axis 1 at joint 1
9. Moment about axis 2 at joint 1
10. Moment about axis 3 at joint 1
11. Force in direction 1 at joint 2
12. Force in direction 2 at joint 2
13. Force in direction 3 at joint 2
14. Moment about axis 1 at joint 2
15. Moment about axis 2 at joint 2
16. Moment about axis 3 at joint 2

STRS E31 iset icase

iset = Load set
icase = Load case within set
Created in processor GSF.
NJ = Number of E31 elements
NI = 11

Contents of each entry:
1. Group number
2. Element number within group
3. Joint #1
4. Joint #2
5. Joint #3
6. T11
7. T22
8. T12
9. Tractive force in x-direction Nx
10. Tractive force in y-direction Ny
11. Shearing force Nxy

Formulae:
Sx = Nx/thickness
Sy = Ny/thickness
Txy = Nxy/thickness
STRS E32 iset icase

iset = Load set
icase = Load case within set
Created in processor GSF.
NJ = Number of E32 elements
NI = 28

Contents of each entry:
1. Group number
2. Element number within group
3. Joint #1
4. Joint #2
5. Joint #3
6. ?
7. ?
8. ?
9. Mx Bending moment about x-axis, at joint 1
10. My Bending moment about y-axis at joint 1
11. Mxy Twisting moment at joint 1
12. Qx Transverse shear in x-direction at joint 1
13. Qy Transverse shear in y-direction at joint 1
14. Mx Bending moment about x-axis at joint 2
15. My Bending moment about y-axis at joint 2
16. Mxy Twisting moment about joint 2
17. Qx Transverse shear in x-direction at joint 2
18. Qy Transverse shear in y-direction at joint 2
19. Mx Bending moment about x-axis at joint 3
20. My Bending moment about y-axis at joint 3
21. Mxy Twisting moment at joint 3
22. Qx Transverse shear in x-direction at joint 3
23. Qy Transverse shear in y-direction at joint 3
24. Mx Bending moment about x-axis at the center
25. My Bending moment about y-axis at the center
26. Mxy Twisting moment at the center
27. Qx Transverse shear in x-direction at the center
28. Qy Transverse shear in y-direction at the center

Formulae:
\[ S_x = f_{41} M_x \]
\[ S_y = f_{42} M_y \]
\[ T_{xy} = f_{43} M_{xy} \]
\[ f_{41} = ? \]
\[ f_{51} = ? \]
\[ f_{61} = ? \]
\[ f_{42} = f_{52} = -f_{62} = \frac{6}{(\text{thickness})^2} \]
\[ f_{43} = f_{53} = -f_{63} = -\frac{6}{(\text{thickness})^2} \]

---

STRS E33 iset icase

iset = Load set
icase = Load case within set
Created in processor GSF.
NJ = Number of E33 elements
NI = 31
Contents of each entry:
1. Group number
2. Element number within group
3. Joint #1
4. Joint #2
5. Joint #3
6. ?
7. ?
8. ?
9. Nx Tractive force in x-direction
10. Ny Tractive force in y-direction
11. Nxy Shearing force
12. Mx Bending moment about x-axis at joint 1
13. My Bending moment about y-axis at joint 1
14. Mxy Twisting moment at joint 1
15. Qx Transverse shear in x-direction at joint 1
16. Qy Transverse shear in y-direction at joint 1
17. Mx Bending moment about x-axis at joint 2
18. My Bending moment about y-axis at joint 2
19. Mxy Twisting moment at joint 2
20. Qx Transverse shear in x-direction at joint 2
21. Qy Transverse shear in y-direction at joint 2
22. Mx Bending moment about x-axis at joint 3
23. My Bending moment about y-axis at joint 3
24. Mxy Twisting moment at joint 3
25. Qx Transverse shear in x-direction at joint 3
26. Qy Transverse shear in y-direction at joint 3
27. Mx Bending moment about x-axis at the center
28. My Bending moment about y-axis at the center
29. Mxy Twisting moment at the center
30. Qx Transverse shear in x-direction at the center
31. Qy Transverse shear in y-direction at the center

Formulae:
\[ S_x = f_{1i}N_x + f_{4j}M_x \]
\[ S_y = f_{2i}N_y + f_{5j}M_y \]
\[ T_{xy} = f_{3i}N_{xy} + f_{6j}M_{xy} \]

\[ f_{43} = f_{53} = -f_{63} = -6/(\text{thickness})^2 \]
\[ f_{42} = f_{52} = -f_{62} = 6/(\text{thickness})^2 \]

\[ f_{41} = 1/\text{thickness} \text{ for } i \text{ and } j = 1, 2, 3 \]

STRS E41 iset icase
iset = Load set
icase = Load case within set
Created in processor GSF.
NJ = Number of E41 elements
NI = 23
Contents of each entry:
1. Group number
2. Element number within group
3. Joint #1
4. Joint #2
5. Joint #3
6. Joint #4
7. ?
8. ?
9. \( N_x \) Tractive force in x-direction at joint 1
10. \( N_y \) Tractive force in y-direction at joint 1
11. \( N_{xy} \) Shearing force at joint 1
12. \( N_x \) Tractive force in x-direction at joint 2
13. \( N_y \) Tractive force in y-direction at joint 2
14. \( N_{xy} \) Shearing force at joint 2
15. \( N_x \) Tractive force in x-direction at joint 3
16. \( N_y \) Tractive force in y-direction at joint 3
17. \( N_{xy} \) Shearing force at joint 3
18. \( N_x \) Tractive force in x-direction at joint 4
19. \( N_y \) Tractive force in y-direction at joint 4
20. \( N_{xy} \) Shearing force at joint 4
21. \( N_x \) Tractive force in x-direction at the center
22. \( N_y \) Tractive force in y-direction at the center
23. \( N_{xy} \) Shearing force at the center

Formulae:
\[
S_x = N_x /\text{thickness} \\
S_y = N_y /\text{thickness} \\
T_{xy} = N_{xy} /\text{thickness}
\]

STRS E42 iset icase

iset = Load set
icase = Load case within set
Created in processor GSF

NJ = Number of E42 elements
NI = 33

Contents of each entry:
1. Group number
2. Element number within group
3. Joint #1
4. Joint #2
5. Joint #3
6. Joint #4
7. ?
8. ?
1. Mx Bending moment about x-axis at joint 1
2. My Bending moment about y-axis at joint 1
3. Mxy Twisting moment at joint 1
4. Qx Transverse shear in x-direction at joint 1
5. Qy Transverse shear in y-direction at joint 1
6. Mx Bending moment about x-axis at joint 2
7. My Bending moment about y-axis at joint 2
8. Mxy Twisting moment at joint 2
9. Qx Transverse shear in x-direction at joint 2
10. Qy Transverse shear in y-direction at joint 2
11. Mx Bending moment about x-axis at joint 3
12. My Bending moment about y-axis at joint 3
13. Mxy Twisting moment at joint 3
14. Qx Transverse shear in x-direction at joint 3
15. Qy Transverse shear in y-direction at joint 3
16. Mx Bending moment about x-axis at joint 4
17. My Bending moment about y-axis at joint 4
18. Mxy Twisting moment at joint 4
19. Qx Transverse shear in x-direction at joint 4
20. Qy Transverse shear in y-direction at joint 4
21. Mx Bending moment about x-axis at the center
22. My Bending moment about y-axis at the center
23. Mxy Twisting moment at the center
24. Qx Transverse shear in x-direction at the center
25. Qy Transverse shear in y-direction at the center

Formulae:

\[ S_x = f_{4j}M_x \]
\[ S_y = f_{5j}M_y \]
\[ T_{xy} = f_{6j}M_{xy} \]

\[ f_{42} = f_{52} = -f_{62} = \frac{6}{(\text{thickness})^2} \]
\[ f_{43} = f_{53} = -f_{63} = -\frac{6}{(\text{thickness})^2} \]

STRS E43 iset icase

iset = Load set
icase = Load case within set
Created in processor GSF
NJ = Number of E43 elements
NI = 48

Contents of each entry:
1. Group number
2. Element number within group
3. Joint #1
4. Joint #2
5. Joint #3
6. Joint #4
7. ?
8. ?
9. **Nx** Tractive force in x-direction at joint 1
10. **Ny** Tractive force in y-direction at joint 1
11. **Nxy** Shearing force at joint 1
12. **Nx** Tractive force in x-direction at joint 2
13. **Ny** Tractive force in y-direction at joint 2
14. **Nxy** Shearing force at joint 2
15. **Nx** Tractive force in x-direction at joint 3
16. **Ny** Tractive force in y-direction at joint 3
17. **Nxy** Shearing force at joint 3
18. **Nx** Tractive force in x-direction at joint 4
19. **Ny** Tractive force in y-direction at joint 4
20. **Nxy** Shearing force at joint 4
21. **Nx** Tractive force in x-direction at the center
22. **Ny** Tractive force in y-direction at the center
23. **Nxy** Shearing force at the center
24. **Mx** Bending moment about x-axis at joint 1
25. **My** Bending moment about y-axis at joint 1
26. **Mxy** Twisting moment at joint 1
27. **Qx** Transverse shear in x-direction at joint 1
28. **Qy** Transverse shear in y-direction at joint 1
29. **Mx** Bending moment about x-axis at joint 2
30. **My** Bending moment about y-axis at joint 2
31. **Mxy** Twisting moment at joint 2
32. **Qx** Transverse shear in x-direction at joint 2
33. **Qy** Transverse shear in y-direction at joint 2
34. **Mx** Bending moment about x-axis at joint 3
35. **My** Bending moment about y-axis at joint 3
36. **Mxy** Twisting moment at joint 3
37. **Qx** Transverse shear in x-direction at joint 3
38. **Qy** Transverse shear in y-direction at joint 3
39. **Mx** Bending moment about x-axis at joint 4
40. **My** Bending moment about y-axis at joint 4
41. **Mxy** Twisting moment at joint 4
42. **Qx** Transverse shear in x-direction at joint 4
43. **Qy** Transverse shear in y-direction at joint 4
44. **Mx** Bending moment about x-axis at the center
45. **My** Bending moment about y-axis at the center
46. **Mxy** Twisting moment at the center
47. **Qx** Transverse shear in x-direction at the center
48. **Qy** Transverse shear in y-direction at the center

**Formulae:**

\[ S_x = f_{1j} N_x + f_{4j} M_x \]
\[ S_y = f_{2j} N_y + f_{5j} M_y \]
\[ T_{xy} = f_{3j} N_{xy} + f_{6j} M_{xy} \]

\[ f_{1j} = 1/(\text{thickness}) \quad f_{4j} = -f_{6j} = 6/(\text{thickness})^2 \]
\[ f_{2j} = f_{5j} = -f_{6j} = 6/(\text{thickness})^2 \]
STRE E44 iset icase

iset = Load set
icase = Load case within set
Created in processor GSF.
NJ = Number of E44 elements
NI = 8

Contents of each entry:
1. Group number
2. Element number within group
3. Joint #1
4. Joint #2
5. Joint #3
6. Joint #4
7. Element thickness
8. Shear stress

BUCK MODE iset ncon

iset = Load set
ncon = Constraint case
Created in processor EIG.
NJ = Number of joints
NI = 6 minus number of joint motion components constrained on START card
Number of blocks = Number of eigenvectors

Contents:
Each block of data contains an eigenvector corresponding to an eigenvalue
stored in "BUCK EVAL." Data is stored for each joint in each active direction.

BUCK EVAL iset ncon

iset = Load set
ncon = Constraint case
Created in processor EIG
NJ = 1
NI = Number of eigenvalues

Contains frequency eigenvalues corresponding to each eigenvector in "BUCK MODE."
VIBR MODE iset ncon

iset = Load set
ncon = Constraint case
Created in processor EIG.
NJ = Number of joints
NI = 6 minus number of joint motion components constrained on START card
Number of blocks = Number of eigenvectors

Contents:
Each block of data contains one eigenvector corresponding to an eigenvalue stored in "VIBR EVAL." Data is stored for each joint in each active direction.

VIBR EVAL iset ncon

iset = Load set
ncon = Constraint case
Created in processor EIG.
NJ = 1
NI = Number of eigenvalues

Contains eigenvalues corresponding to each eigenvector in "VIBR MODE."
EXAMPLE PROBLEM

The sample problem contained in this section includes the necessary SPAR commands to create all the data sets documented in this report. The SPAR commands are listed so that the user may reproduce these data sets and examine their contents. The resulting table of contents is included to illustrate the SPAR's use of data sets.

STRUCTURAL MODEL

fix $z$, $\theta_x$, $\theta_y$
SPAR INPUT FILE

IXQT TB 5
STAM 1d 3,4,5 $
TEXT 3
"EXAMPLE TO ILLUSTRATE DATA SET CONTENTS"
"PREPARED BY GARY L. GILES 8-13-81."
MATC 3
  1 30.0+6 0.3 0.283 M,3=6 $
MSM 3
  1 23.0 $
ALTHER 3
  2 1 0.0 2 0.0 1.0 45.0 20.0 10.0 0.0 0.0 $
JLOC 3
  1 0.0 10.0 0.0 0.0 10.0 0.0 0.0 5 2 $
  2 80.0 -10.0 0.0 0.0 -10.0 0.0 0.0 5 2 $
  11 0.0 10.0 0.0 0.0 $
  12 0.0 -10.0 0.0 0.0 $
JREF 3
  NHERF 2,7 $
MREF 3
  FOURSEI 1 $
    1 1 3 0 1 1.0 $
  FOURSEI 2 $
    2 1 1000.0 0.0 0.0 $
BRU 3
  1 1 0.0 1.0 0.0 1 0.0 1.0 0.0 0.0 $
BA 5
  NBO 1 1.0 0.1 0.5 0.05 $
BB 5
  1 11.0+3 $
    41.0 22.0+8 $
    31.0 32.0 33.0+8 $
    41.0 42.0 43.0 44.0+8 $
    51.0 52.0 53.0 54.0 55.0+8 $
    61.0 62.0 63.0 64.0 65.0 66.0+8 $
BC 5
  1 0.5 $
BD 5
  1 0.5 100.0 0.0 1.0 1.0 0.0 0.0 $
SA 5
  NMATE 1 $
  FOURSEI ISOTROPIC 3
  1 0.01 $
SB 5
  1 0.01 $
CONT 1
  ZEMU 1,2,11,12 $
JSEQ 4
  1/1UV,12,11 $
NMASS 5
1 100 1.0,2.0,3.0 8
IXGT END 3
E21 3
  4 2 8
  NHFL#2 8
  1 2 3
E31 3
  1 3 2 8
  4 2 1 8
E41 5
  1 3 4 2 8
E22 3
  5 3 8
  6 4 8
  NHFL#2 8
  3 4 8
E32 3
  3 5 4 8
  6 4 9 8
E42 8
  3 5 6 4 8
E23 3
  7 5 8
  8 6 5
  5 6 5
E33 3
  5 7 6 8
  6 6 7 8
E43 3
  5 7 8 0 8
E24 3
  9 7 8
  10 8 5
  NHFL#2 8
  7 8 5
  9 10 3
E44 8
  7 9 10 8 3
E25 3
  11 9 8
  12 10 5
IXGT E 3
IXGT EKS 8
IXGT TUPC 8
IXGT K 8
IXGT INV 8
IXGT AUS 8
ALPHA)CASE TITL 1 8
1" SAMPLE TITLE FOR CASE 1 8
SYSVEL)APPLIED FORCES 1 8
CASE 1$
I^2J=21=1000.0$
SYSYCLE APPLIED MUTIONS 2$
I^2J=11=2.0$
TABLE LOCAL TEMPERATURES 2$
J=1,41100.0$
TABLE LOCAL PRESSURES 2$
J=1,1011.5$
ELDATA TEMP E41 2 1$
G11E=1,1000.0,2000.0,3000.0,4000.0$
ELDATA CIESL E31 2 1$
G11E=1,210.1,0.2,0.3$
ELDATA PRES E43 2 1$
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| 131 | 596 610620 152136 | 0 | 540 | 12 | 540 -1 VIBR MODE | 1 | 1 |
CONCLUDING REMARKS

The SPAR structural analysis system consists of a collection of processors for performing finite element analysis. The data generated by each of these processors is stored in a data file organized as a "library." Each data set, containing a two-dimensional table or matrix, is identified by a four-word name listed in the table of contents.

This report documents the contents of many of the SPAR data sets stored in the data base complex. The creating SPAR processor, number of rows and columns, and definitions of each of the data items, are listed for each data set. An example SPAR problem using these data sets is also presented. The SPAR input for the problem and resulting table of contents are included, so that the user may reproduce these data sets. This information can be used (1) to understand more clearly and to use more productively the existing processors in the SPAR system, (2) to develop new SPAR processors, or (3) to interface SPAR with another software system.
REFERENCES


The SPAR structural analysis system consists of a collection of processors for performing finite element analysis. The data generated by each of these processors is stored in a data file organized as a “Library.” Each data set, containing a two-dimensional table or matrix, is identified by a four-word name listed in a table of contents.

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