TECHNICAL REPORT

SESAM INPUT INTERFACE FILE

FILE DESCRIPTION

DET NORSKE VERITAS

DET NORSKE VERITAS
SESAM AS

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Sesam Input Interface File

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An interface between Finite Element (F.E.) preprocessing and F.E. analysis program is defined. The interface is defined as a file where all data are stored according to a unified file format. This standardisation is performed in order to enable different F.E. preprocessors to be coupled to the same application program, or vice versa.

To obtain computer portability of generated F.E. model data, the interface file is defined as a sequential character file with a fixed record length. An application program may read the interface file by applying a standard formatted FORTRAN read statement. The contents may be displayed and edited by applying an operating system text editor.

The data are divided into groups that naturally belong together.

The interface file is prepared for the superelement technique.

Work carried out by::

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01 November 1996

Developed by
DET NORSKE VERITAS

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Higher Level Data

1 INTRODUCTION

This manual contains a description of the input part of the SESAM Interface File, the Input Interface File. The results part of the SESAM Interface File, is described in a separate manual, "SESAM Results Interface File Description" /1/.

The large amount of input data common to many different finite element (F.E.) program systems has been one of the main reasons for developing general F.E. preprocessors. These general preprocessors, separated from the F.E. application programs, give the user a unified way of defining input data applicable to different program systems.

A separated general F.E. preprocessor offers some important advantages. The data preparation phase can now be performed interactively on a local mini computer, while the real analysis can be executed in batch. Further, the user will be able to apply different F.E. systems without having to spend costly time learning the input of the various systems.

One problem, however, is how to interface the preprocessor to the F.E. programs.

General requirements to this interface are:

1 Analysis portability
The data produced by the preprocessor must be easily applicable to different analysis programs

2 Computer portability
The F.E. analysis programs, applying input from the preprocessor, may run on different types of computers.

3 Extensibility
The interface must be able to handle new data types as the preprocessor is interfaced to new application areas, (e.g. different types of non-linear analysis).

4 Flexibility
The interface should have the ability to transfer all types of non-standard input data, (e.g. input data typical for only one particular application program.

2 INTERFACE FILE FORMAT

2.1 Record Format

To meet the requirements of portability, extensibility and flexibility, an interface has been chosen where the data are stored on a simple sequential, record file, similar to the input of the early F.E. programs.

Each record[1] of this file has a fixed length of 72 characters. Furthermore, each record is subdivided into five fields, one 8 character identifier field and four 16 character data fields. The identifier gives information concerning the type of data stored, like nodal geometry, constraints, etc. Data types consisting of more than four items, will have the remaining items described in the succeeding records (four in each), all with a blank record identifier.

The notation data record is used for the data string starting with a non-blank identifier to the next non-blank identifier. A 72 character record as described above is denoted file record. A data record may consist of several file records.

This record file will be made readable by standard FORTRAN I/O. The data generated will then be simple to use by the application programs.

When data are transferred between computers of different makes, all system-generated information (if any) must be removed. The format of the interface file will have the following characteristics:

1 A sequential character file

2 A fixed record length of 72 characters

3 A standard ASCII character code (when formatted FORTRAN format of the file is chosen).

4 Records with all the same format, i.e. one 8-character identifier field (2A4) and four 16-character data fields (4E16.8). Except text fields which have (18A4).

On each installation the interface file is supported by simple read-and-write routines which will convert the

1 A record may also be called a file record or a line.

data to a format readable by the system editor employing a formatted file, which is the default.. However, to save computing and I/O-time there is an option to write the file unformatted. Then the file is not transferable between different computers.

The sequence of data records is arbitrary within each data type, with some exceptions registered below in the description of the data types. The sequence of data types is arbitrary.

2.2 File Naming Conventions

The records are assembled in one file per superelement. The file name will be determined by following naming convention (where nnnn is the superelement no. and xxx identifies the model):

1 VAX (VMS) - computers
[directory]xxxTnnnn.FEM

2 IBM370 series (MVS).
prefix.FEM(Tnnn)
See also separate User’s Guide for IBM - OS / MVS

3 IBM370 series (VM).
FEMTnn prefix filemode
See also separate User’s Guide for IBM - VM.

4 UNIX
Tnnnn.FEM

5 ND (SINTRAN) - computers
(user)xxxTnnnn:FEM
See also ND User’s Guide

A special feature is possible if the interface files are formatted. They may then be appended to one file. Refer to IEND record on page 4-3.

3 INTERFACE FILE CONTENTS

The data transferred to and from the F.E. analysis program are divided into separate groups. The Results part of the interface file is described in a separate manual: "SESAM Results Interface File Description" /1/.

1	Identification data for superelements / File data	**I**
2	Nodal data and element geometry definition	**G**
3	Material data	**M**
4	Additional element data	**A**
5	Boundary conditions, loads and point masses	**B**
6	Results	**R**
7	Hierarchy data	**H**
8	Text data	**T**

To distinguish between the various groups, one or more characters of the record identifier is used as a group identifier. The codes are:

A	Additional element data
B	Boundary conditions, loads and point masses
BE	· Elements
BN	· Nodes
G	Geometry: Nodal data and element geometry definition
GE	· Elements
GN	· Nodes
H	Hierarchy data
I	Identification data for superelements / File data

M	Material data
R	Results
RV	· Values
RD	· Definitions
T	Text data

To reduce the size of the input interface files, a reference system is built into the file so that repeated element data do not have to be duplicated.

3.1 Input Interface File Relations

3.1.1 Legend

→	= refers to
number *n	= several key values out from one entry of DATATYPE
DATATYPE *n	= multiple occurrences of DATATYPE for one key value
(M)	= mandatory
(O)	= optional optional

3.1.2 Master data

superelement type number

→ IDENT	(M)	(superelement identification number)
DATE	(O)	(date, time and program information)
TEXT	(O)	(descriptive text for superelement)
IEND	(O)	(end of superelement)

3.1.3 Nodes

```
int node number
 |
 |    ext node number
 |     |
 |--> GNODE      (M)   (external and internal node number)
 |--> GCOORD     (M)   (node coordinates)
 |
 |--> BNBCD      (O)   (boundary conditions)
 |--> BLDEP      (O)   (linear dependency)    ®  int node number *2   ®  GNODE
 |--> BQDP       (O)   (quadratic dependency) ®  int node number *n   ®  GNODE
 |--> BNDOF      (O)   (transformation ref.)  ®  trans number    *2   ®  BNTRCOS
 |
 |--> BNMASS *n  (O)   (nodal mass)
```

3.1.4 Elements[1]

```
int element number
 |
 |    ext element number
 |     |
 |--> GELMNT1(M)     →  int node number*n  →  GNODE
 |
 |--> GELREF1(M)     →  material number    →  class MATERIAL (M)
 |                   →  section  number*n  →  class SECTION  (M)
 |                   →  fixation number*n  →  BELFIX     (O)  →  trans   →  BNTRCOS
 |                   →  transformation *n  →  GUNIVEC (M)  (if el.typ.beam)
 |                                         →  BNTRCOS (O)  (if anisotropic shell/solid)
 |                   →  eccentricity   *n  →  GECCEN  (O)
 |                   →  additional data    →  ADDATA  (O)  (not used by SESAM)
 |                   →  integration data   →  GELINT  (O)  →  ref     →  GCROINT
 |                                                         (not used by SESAM)
 |                                         →  GELSTRP (O)  (not used by SESAM)
 |
 |--> MTRSOL     (O)   (- if material of type MORSMEL)
 |--> MTRMEL     (O)   (- if material of type MORSSEL)
 |--> MTRSEL     (O)   (- if material of type MORSSOL)
 |
 |--> BEMASS1    (O)   (element added mass)
```

[1] For the general eccentric sandwich element type, see the element description for LCTS(34) or LCQS(35).

3.1.5 Materials

material number

- → AMATRIX (matrix control data)
- → MISOSEL (linear elastic,isotropic)
- → MISOPL (non-linear elastic,isotropic)
- → MISOHL (linear heat conduction,isotropic)
- → MISOHNL (non-linear heat conduction,isotropic)
- → MISOEML (linear electromagnetic field problem,isotropic)
- → MISOAL (linear acoustic field problem, isotropic)
- → MORSMEL (linear elastic,anisotropic, 2-d thin shell)
- → MORSSEL (linear elastic,anisotropic, 2-d thick shell)
- → MORSSOL (linear elastic,anisotropic, solid elements)
- → MAXSPR (spring constant - if element type axial spring)
- → MAXDMP (damping constant - if element type axial damper)
- → MGSPRNG (spring matrix - if element type spring to ground)
- → MGDAMP (damping matrix - if element type damper to ground)
- → MSHGLSP (general spring between nodes)
- → MGLMASS (general mass between nodes)
- → MGLDAMP (general damper between nodes)
- → MGMASS (general mass in node)
- → MTEMP (scaling curve for temperature variation)
- → MISTEL (temperature dependent linear elastic,isotropic)
- → MTENOL (general material with temperature dependency)

one of the datatypes above per element is mandatory (M)

3.1.6 Sections

section number

→ GELTH	(M)	(thickness - if element type shell)
→ GBEAMG	(M)	(general beam data - if element type beam)
→ GIORH	(O)	(I-section description - if element type beam)
→ GUSYI	(O)	(unsymm.I-section)
→ GCHAN	(O)	(Channel section)
→ GBOX	(O)	(Box section)
→ GPIPE	(O)	(Pipe section)
→ GBARM	(O)	(Massive bar)
→ GTONP	(O)	(T on plate)
→ GDOBO	(O)	(Double box)
→ GLSEC	(O)	(L section)
→ GIORHR	(O)	
→ GCHANR	(O)	
→ GLSECR	(O)	

either GELTH if shell or GBEAMG if beam,
if GBEAMG then one of the other types is optional (O)

3.1.7 Loads

loadcase number

- BGRAV (O) (gravity load)
- int node number
  - BNLOAD *n (O) (nodal force)
  - BNDISPL (O) (prescribed displacement)
  - BNTEMP (O) (temperature load)
  - BNACCLO*n (O) (nodal acceleration)
  - BNWALO (O) (wave loads in node)
  - BNLOAX (O) (axisymmetric load)
- int element number
  - BEUSLO *n (O) (surface load)
  - BEUVLO *n (O) (volume load)
  - BELLO2 (O) (line load shell)
  - BELOAD1*n (O) (line load beam)
  - BEWALO1 (O) (wave loads on line)
  - BELLAX (O) (axisymmetric load)

initial condition number

- int node number
  - BNINCO (O) (initial displacement)
- integr. station number
  - BEISTE (O) (initial temperature load)

3.2 Results Interface File Relations

3.2.1 Legend

$\rightarrow$	= refers to
number *n	= several key values out from one entry of DATATYPE
DATATYPE *n	= multiple occurrences of DATATYPE for one key value
(M)	= mandatory
(O)	= optional

3.2.2 Result case

```
result case number
|
|--> RDRESREF  (M)   (result case description)
|                    → load case number
|
|--> TDRESREF  (O)   (text description)
|
|--> RMLFACT   (O)   (modal load factors)
|
| int node number
|   |
|---|--> RVNODDIS    (O)   (nodal displacements)
|   |                      → RDNODRES (M)
|   |                      → BNDOF    (O)  → BNTRCOS  (M)
|   |
|---|--> RVNODVEL    (O)   (nodal velocities)
|   |                      → RDNODRES (M)
|   |                      → BNDOF    (O)  → BNTRCOS  (M)
|   |
|---|--> RVNODACC    (O)   (nodal accelerations)
|                          → RDNODRES (M)
|                          → BNDOF    (O)  → BNTRCOS  (M)
|
| int element number
|   |
|---|--> RVSTRESS    (O)   (element stresses)
|   |                      → RDPOINTS (M)  → RDIELCOR (M)
|   |                      → RDSTRESS (M)
|   |
|---|--> RVSTRAIN    (O)   (element strains))
|   |                      → RDPOINTS (M)  → RDIELCOR (M)
|   |                      → RDSTRAIN (M)
|   |
|---|--> RVFORCES    (O)   (element forces)
                           → RDFORCES (M)


time series number
|
|--> RDSERIES  (M)   → internal node or element number
|                    → degree of freedom / force component
|                    → RVORDINA (M)
|                    → RVABSCIS (M)
|
|--> TDSERIES (O)
```

4 IDENTIFICATION DATA FOR SUPERELEMENTS AND TEXT DATA

The term identification data is used on the type of data that identify each superelement, and the build-up of the superelement hierarchy.

Contents Page

Element Type (Number)

Date and Program Information

DATE

DATE	TYPE	SUBTYPE	NRECS	NBYTE

	<text lines>

	<text lines>

The identifier is used to transfer date and program information on the Interface File.

The following NRECS records must be read in A format, 72 characters per record.

TYPE — Value giving information on how to use this text.
= 1 Text concerning current superelement.
= 2 Text concerning children of current superelement (not implemented).

SUBTYPE — = 0 If current superelement (TYPE = 1).
> 0 Subelement no. referring to the current superelement (only if TYPE = 2).

NRECS — Number of records to be read in A-format, NRECS ≥ 1.

NBYTE — Number of significant bytes on the text records, 1 ≤ NBYTE ≤ 72.
The eight first bytes on the text records shall be filled with blanks.

Example of format of "DATE" record as used in SESAM:

```
DATE      0.10000000E+01  0.00000000E+00  0.40000000E+01  0.72000000E+02
        DATE:     23-MAY-86           TIME:         13:53:03
        PROGRAM:  SESAM WALOCO        VERSION:      5.1-0  15-MAY-86
        COMPUTER: VAX VMS V4.3        INSTALLATION: VERITEC
        USERID:   999XXXX             ACCOUNT:      ZZZZZZZ


------------------------------------------------------------------------
123456789.123456789.123456789.123456789.123456789.123456789.123456789.12
        1         2         3         4         5         6         7
------------------------------------------------------------------------
```

Identification of Superelements

IDENT

IDENT	SLEVEL	SELTYP	SELMOD	

SLEVEL	Superelement level. The level of a superelement is defined as the highest level number among its subelements plus 1. (Basic elements, i.e. beams, shells, springs, etc. have level zero.)
SELTYP	Superelement type number.
SELMOD	Superelement model dimension = 2, 2-dimensional model = 0 or 3, 3-dimensional model.

End of a Superelement

IEND

IEND	CONT			

Defines end of a superelement.

CONT	= 0 (Default). This is also end of the file.
	= 1 The superelements are concatenated on one file. More superelements follows.
	= 2 Last superelement in a structure for a concatenated file.

Name of a Material Type

TDMATER

TDMATER	NFIELD	GEONO	CODNAM	CODTXT
	<GS-name>			
	<GS-comment>			
	. . . . . .			
	<text line>			

This record will associate a name to a general eccentric sandwich description.

NFIELD Number of numeric data fields on this record before text data (MAX = 1024).

GEONO Identification of the general eccentric sandwich type.

CODNAM Coded dimension of the GS-name:
CODNAM = NLNAM*100 + NCNAM. The inverse relation will then be:
NLNAM = integer part of (CODNAM/100)
NCNAM = remaindering of (CODNAM/100)
NLNAM - number of physical records used for storing of name of the general eccentric sandwich construction. Legal range = [0,1]
= 0, no name defined
= 1, name is defined
NCNAM - number of characters in set name. Legal range = [0,64]

CODTXT Coded dimension of the comment text ('GS-comment'):
CODTXT = NLTXT*100 + NCTXT. The inverse relation will then be:
NLTXT = integer part of (CODTXT/100)
NCTXT = remaindering of (CODTXT/100)
NLTXT - number of physical records used for storing of text associated with the general eccentric sandwich construction. Legal range = [0,5]
= 0, no description text defined
≥ 1, number of physical records with description text
NCTXT - number of characters per physical set description text record. Legal range = [0,64]

GS-name Name of the general eccentric sandwich construction.

GS-comment Text associated with the general eccentric sandwich construction.

Name of a General Eccentric Sandwich Section

TDSECT

TDSECT	NFIELD	GEONO	CODNAM	CODTXT
	<GS-name>			
	<GS-comment>			
	. . . . . .			
	<text line>			

This record will associate a name to a general eccentric sandwich description.

NFIELD Number of numeric data fields on this record before text data (MAX = 1024).

GEONO Identification of the general eccentric sandwich type.

CODNAM Coded dimension of the GS-name:
CODNAM = NLNAM*100 + NCNAM. The inverse relation will then be:
NLNAM = integer part of (CODNAM/100)
NCNAM = remaindering of (CODNAM/100)
NLNAM - number of physical records used for storing of name of the general eccentric sandwich construction. Legal range = [0,1]
= 0, no name defined
= 1, name is defined
NCNAM - number of characters in set name. Legal range = [0,64]

CODTXT Coded dimension of the comment text ('GS-comment'):
CODTXT = NLTXT*100 + NCTXT. The inverse relation will then be:
NLTXT = integer part of (CODTXT/100)
NCTXT = remaindering of (CODTXT/100)
NLTXT - number of physical records used for storing of text associated with the general eccentric sandwich construction. Legal range = [0,5]
= 0, no description text defined
≥ 1, number of physical records with description text
NCTXT - number of characters per physical set description text record. Legal range = [0,64]

GS-name Name of the general eccentric sandwich construction.

GS-comment Text associated with the general eccentric sandwich construction.

Name and Description of a Set (group) **TDSETNAM**

TDSETNAM	NFIELD	ISREF	CODNAM	CODTXT
	<set name>			
	<text line>			
	. . . . . .			
	<text line>			

This record together with the set of nodes or elements record(s) (GSETMEMB) constitutes the set (group) datatype.

NFIELD Number of numeric data fields on this record before text data (MAX = 1024).

ISREF Internal set identification number. Legal range [1,NSET], where NSET is number of sets which is equeal to number of "Name and Description of a Set" records (TDSETNAM). Two TDSETNAM records may *not* have identical set identification numbers (ISREF).

CODNAM Coded dimension of set name:
CODNAM = NLNAM*100 + NCNAM. The inverse relation will then be:
NLNAM = integer part of (CODNAM/100)
NCNAM = remaindering of (CODNAM/100)
NLNAM - number of physical records used for storing of set name. Legal range = [0,1]
= 0, no name defined
= 1, name is defined
NCNAM - number of characters in set name. Legal range = [0,64]

CODTXT Coded dimension of set description text:
CODTXT = NLTXT*100 + NCTXT. The inverse relation will then be:
NLTXT = integer part of (CODTXT/100)
NCTXT = remaindering of (CODTXT/100)
NLTXT - number of physical records used for storing of set description text. Legal range = [0,5]
= 0, no description text defined
≥ 1, number of physical records with description text
NCTXT - number of characters per physical set description text record. Legal range = [0,64]

Name and Description of a Super-Element

TDSUPNAM

TDSUPNAM	NFIELD	IHREF	CODNAM	CODTXT
	<super-element name>			
	<text line>			
	. . . . . .			
	<text line>			

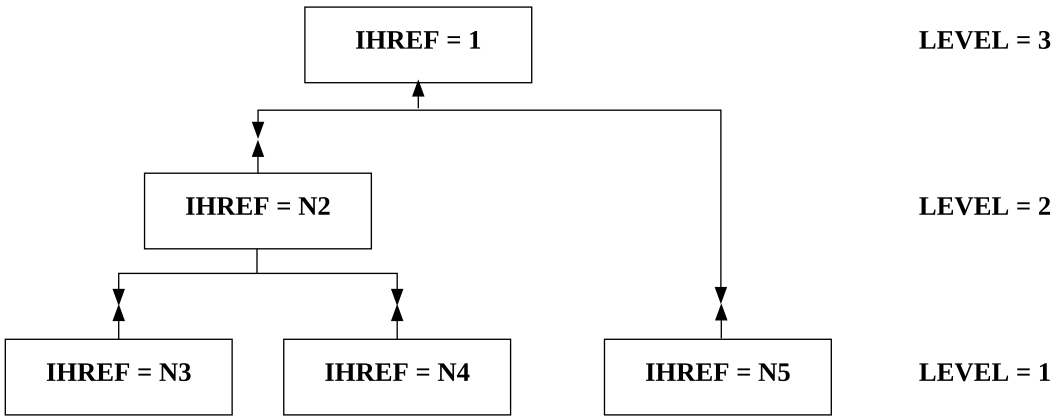
This record will associate a name with a super-element in the super-element hierarchy.

NFIELD Number of numeric data fields on this record before text data (MAX = 1024).

IHREF Hierarchy reference number. Number 1 is reserved for the top level superelement. In SESAM, PRESEL (super-element pre-processor) is writing the HIERARCH records and defining a unique number (IHREF) for each appearance of the differenet superelements. See also Fig. 4-1 below.

CODNAM Coded dimension of set name:
CODNAM = NLNAM*100 + NCNAM. The inverse relation will then be:
NLNAM = integer part of (CODNAM/100)
NCNAM = remaindering of (CODNAM/100)
NLNAM - number of physical records used for storing of set name. Legal range = [0,1]
= 0, no name defined
= 1, name is defined
NCNAM - number of characters in set name. Legal range = [0,64]

CODTXT Coded dimension of set description text:
CODTXT = NLTXT*100 + NCTXT. The inverse relation will then be:
NLTXT = integer part of (CODTXT/100)
NCTXT = remaindering of (CODTXT/100)
NLTXT - number of physical records used for storing of set description text. Legal range = [0,5]
= 0, no description text defined
≥ 1, number of physical records with description text
NCTXT - number of characters per physical set description text record. Legal range = [0,64]



Note that N2, N3, N4 and N5 may take any values as long as they are unique in the hierarchy

Figure 4-1 Superelement hierarchy with 3 levels.

User supplied Text

TEXT

User supplied Text

TEXT	TYPE	SUBTYPE	NRECS	NBYTE

The identifier is used to transfer text-strings on the interface file. The following NRECS records must be read in A-format, 72 characters per ecord.

TYPE Value giving information of how to use this text
= 1 Texts describing this analysis/global text
= 2 Texts concerning current superelement
= 3 Text concerning specific load cases
≥ 4 The meaning of text to be mutually agreed on by preprosessor and analysis program

SUBTYPE Value giving additional information to TYPE
Example: For TYPE = 3, SUBTYPE gives load case number

NRECS Number of records following to be read in A-format. NRECS ≥ 1

NBYTE Number of significant bytes (characters) on the following NRECS records.
1 ≤ NBYTE ≤ 72
The eight first bytes on the text records shall be filled with blanks.

Name of a General Eccentric Sandwich Type

TSLAYER

TSLAYER	NFIELD	GEONO	CODNAM	CODTXT
	<GS-name>			
	<GS-comment>			
	. . . . . .			
	<text line>			

This record will associate a name to a general eccentric sandwich description.

NFIELD Number of numeric data fields on this record before text data (MAX = 1024).

GEONO Identification of the general eccentric sandwich type.

CODNAM Coded dimension of the GS-name:
CODNAM = NLNAM*100 + NCNAM. The inverse relation will then be:
NLNAM = integer part of (CODNAM/100)
NCNAM = remaindering of (CODNAM/100)
NLNAM - number of physical records used for storing of name of the general eccentric sandwich construction. Legal range = [0,1]
= 0, no name defined
= 1, name is defined
NCNAM - number of characters in set name. Legal range = [0,64]

CODTXT Coded dimension of the comment text ('GS-comment'):
CODTXT = NLTXT*100 + NCTXT. The inverse relation will then be:
NLTXT = integer part of (CODTXT/100)
NCTXT = remaindering of (CODTXT/100)
NLTXT - number of physical records used for storing of text associated with the general eccentric sandwich construction. Legal range = [0,5]
= 0, no description text defined
≥ 1, number of physical records with description text
NCTXT - number of characters per physical set description text record. Legal range = [0,64]

GS-name Name of the general eccentric sandwich construction.

GS-comment Text associated with the general eccentric sandwich construction.

5 ELEMENT TYPES

5.1 Element Types in SESAM

Conventions for use of the interface file for the elements in SESAM are defined here. Other element types may be introduced for use in other programs.

The table below contains element type numbers already reserved. (Not all of them are included in SESAM).

For ADVANCE, the element types listed are those available from the SESAM preprocessors. In addition to that ADVANCE has a lot of other element types.

Table 5.1 List of existing Element Types

ELTYP	Name	Nodes	Description of Element	Ref.	PREFRAME	PREFEM	SESTRA	ADVAN.	Other
					Included in Program:				
1			Not yet defined						
2	BEPS	2	2-D, 2 Node Beam	3,5	X			X	
3	CSTA	3	Plane Constant Strain Triangle	2,4		X	X	X	
4			Not yet defined	3					
5	RPBQ	4	Rect. Plate. Bending Modes	3					
6	ILST	6	Plane Lin. Strain Triangle	2		X	X		
7			Not yet defined						
8	IQQE	8	Plane Quadrilateral Membrane Element	2		X	X		
9	LQUA	4	Plane Quadrilateral Membrane Element	2,4		X	X	X	
10	TESS	2	Truss Element	2,4	X	X	X	X	
11	GMAS	1	1-Noded Mass-Matrix			X	X		
12	GLMA	2	2-Noded Mass-Matrix				X		
13	GLDA	2	2-Noded Damping-Matrix						
14			Not yet defined						
15	BEAS	2	3-D, 2 Node Beam	2,4	X	X	X	X	FR,LA,PL, PR,WA
16	AXIS	2	Axial Spring		X	X	X	X**	FR
17	AXDA	2	Axial Damper		X	X	X		
18	GSPR	1	Spring to Ground	4	X	X	X	X	FR
19	GDAM	1	Damper to Ground		X	X	X		
20	IHEX	20	Isoparametric Hexahedron	2		X	X	X	PR
21	LHEX	8	Linear Hexahedron	2,4		X	X	X	PR
22	SECB	3	Subparametric Curved Beam	2					
23	BTSS	3	General Curved Beam	2		X	X		PL,PR.
24	FQUS	4	Flat Quadrilateral Thin Shell	4		X	X		PL,PR
24	FFQ	4	Free Formulation Quadrilateral Shell	5				X	
25	FTRS	3	Flat Triangular Thin Shell	4		X	X		PL
25	FFTR	3	Free Formulation Triangular Shell	5				X	
26	SCTS	6	Subparametric Curved Triangular Thick Shell	2		X	X		PL
27	MCTS	6	Subparam. Curved Triang. Thick Sandwich Elem.	2*		X	X		
28	SCQS	8	Subparametric Curved Quadrilateral Thick Shell	2		X	X		PL,PR
29	MCQS	8	Subparam. Curved Quadr. Thick Sandwich Elem.	2*		X	X		
30	IPRI	15	Isoparametric Triangular Prism	2		X	X	X	
31	ITET	10	Isoparametric Tetrahedron	2			X		
32	TPRI	6	Triangular Prism	2,4		X	X	X	
33	TETR	4	Tetrahedron	2			X		
34	LCTS	6	Subparam. Layered Curved Triangular Thick Shell	2*		X	X		
35	LCQS	8	Subparam. Layered Curved Quadrilat. Thick Shell	2*		X	X		

FR= FRAMEWORK, LA= LAUNCH, PL= PLATEWORK, PR= PRETUBE, SP= SPLICE, WD= WADAM, WJ= WAJAC

* The element subroutines are the same as for the subparametric curved thick shells (SCQS and SCTS).

** Temporarily ADVANCE interprets Axisl Spring as link element, ignoring the material reference. The 6 matrix numbers are given in direct input to ADVANCE.

Table 5.2 List of existing Element Types, continued

ELTYP	Name	Nodes	Description of Element	Ref.	Included in Program:				
					PREFRAME	PREFEM	SESTRA	ADVAN.	Other
36	TRS1	18	2nd Order Hexahed. Transition Elem., Solid / Shell	6			X		PR
37	TRS2	15	2nd Order Hexahed. Transition Elem., Solid / Shell	6			X		PR
38	TRS3	12	2nd Order Hexahed. Transition Elem., Solid / Shell	6			X		PR
39			Not yet defined						
40	GLSH	2	General Spring / Shim Element	*	X		X		
41	AXCS	3	Axisymmetric Constant Strain Triangle	7,5		X	X	X	
42	AXLQ	4	Axisymmetric Quadrilateral	7,5		X	X	X	
43	AXLS	6	Axisymmetric Linear Strain Triangle	7		X	X		
44	AXQQ	8	Axisymmetric Linear Strain Quadrilateral	7		X	X		
45	PILS	1	Pile / Soil	4	X			X	
46	PCAB	2	Plane Cable-Bar Element	4	X			X	
47	PSPR	1	Plane Spring Element	4	X			X	
48		4	4-node Contact Element with triangular Shape	4				X	
49		2	2-Noded Link Element	4				X	
50			Not yet defined						
51	CTCP	2	2-Noded Contact Element						
52	CTCL	4	4-Noded Contact Element						
53	CTAL	4	4-Noded Axisymmetric Contact Element						
54	CTCC	6	6-Noded Contact Element						
55	CTAQ	6	6-Noded (3+3) Axisymmetric Contact Element			X			
56	CTLQ	8	8-Noded (4+4) Contact Element	8,9					PR
57	CTCQ	16	16-Noded (8+8) Contact Element	8,9		X			PR
58	CTMQ	18	18-Noded (9+9) Contact Element	8,9					PR
59			Not yet defined						
60			Not yet defined						
61	HCQS	9	9-Noded Shell Element			X			PR
62			Not yet defined						
63			Not yet defined						
64			Not yet defined						
65			Not yet defined						
66	SLQS	8	Semiloof Quadrilateral Curved Thin Shell (32 d.o.fs)						
67	SLTS	6	Semiloof Triangular Curved Thin Shell (24 d.o.fs)						
68	SLCB	3	Semiloof Curved Beam (11 d.o.fs)						
69			Not yet defined						
70	MATR	n	General Matrix Element with arbitrary no. of nodes (n)				X		SP
.									
.									
.									
100	GHEX	21	General Hexahedron					X	
.									
.									
.									
163	GHEX	27	General Hexahedron					X	

FR= FRAMEWORK, LA= LAUNCH, PL= PLATEWORK, PR= PRETUBE, SP= SPLICE, WD= WADAM, WJ= WAJAC

* As General Spring it is just a 2-noded spring (12x12 matrix) which may be in a local coordinate system. As a shim element the preprocessor(s) will only insert stiffness in the local x- and y-direction. In the analysis program(s), shim members and general springs are treated exactly in the same manner.

5.2 Element Type (Number)

Element Type (Number)

ELTYP=2: Beam Element for Plane Systems (BEPS)

BEPS(2)

- 2 nodes
- 6 degrees of freedom, 3 (u,v and q) at each of the two nodes
- Bending, shear and axial deformations are considered
- The element is straight and has a constant cross section
- offset nodes (i.e. the nodes may be located eccentric in space)
- element loads:
  - load linearly distributed over all, or a part, of the element (Figure 5-1 b)
  - gravitational load
  - general inertia load
  - initial strain (temperature load)

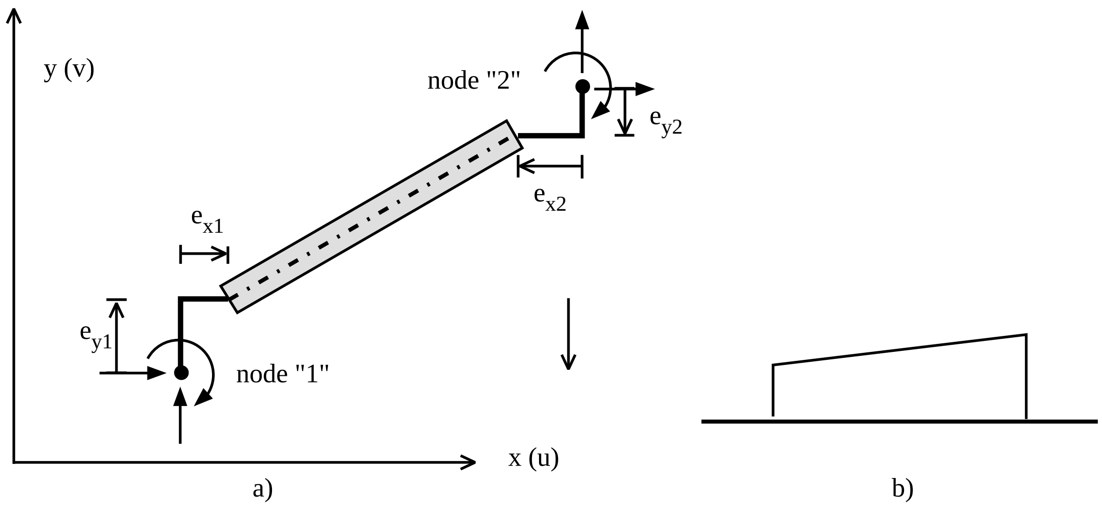


Figure 5-1 a)2Ð Beam Element b)Linearly Distributed Load

Element coordinate system (reference axes):

The local x-axis is directed along the beam, coinciding with the center of gravity and pointing from the beam node "1" to node "2". The local z-axis is defined on GUNIVEC-record.

BEPS(2)

Data types used for this element:

GELMNT1 *
GELREF1 *
GBEAMG *
GIORH, GUSYI, GCHAN, GBOX, GPIPE, GBARM, GTONP or GDOBO;
for SESTRA these reecords are transferred to postprocessor, and only referred when storing on result file.

MISOSEL *
GUNIVEC *
GECCEN
BELOAD1
BGRAV
BNACCLO
BEISTE
BELFIX

*) Mandatory

ELTYP=3: Plane Constant Strain Triangle (CSTA), /2/

CSTA(3)

- 3 nodes
- 3 x 2 degrees of freedom
- straight (two dimensional)
- linearly varying thickness
- deformation considered: translational strain
- element loads:
  - line loads
  - initial strain (temperature load)
  - gravitational load (only in the mebrane plane)
  - general inertia load (only in the membrane plane)
- isotropic or anisotropic material data

Local node numbering:

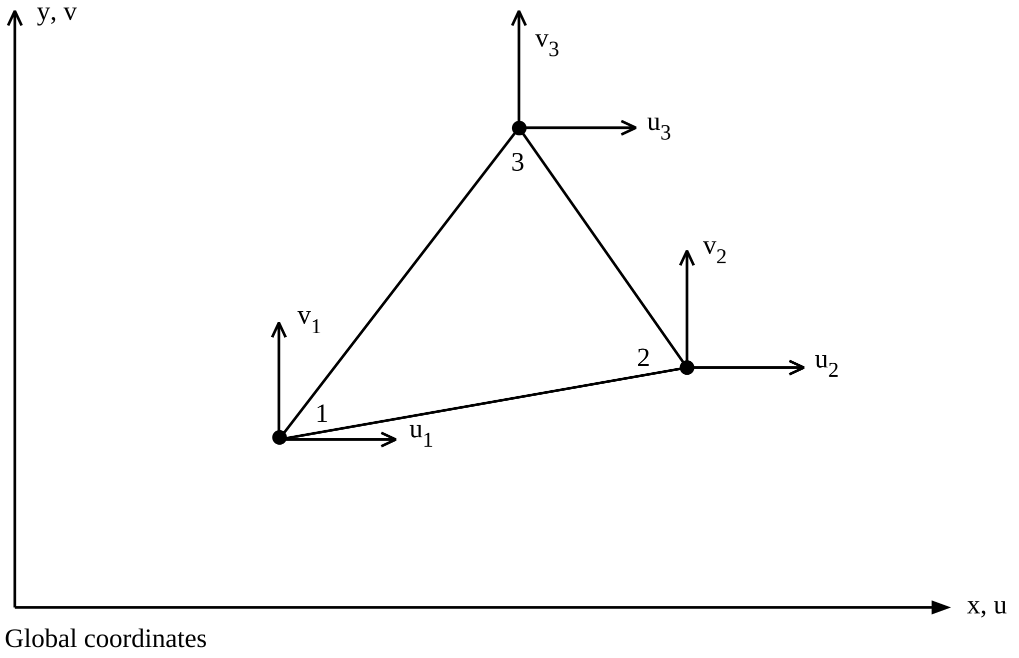


Figure 5-2 Plane constant strain triangle.

When line load is specified, the relation between local node numbers and loaded line will be:

Line 1 means load along the line defined by the nodes 2 and 3.
Line 2 means load along the line defined by the nodes 1 and 3.
Line 3 means load along the line defined by the nodes 1 and 2.

The direction of node numbering can be as well clockwise as counterclockwise.

CSTA(3)

Data types used for this element:

GELMNT1 *
GELREF1 *
GNODE *
GCOORD *
GELTH *

MISOSEL * or
MORSMEL *
MTRMEL

BELLO2
BEISTE
BGRAV
BNACCLO

*) Mandatory

ELTYP=6: Plane Linear Strain Triangle (ILST), /2/

ILST(6)

- 6 nodes
- 6 x 2 degrees of freedom
- curved (two-dimensional)
- linearly varying thickness
- deformations considered: translational strain
- element loads:
  - line loads
  - initial strain (temperature loads)
  - gravitational load
  - general inertia load
- isotropic or anisotropic material data

Local node numbering:

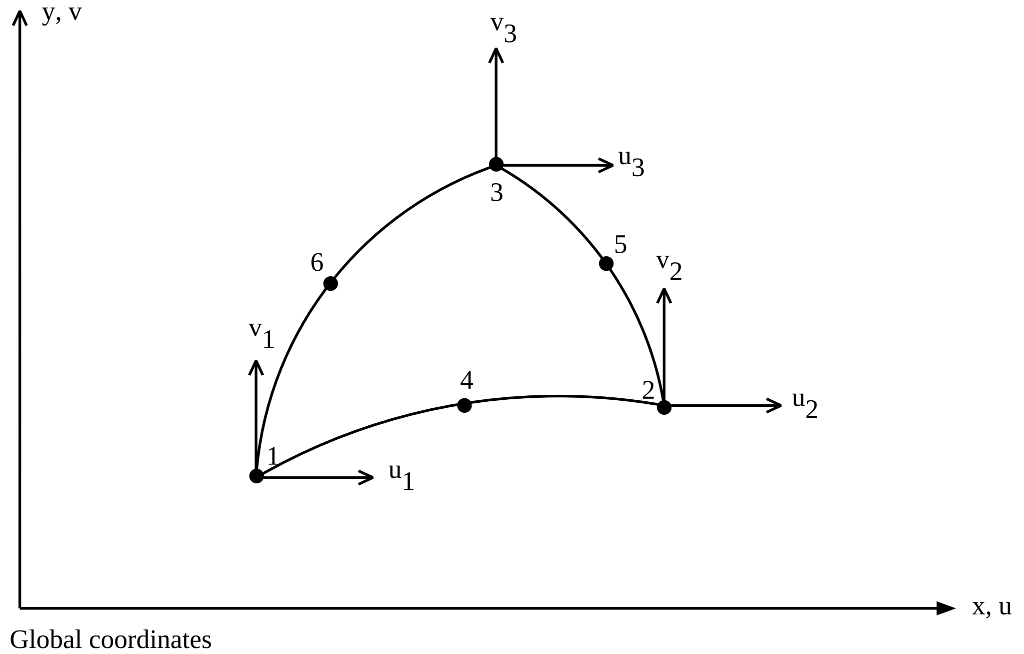


Figure 5-3 Plane linear strain triangle.

When line load is specified, the relation between local node numbers and loaded line will be:

Line 1 means load along the line defined by the nodes 2, 5 and 3.
Line 2 means load along the line defined by the nodes 1, 6 and 3.
Line 3 means load along the line defined by the nodes 1, 4 and 2.

The direction of node numbering can be as well clockwise as counterclockwise.

ILST(6)

The following restrictions are put on the data types

GELINT The integration stations must be distributed according to the Gaussian integration scheme, i.e. INTYPE =1. For this element type the GELINT specifications consist of the first filerecord (line) only.

Stiffness matrix: For stiffness matrix calculations the number of integration stations will be the same in both coordinate directions and equal to the value specified for N1.
Legal values are 3 and 4.
Default value is 3.

Mass matrix: For mass matrix calculations the number of integration stations will be the same in both coordinate directions and equal to the value specified for N1.
Legal values are 1,3,4 and 7.
Default value is 7.

Load vector: For load vector calculations due to initial strains the number of integration stations will be the same in both coordinate directions and equal to the value specified for N1.
Legal values are 1,3 and 4.
Default value is 3.

Data types used for this element:

GELMNT1 *
GELREF1 *
GNODE *
GCOORD *
GELTH *
GELINT
MISOSEL or MORSMEL *

MTRMEL
BELLO2
BEISTE
BGRAV
BNACCLO

*) Mandatory

ELTYP=8: Plane Quadril. Membrane Element (IQQE), /2/ IQQE(8)

- 8 nodes
- 8 x 2 degrees of freedom
- curved (two-dimensional)
- linearly varying thickness
- deformations considered: translational strain
- element loads:
  - line loads
  - initial strain (temperature loads)
  - gravitational load
  - general inertia load
- isotropic or anisotropic material data

Local node numbering:

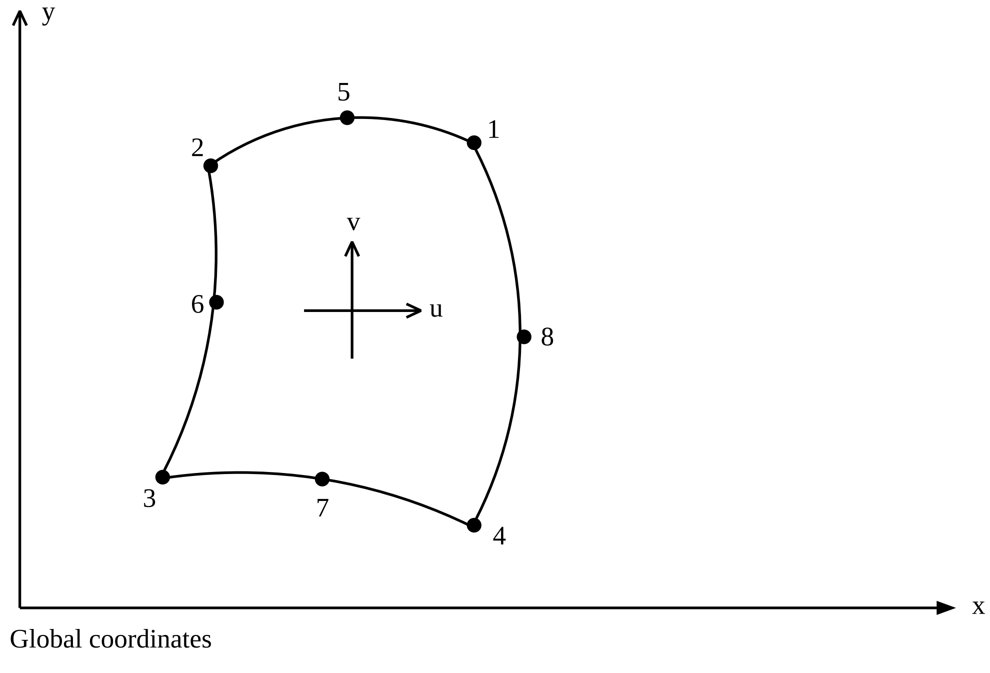


Figure 5-4 Plane quadrilateral membrane element.

When line load is specified, the relation between local node numbers and loaded line will go:

LINE 1 means load along the line defined by the nodes 2, 6 and 3
LINE 2 means load along the line defined by the nodes 5 and 7
LINE 3 means load along the line defined by the nodes 1, 8 and 4
LINE 4 means load along the line defined by the nodes 1, 5 and 2
LINE 5 means load along the line defined by the nodes 8 and 6
LINE 6 means load along the line defined by the nodes 4, 7 and 3

The direction of node numbering can be as well clockwise as counterclockwise.

IQQE(8)

The following restrictions are put on the data types

GELINT The integration stations must be distributed according to the Gaussian integration scheme, i.e. INTYPE =1. For this element type the GELINT specifications consist of the first filerecord only.

Stiffness matrix: For stiffness matrix calculations the number of integration stations will be the same in both coordinate directions and equal to the value specified for N1. Legal values are 2, 3 and 4. Default value is 2.

Mass matrix: For mass matrix calculations the number of integration stations will be the same in both coordinate directions and equal to the value specified for N1. Legal values are 2, 3 and 4. Default value is 4.

Load vector: For load vector calculations due to initial strains the number of integration stations will be the same in both coordinate directions and equal to the value specified for N1. Legal values are 2, 3 and 4. Default value is 2.

BELLO2 LINE = 2, and LINE = 5 are not operative.

Data types used for this element:

GELMNT1 *
GELREF1 *
GNODE *
GCOORD *
GELTH *
GELINT
MISOSEL or MORSMEL *
MTRMEL
BELLO2
BEISTE
BGRAV
BNACCLO

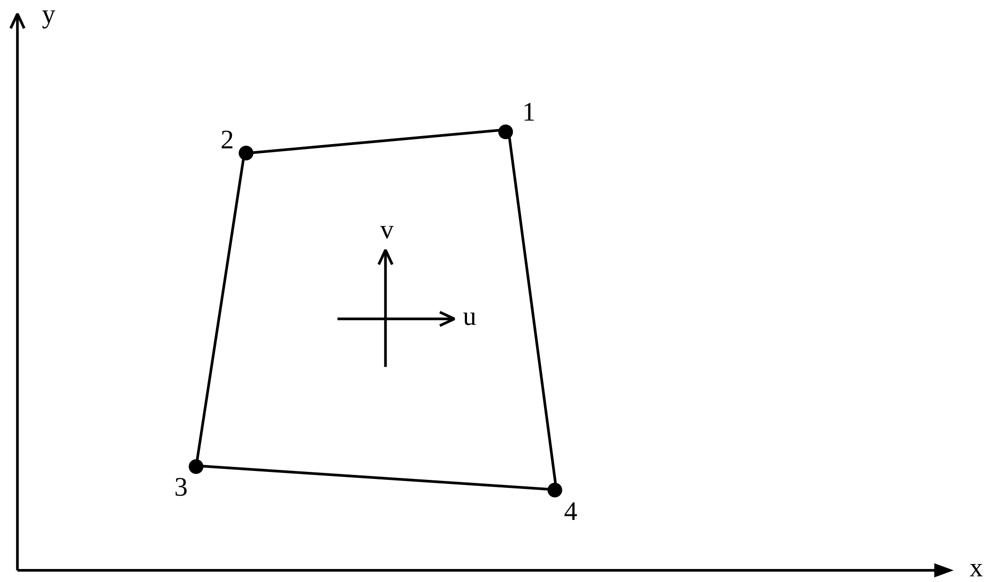
*) Mandatory

ELTYP=9: Plane Quadrilateral Membrane Element (LQUA), /2/

LQUA(9)

- 4 nodes
- 4 x 2 degrees of freedom
- straight (two-dimensional)
- linearly varying thickness
- isotropic or anisotropic material data
- deformations considered: translational strain
- element loads
  - line loads
  - initial strain (temperature load)
  - gavitational load
  - general inertia load

Local node numbering:



Global coordinates

Figure 5-5 Plane Quadrilateral Membrane Element.

When line load is specified, the relation between local node numbers and loaded line will go:

LINE 1 means load along the line defined by the nodes 1 and 2
LINE 2 means load along the line defined by the nodes 2 and 3
LINE 3 means load along the line defined by the nodes 3 and 4
LINE 4 means load along the line defined by the nodes 4 and 1

The direction of node numbering can be as well clockwise as counterclockwise.

LQUA(9)

Data types used for this element:

GELMNT1 *
GELREF1 *
GNODE *
GCOORD *
GELTH *
GELINT
MISOSEL or *
MORSMEL
BELLO2
MTRMEL
BEISTE
BGRAV
BNACCLO

*) Mandatory

The following restrictions are put on data types:

GELINT The integration stations must be distributed according to the Gaussian integration scheme, i.e.
INTYPE =1. For this element type the GELINT specifications consist of the first line.

Stiffness matrix:
Legal values for N1 and N2 are 1, 2, 3 and 4.
Default value is N1=N2=2.

Mass matrix: For mass matrix calculations the number of integration stations will be the same
in both coordinate directions and equal to the value specified for N1.
Legal values are 2 and 3.
Default value is N1=N2=3.

ELTYP=10: Truss Element (TESS) /2/

TESS(10)

- 2 nodes
- 2 x 3 = 6 degrees of freedom
- straight
- constant cross section
- axial stiffness only
- element loads:
  - initial strain (temperature)

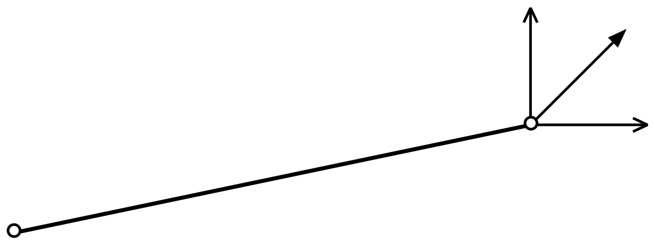


Figure 5-6 Truss element

Data types used for this element:

BEISTE

GELMNT1 *
GBEAMG (only AREA) *
GELREF1 *

MISOSEL

*) Mandatory

ELTYP=11: 1-Noded Mass Element (GMAS)

GMAS(11)

- 1 node
- degrees of freedom, arbitrary
- mass matrix

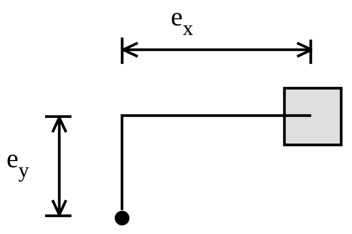


Figure 5-7 1-noded mass element

The mass point may be specified with eccentricities (e_x, e_y and e_z) in all three global directions and the mass matrix may be specified in a transformed local coordinate system.

The mass matrix is a full symmetric matrix where all values on and below the diagonal are stored.

Data types used for this element:

GELMNT1 *
MGMASS * (NDOF must be equal to NDOF on data type GNODE)
GELREF1 *
GECCEN
BNTRCOS (NDOF = 3 or 6 is required for transformations)

*) Mandatory

ELTYP=12: General 2-Noded Mass Element (GLMA)

GLMA(12)

- 2 nodes
- degrees of freedom, arbitrary
- general mass matrix

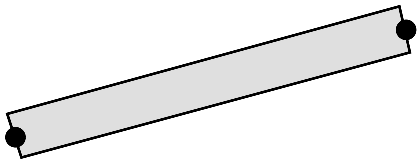


Figure 5-8 General 2-noded mass element.

The resulting mass matrix is a full symmetric matrix where all values on and below the main diagonal are stored.

Data types used for this element:

GELMNT1 *
MGLMASS * (NDOF1 and NDOF2 must be equal to NDOF on data type GNODE for "node 1" and "node 2")
GELREF1 *
BNTRCOS (Transformation in the two nodes may be different. But NDOF1 = NDOF2 = 3 or 6 is required for transformation).

*) Mandatory

ELTYP=13: General 2-Noded Damping Element (GLDA)

GLDA(13)

- 2 nodes
- degrees of freedom, arbitrary
- general damping matrix

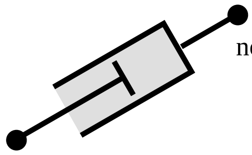


Figure 5-9 General 2-noded damping element

The resulting damping matrix is a full symmetric matrix where all values on and below the main diagonal are stored.

Data types used for this element:

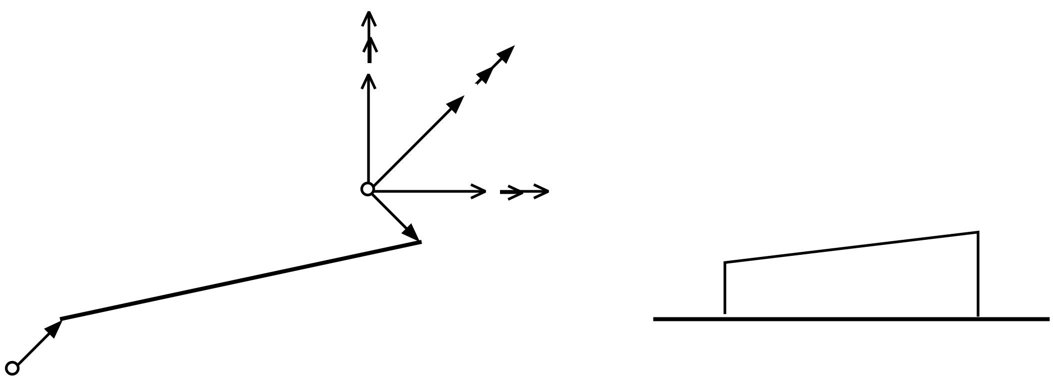
GELMNT1 *
MGLDAMP * (NDOF1 and NDOF2 must be equal to NDOF on data type GNODE for node "1" and node "2")
GELREF1 *
BNTRCOS (Transformation in the two nodes may be different. But NDOF1 = NDOF2 = 3 or 6 is required for transformation).

*) Mandatory

ELTYP=15: Beam Element (BEAS) /2/

BEAS(15)

- 2 nodes
- 2 x 6 = 12 degrees of freedom
- straight
- constant cross section
- offset nodes (i.e. the nodes may be located eccentrically in space)
- deformations considered: bending and shear about the two principal axes, axial deformations and St.Venant torsion
- the transverse load must be located in the shear centre of the beam
- eccentric shear center
- element loads:
  - load linearly distributed over all, or a part, of the element (Figure 5-10 b)
  - gravitational load
  - general inertia load
  - initial strain (temperature load)



a) b)

Figure 5-10 a)Beam element b)Linearly distributed load

Element coordinate system (reference axes). The local x-axis is directed along the beam, coinciding with the center of gravity and pointing from node "1" to node "2". The local z-axis is defined on GUNIVEC-record.

BEAS(15)

Data types used for this element:

GELMNT1 *
GBEAMG *
GELREF1 *
GIORH, GUSYI, GCHAN, GBOX, GPIPE, GBARM, GTONP or,GDOBO;
for SESTRA these reecords are transferred to postprocessor, and only referred when storing on result file.

MISOSEL *
GUNIVEC *
GECCEN
BEDRAG1
BEMASS1
BELOAD1
BGRAV
BNACCLO
BEISTE
BELFIX

*) Mandatory

ELTYP=16: Axial Spring (AXIS)

AXIS(16)

- 2 nodes
- degrees of freedom at each node: 2, 3 or 6
- axial stiffness

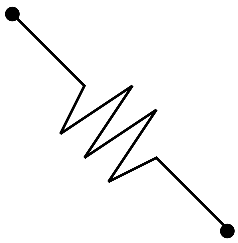


Figure 5-11 Axial spring

Data types used for this element:

GELMNT1 *
GELREF1 *
MAXSPR *

*) Mandatory

ELTYP=17: Axial Damper (AXDA)

AXDA(17)

- 2 nodes
- degrees of freedom at each node: 2, 3 or 6.
- axial damping

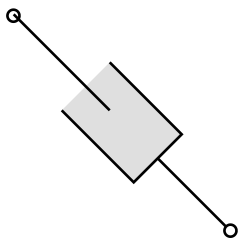


Figure 5-12 Axial damper.

Data types used for this element:

GELMNT1 *
GELREF1 *
MAXDMP *

*) Mandatory

ELTYP=18: Ground Spring (GSPR)

GSPR(18)

- 1 node
- degrees of freedom, arbitrary
- stiffness matrix

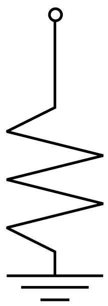


Figure 5-13 Ground spring

Data types used for this element:

GELMNT1 *
GELREF1 *
MGSPRNG * (NDOF must be equal to NDOF on data type GNODE)
BNTRCOS (NDOF = 3 or 6 is required for transformations)

*) Mandatory

ELTYP=19: Damper to Ground (GDAM)

GDAM(19)

- 1 node
- degrees of freedom arbitrary
- damping matrix

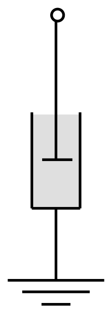


Figure 5-14 Damper to ground

Data types used for this element:

GELMNT1 *
GELREF1 *
MGDAMP * (NDOF must be equal to NDOF on data type GNODE)
BNTRCOS (NDOF = 3 or 6 is required for transformations)

*) Mandatory

ELTYP=20: Isoparametric Hexahedron (IHEX), /2/

IHEX(20)

- 20 nodes
- 20 x 3 degrees of freedom
- curved element sides
- isotropic or anisotropic material data
- deformations considered: translational strain
- element loads:
  - initial strain (temperature load)
  - surface forces
  - line loads
  - gravitational load
  - general inertia load

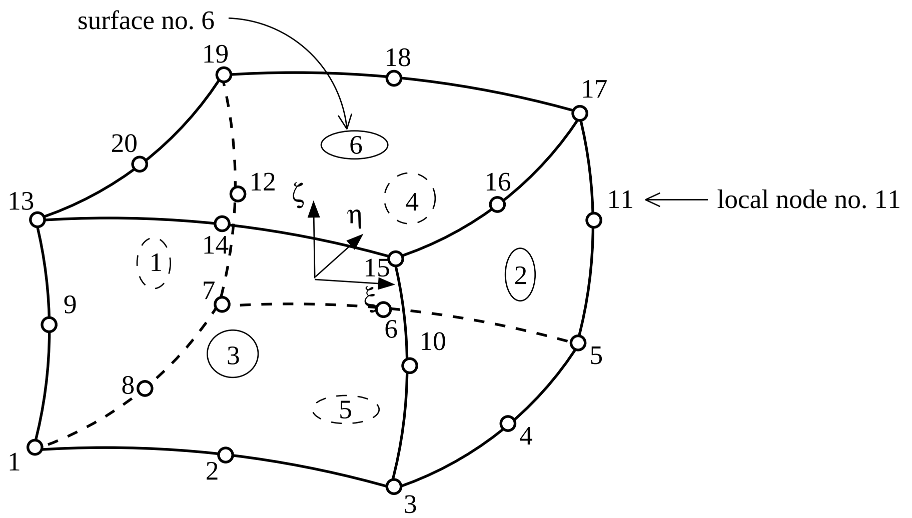


Figure 5-15 Isoparametric hexahedron with local nodenumbering and corresponding surface numbering

IHEX(20)

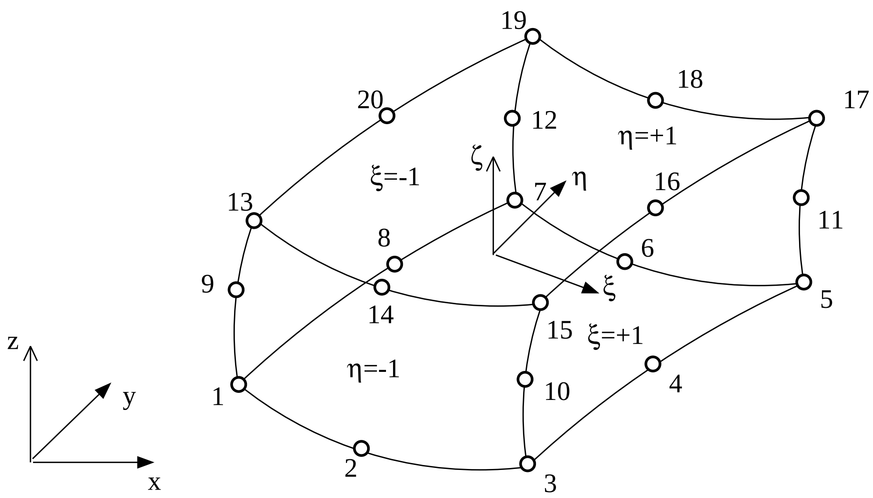


Figure 5-16 Typical isoparametric hexahedron

When surface loads are specified for the element side, the surface numbers shown are used for identification of the side in question.

The local node numbering for each side is defined as follows:

Side no.	Node number 1	2	3	4	5	6	7	8
1	7	8	1	9	13	20	19	12
2	5	11	17	16	15	10	3	4
3	1	2	3	10	15	14	13	9
4	7	12	19	18	17	11	5	6
5	7	6	5	4	3	2	1	8
6	19	20	13	14	15	16	17	18

IHEX(20)

When line load is specified, the relation between the local node numbers and the loaded line will be as follows:

	Node number		
Line no.	1	2	3
1	1	2	3
2	3	4	5
3	5	6	7
4	7	8	1
5	1	9	13
6	3	10	15
7	5	11	17
8	7	12	19
9	13	14	15
10	15	16	17
11	17	18	19
12	19	20	13
13	8	4	
14	6	2	
15	9	10	
16	2	14	
17	10	11	
18	4	16	
19	11	12	
20	6	18	
21	12	9	
22	8	20	
23	20	16	
24	14	18	

IHEX(20)

Data types used for this element:

GELMNT1 *
GNODE *
GCOORD *
GELREF1 *
GELSTRP
MISOSEL * or
MISOPL * or
MORSSOL *
MTRSOL
BEUSLO
BELLO2
BEISTE
BGRAV
BNACCLO

*) Mandatory

IHEX(20)

The following restrictions are put on the data types

GELINT

The integration stations must be distributed according to the Gaussian integration scheme, i.e. INTYPE=1. For this element type the GELINT specifications consist of the first two lines.

Stiffness matrix: For stiffness matrix calculations the number of integration stations will be the same in all coordinate directions and equal to the value specified for N1.
Legal values are 2, 3 and 4.
For a regular element N1 = 2 may cause a singular stiffness matrix.
Default value is 3.

Load calculations: Here, the number of integration stations in each coordinate direction must be specified individually. If volume forces are calculated, legal values for N1, N2 and N3 are 2, 3 and 4.
For surface forces, the legal value for N1, N2 and N3 is 2.
Default value is 2.

Initial strain: The number of integration stations in each coordinate direction must be specified individually.
Legal values for N1, N2 and N3 are 2, 3 and 4.
Default value is 2.

Mass matrix: Again the number of integration stations in each direction must be specified individually.
Legal values for N1, N2 and N3 are 3 and 4.
Default value is 3.

GELSTRP

The stress points must be distributed according to the Gaussian integration scheme, i.e. STRPTYP=1. Only the first two records of the GELSTRP specification are therefore used in this element type.
Legal values for N1, N2 and N3 are 1, 2, 3 and 4.
Default value is 2.

BELLO2

The SIDE definition is not used. The load components are given nodewise in global coordinates.

BEUSLO

Only one side can be loaded for each BEUSLO record. For the same reason only one side identification may be given in SIDE on the BEUSLO record.

ELTYP=21: Linear Hexahedron (LHEX), /2/

LHEX(21)

- 8 nodes
- 8 x 3 = 24 degrees of freedom
- linear element sides
- isotropic or anisotropic material data
- deformation considered: translational displacement
- element load
  - gravitational load
  - general inertia load
  - initial strain (temperature load)
  - surface forces
  - line loads

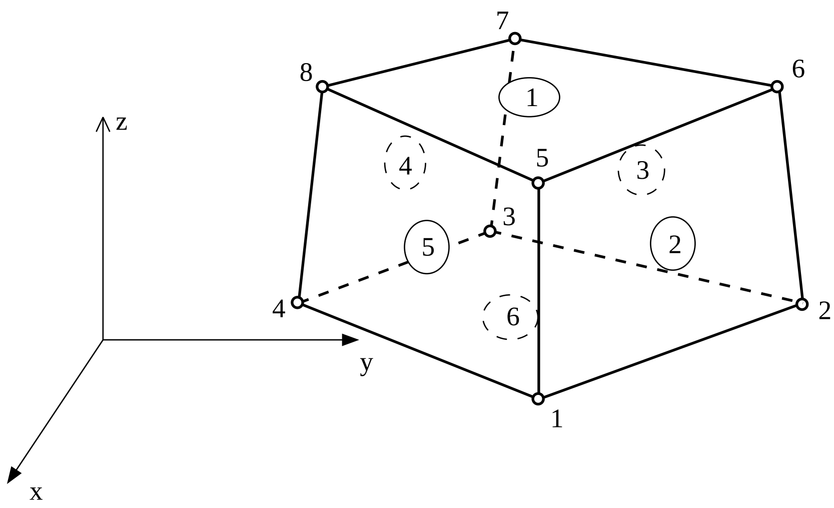


Figure 5-17 Linear hexahedron solid element with local nodenumbering and corresponding surface numbering.

LHEX(21)

When surface loads are specified for an element side, the surface numbers shown are used for identification of the surface in question.
The local nodenumbering for each side is defined as follows:

	Node number			
Side no.	1	2	3	4
1	5	6	7	8
2	1	2	6	5
3	2	3	7	6
4	3	4	8	7
5	4	1	5	8
6	1	4	3	2

When line load is specified, the relation between the local node numbers and the loaded line will be as follows:

	Node number	
Line no.	1	2
1	1	2
2	2	3
3	3	4
4	4	1
5	1	5
6	2	6
7	3	7
8	4	8
9	5	6
10	6	7
11	7	8
12	8	5

LHEX(21)

Data types used for this element:

GELMNT1 *
GNODE *
GCOORD *
GELREF1 *
MISOSEL * or
MORSSOL *
BELLO2
BEUSLO
BEISTE
BGRAV
BNACCLO

*) Mandatory

LHEX(21)

The following restrictions are put on data type:

GELINT — The integration stations must be distributed according to the Gaussian integration scheme, i.e. INTYPE = 1. For this element type the GELINT specifications consist of only the first line.

Stiffness matrix calculation: Number of integration stations will be the same in all coordinate directions and equal to the value specified for N1.
Legal values are 2 and 3.
Default value is 2.

Load calculations: Number of integration stations is the same in all coordinate directions. The only legal value is N1=2.

Initial strain: Number of integration stations is the same in all coordinate directions and is given by N1.
Legal values are 2 and 3.
Default value for N1 is 2.

Mass matrix calculation: The same number of integration points in each coordinate direction as in stiffness matrix calculation is also used in mass matrix calculation.

GELSTRP — The stress points must be distributed according to the Gaussian integration scheme, i.e. STRPTYP=1. Number of stress points in each of the coordinate directions are the same and equal to the number specified by N1. Only the first record of the GELSTRP specification is therefore used for this element type.
Legal values of N1 are 2 and 3.
The default value is 2.

BELLO2 — The SIDE definition is not used. The load components are given nodewise in global coordinates.

BEUSLO — An element side may only be loaded once for each BEUSLO-record.

ELTYP=22: Subparametric Curved Beam (SECB) /2/ SECB(22)

- 3 nodes
- 3 x 6 degrees of freedom
- curved element
- isotropic material data
- deformations considered:
  bending, shear and axial strain
- element loads:
  - line loads
  - gravitational load
  - general inertia load

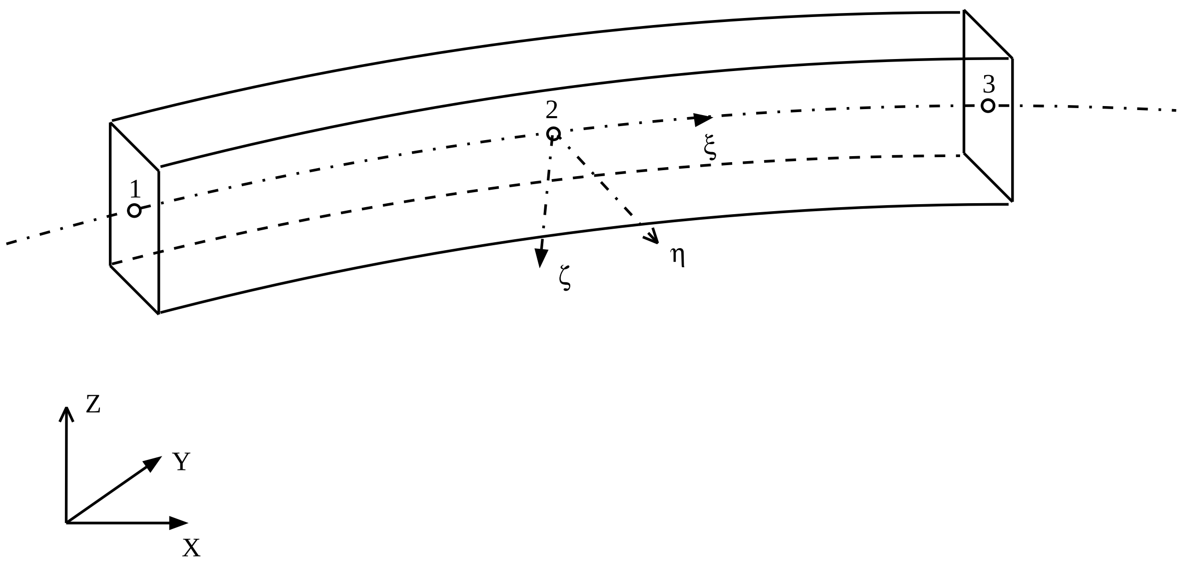


Figure 5-18 Typical beam element
Global cartesian - local curvilinear coordinate system

SECB(22)

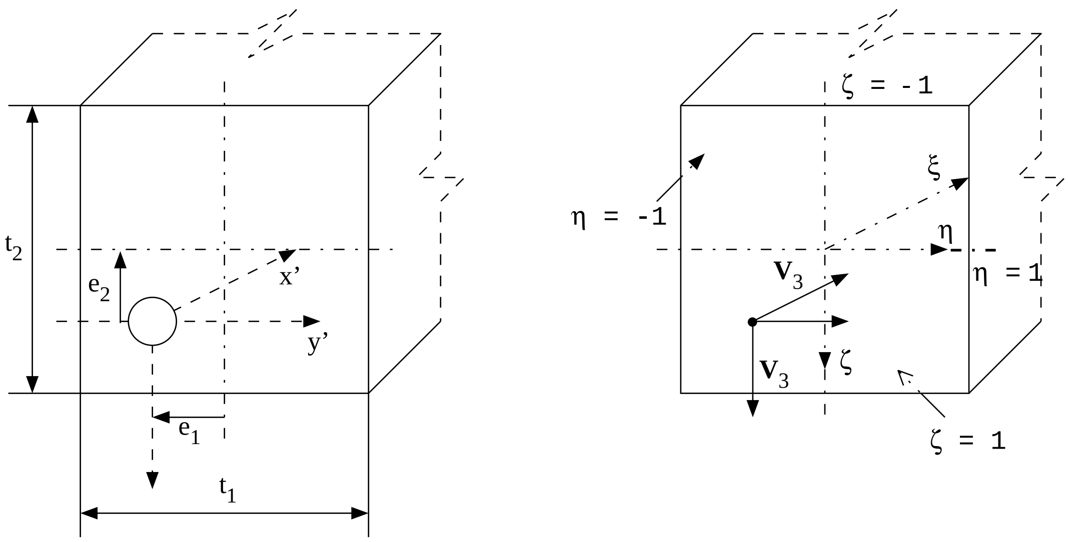


Figure 5-19 Cross-section data, for the beam element.

Data types used for this element:

GELMNT1 *
GELREF1 *
MISOSEL *
GUNIVEC *
GECCEN
GELINT
GBARM *
BELLO2
BGRAV
BNACCLO

*) Mandatory

SECB(22)

The following restrictions are put on the data-types.

GECCEN For this element only eccentricities in the local (h, z)-plane is allowed.

GELINT The integration stations must be distributed according to the Gaussian integration scheme, i.e. INTYPE=1. For this element type the GELINT specifications consist of the first two lines.

Stiffness matrix: Here, the number of integration stations in each coordinate direction must be specified individually. N1 must always be equal to 2. Legal values for N2 and N3 are 1 and 2. In the directions where one integration station is specified, analytical integration is used, else numerical integration is used. Default value for N1, N2 and N3 is 2.

Load calculations: Only the number of integration stations in the first coordinate direction is used (line load along beam axis). Legal values are 2, 3 or 4. Default value for N1 is 2.

Mass matrix: As for stiffness matrix calculations.

GBARM Since the element cross-section must be rectangular, only H2I and BT are needed to specify the cross-section geometry at a node.

BELLO2 LINE and SIDE will not be employed for this element.

ELTYP=23: Subparam. General Curved Beam /2/ & /12/ **BTSS(23)**

- 3 nodes
- 3 x 6 degrees of freedom
- curved element
- isotropic material data
- constant cross section along the beam
- general cross section
- offset nodes (i.e. the nodes may be located eccentrically in space)
- deformations considered: bending and shear, axial deformations and St.Venant torsion
- the transverse load must be located in the shear centre of the beam
- eccentric shear center
- element loads:
  - line load
  - line moment load
  - gravitational load
  - general inertia load
  - temperature load

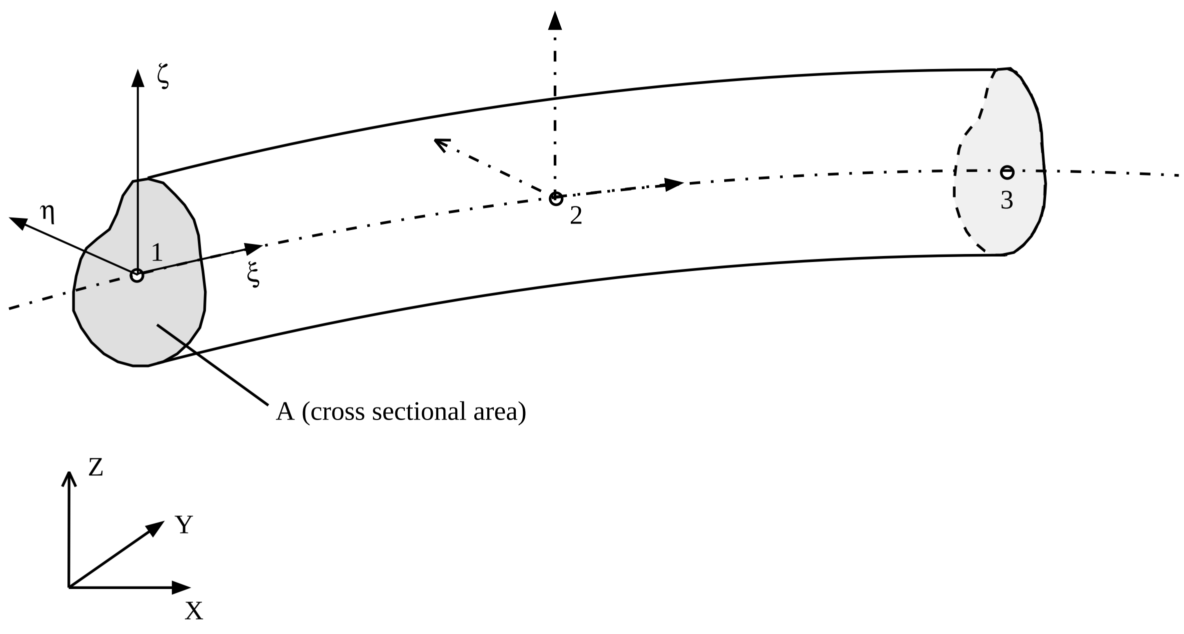


Figure 5-20 Typical general beam element
Global cartesian - local curvilinear coordinate system

BTSS(23)

Data types used for this element:

GELMNT1 *
GELREF1 *
MISOSEL *
GUNIVEC *
GECCEN
GBEAMG *
GELREF1 *
GIORH, GUSYI, GCHAN, GBOX, GPIPE, GBARM, GTONP or,GDOBO;
for SESTRA these records are transferred to postprocessor, and only referred when storing on result file.

BELLO2
BGRAV
BNACCLO
BEISTE

*) Mandatory

The following restrictions are put on the data-types.

GECCEN	General eccentricities in the local (ξ, η, ζ)-directions are allowed.
GBEAMG	Cross section properties are fetched from this record in SESTRA. Geometry of cross sections specified on other records (GBARM, GIORH etc.) are only transferred to the result file.
BELLO2	LINE and SIDE will not be employed for this element.

ELTYP=24: Flat Quadrilateral Thin Shell (FQUS), /2/

FQUS(24)

- 4 nodes
- 4 x 5 degrees of freedom
- linear element sides
- isotropic or anisotropic material data
- deformations considered:
  bending, shear and translational strain
- constant element thickness
- element loads:
  - initial strain (temperature loads)
  - surface forces
  - line loads
  - line moment load
  - gravitational load
  - general inertia loade

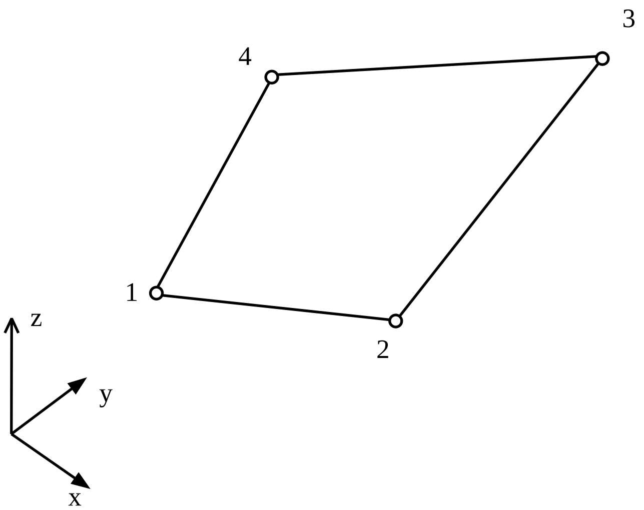


Figure 5-21 Element node numbering on flat quadrilateral shell element.

FQUS(24)

When line load is specified, the relation between local node numbers and loaded line will be:

LINE =1 means line load between node 1 and 2
LINE =2 means line load between node 2 and 3
LINE =3 means line load between node 3 and 4
LINE =4 means line load between node 4 and 1

Data types for this element:

GELMNT1 *
GNODE *
GCOORD *
GELREF1 *
GELTH *
MISOSEL * or
MORSMEL *
MTRMEL
BEUSLO
BELLO2
BEISTE
BGRAV
BNACCLO

*) Mandatory

FQUS(24)

The following restrictions are put on the data types:

GELREF
- INTNO and ISPONO are not read because number of integration and stress points are constant in the program and can not be set by user.
- No thickness variation is allowed for this element. If thickness variation is specifed by the GEONO / OPT option, the finite element program executing this element must use a mean thickness calculated from the nodal thicknesses.

BEUSLO
This element type is only able to calculate surface loads which are acting perpendicular to the element surface. Hence LOTYP=1 (normal pressure) should be used. If LOTYP=2 (loads given in component form) are specified, the in-plane components are ignored by the program. Surface loads are always referred to the middle plane of these elements, i.e. SIDE=2 (nead not be specified).

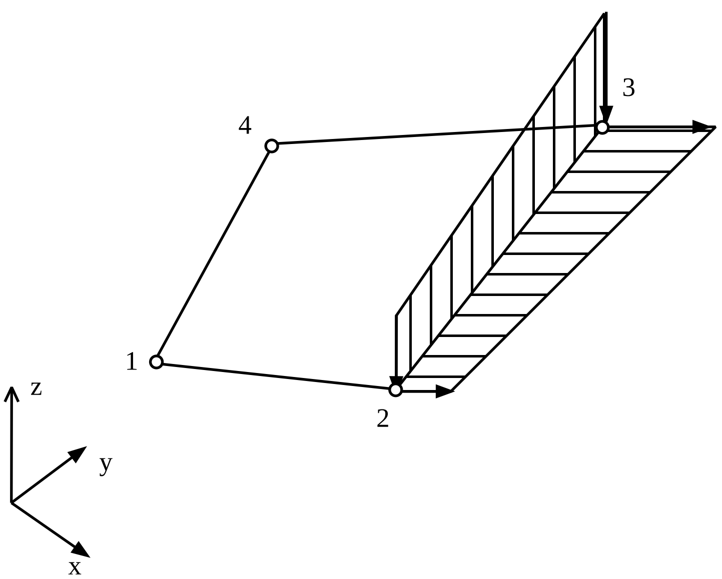


Figure 5-22 Linear variation of line load component normal to the element plane and in the plane.

ELTYP=25: Flat Triangular Thin Shell (FTRS), /2/

FTRS(25)

- 3 nodes
- 3 x 5 degrees of freedom
- linear element sides
- isotropic or anisotropic material data
- deformations considered:
  bending, shear and translational strain
- constant element thickness
- element loads:
  - initial strain (temperature loads)
  - surface forces
  - line loads
  - line moment load
  - gravitational load
  - general inertia load

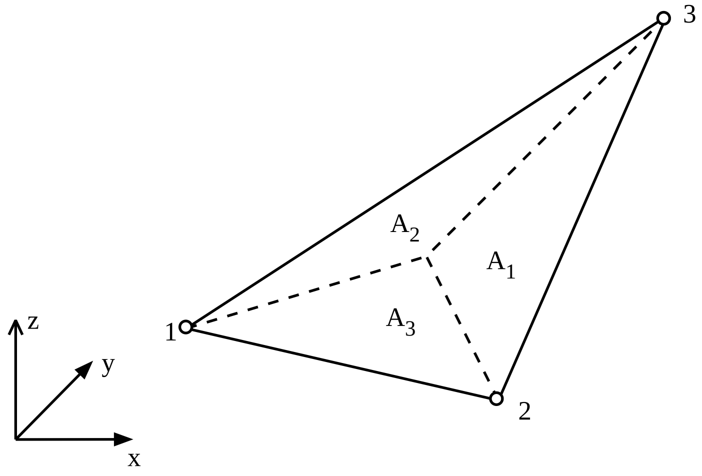


Figure 5-23 Element node numbering and local area coordinates (A_1, A_2 and A_3) on flat triangular shell element.

FTRS(25)

When line load is specified for one of the element sides, the relation between local node numbers and loaded line will be:

LINE=1 means line load between node 2 and 3
LINE=2 means line load between node 1 and 3
LINE=3 means line load between node 1 and 2

Data types used for this element:

GELMNT1 *
GNODE *
GCOORD *
GELREF1 *
GELTH *
MISOSEL *
MORSMEL *
MTRMEL
BEUSLO
BELLO2
BEISTE
BGRAV
BNACCLO

*) Mandatory

FTRS(25)

The following restrictions are put on the data types:

GELREF — INTNO and ISPONO are not read because number of integration and stress points are constant in the program and cannot be set by user.
GEONO / OPT should be set>0 because no thickness variation is allowed for this element type.

BEUSLO — This element type is only able to calculate surface loads which are acting perpendicular to the element surface. Hence LOTYP=1 (normal pressure) should be used. If LOTYP=2 (loads given in component form) are specified, the in-plane components are ignored by the program. Surface loads are always referred to the middle plane of these elements, i.e. SIDE=2 (need not be specified).

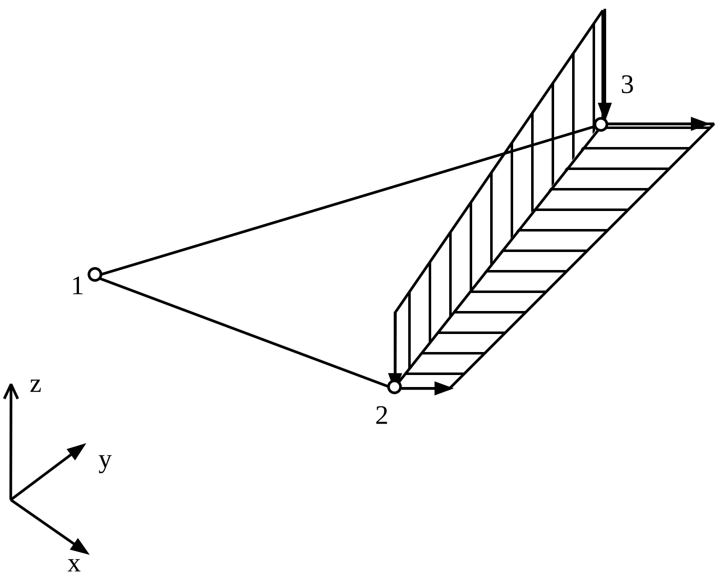


Figure 5-24 Constant line load in element plane and linear variation of component normal to the plane

ELTYP=26: Subparametric Curved Triangular Shell (SCTS), /2/

SCTS(26)

- 6 nodes
- 6 x 6 degrees of freedom
- curved element shape
- isotropic or anisotropic material data
- deformations considered:
  bending, shear and translational strain
- parabolically varying element thickness
- element loads:
  - initial strain
  - surface forces
  - line loads
  - line moment load
  - gravitational load
  - general inertia load

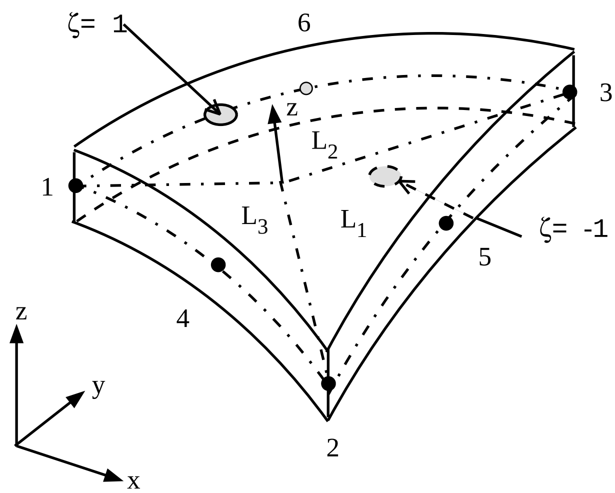


Figure 5-25 Element node numbering. Global Cartesian and local area coordinate system.

When line load is specified for one of the element sides, the relation between local node numbers and loaded line will be:

SCTS(26)

LINE=1 means line load on the element side defined by nodes 2, 5 and 3
LINE=2 means line load on the element side defined by nodes 1, 6 and 3
LINE=3 means line load on the element side defined by nodes 1, 4 and 2

The orientation of the local nodal coordinate system is related to the nodenumbering sequence (see Figure 5-25). The positive z-direction, normal to the element middle surface, is chosen according to the normal convention of the right hand rule, i.e. the positive ζ-direction is found when the node numbers are followed in ascending order, counterclockwise.

The SIDE definition on the BEUSLO records is as follows:

SIDE=1 means that load is given on the element surface where ζ=-1,
SIDE=2 that ζ=0 is loaded, and
SIDE=3 that ζ=1 is loaded.

Data types for this element:

GELMNT1 *
GNODE *
GCOORD *
GELREF1 *
GELINT
GELTH *
GELSTRP
MISOSEL * or
MORSSEL *
MTRSEL
BEUSLO
BELLO2
BEISTE
BGRAV
BNACCLO

*) Mandatory

SCTS(26)

The following restrictions are put on the data types.

GELINT The integration stations must be distributed according to a scheme similar to the Gaussian integration scheme, i.e. INTYPE=1. For this element type the GELINT specifications consist of the first line only. The integration stations will be specified in the triangle plane, and not along local coordinate axes. The value specified for N1 is **not** the number of integration stations but a reference number to specified distributions of integration stations, which may have the same number of integration stations, but different positions in the triangle plane. Therefore, N3 has no meaning for this element type. Legal values for N1 are 1, 2, 3, 4, 5, 6, 7, 8, 9, see description of subroutine HAMC30 in the finite element library, /2/. N2 ("ζ-direction") is not possible to specify and the value 2 is used for each layer. The integration in ζ-direction will be performed analytically if max deviation from mean thickness is 5% and the element is nearly flat.

Stiffness matrix: Default value for N1 is 7.

Load calculations: Default value for N1 is 6 for surface loads.

Initial strain: Default value for N1 is 6.

Mass matrix: N1 should be specified ³ 7 to ensure positive definite mass matrix. Default value is N1=7.

GELSTRP The stress points must be distributed according to the same scheme as the integration points in the GELINT specification, for stress point coordinates in the triangular plane. The stress point coordinates in the ζ-direction are distributed according to the usual Gaussian integration scheme STRPTYP=1. Legal values for N1 are 1, 3, 4, 7, 9, and for N2 2, 3, 4.
Default values for N1 is 3 and for N2 the default value is 2.
Only the first record of the GELSTRP specification is used for this element type.

BELLO2 The SIDE-definition is not used.

ELTYP=27: Subparametric Multilayered Curved Triangular Shell (MCTS), /2/

MCTS(27)

- 6 nodes
- 6 x 6 degrees of freedom
- curved element shape
- isotropic or anisotropic material data
- two or more material layers (sandwich)
- deformations considered:
  bending, shear and translational strain
- parabolically varying element thickness
- element loads:
  - initial strain
  - surface forces
  - line loads
  - line moment load
  - gravitational load
  - general inertia load

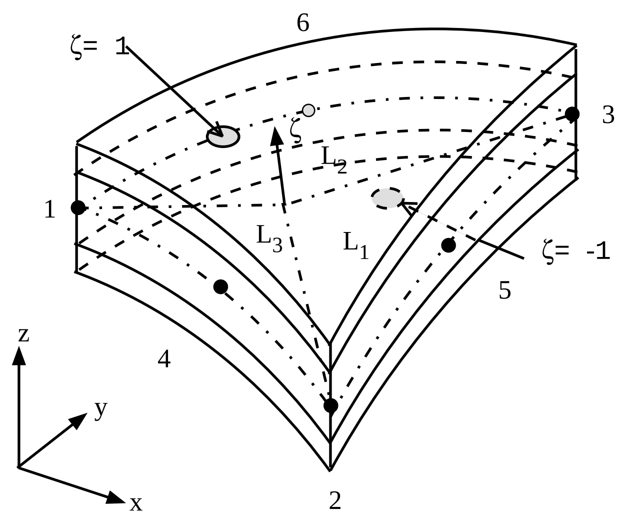


Figure 5-26 Element node numbering. Global Cartesian and local area coordinate system. Three layers.

When line load is specified for one of the element sides, the relation between local node numbers and loaded line will be:

MCTS(27)

LINE=1 means line load on the element side defined by nodes 2, 5 and 3
LINE=2 means line load on the element side defined by nodes 1, 6 and 3
LINE=3 means line load on the element side defined by nodes 1, 4 and 2

The orientation of the local nodal coordinate system is related to the nodenumbering sequence (see Figure 5-26). The positive ζ-direction, normal to the element middle surface, is chosen according to the normal convention of the right hand rule, i.e. the positive ζ-direction is found when the node numbers are followed in ascending order.

The SIDE definition on the BEUSLO records is as follows:

SIDE=1 means that load is given on the element surface where ζ=-1,
SIDE=2 that ζ=0 is loaded, and
SIDE=3 that ζ=1 is loaded.

Data types for this element:

GELMNT1 *
GNODE *
GCOORD *
GELREF1 *
GELINT
GELTH *
GELSTRP
MORSSEL *
MTRSEL
BEUSLO
BELLO2
BEISTE
BGRAV
BNACCLO

*) Mandatory

MCTS(27)

The following restrictions are put on the data types.

GELINT The integration stations must be distributed according to a scheme similar to the Gaussian integration scheme, i.e. INTYPE=1. For this element type the GELINT specifications consist of the first line only. The integration stations will be specified in the triangle planes, and not along local coordinate axes. The value specified for N1 is **not** the number of integration stations but a reference number to specified distributions of integration stations, which may have the same number of integration stations, but different positions in the triangle planes. Therefore, N3 has no meaning for this element type. Legal values for N1 are 1, 2, 3, 4, 5, 6, 7, 8, 9, see description of subroutine HAMC30 in the finite element library, /2/. N2 ("ζ-direction") is not possible to specify and the value 2 is used for each layer. The integration in ζ-direction will be performed analytically if max deviation from mean thickness is 5% and the element is nearly flat.

Stiffness matrix: Default value for N1 is 7.

Load calculations: Default value for N1 is 6 for surface loads.

Initial strain: Default value for N1 is 6.

Mass matrix: N1 should be specified ^{3} 7 to ensure positive definite mass matrix. Default value is N1=7.

GELSTRP The stress points must be distributed according to the same scheme as the integration points in the GELINT specification, for stress point coordinates in the triangular plane. The stress point coordinates in the ζ-direction are distributed according to the usual Gaussian integration scheme STRPTYP=1. Legal values for N1 are 1, 3, 4, 7, 9, and for N2 2, 3, 4.
Default values for N1 is 3 and for N2 ("z-direction") the default value is 2.
Only the first record of the GELSTRP specification is used for this element type.

BELLO2 The SIDE-definition is not used.

ELTYP=28: Subparametric Curved Quadrilateral Shell (SCQS), /2/

SCQS(28)

- 8 nodes
- 8 x 6 degrees of freedom
- curved element shape
- isotropic or anisotropic material data
- deformations considered:
  bending, shear and translational strain
- parabolically varying element thickness
- element loads:
  - initial strain
  - surface forces
  - line loads
  - line moment load
  - gravitational load
  - general inertia load

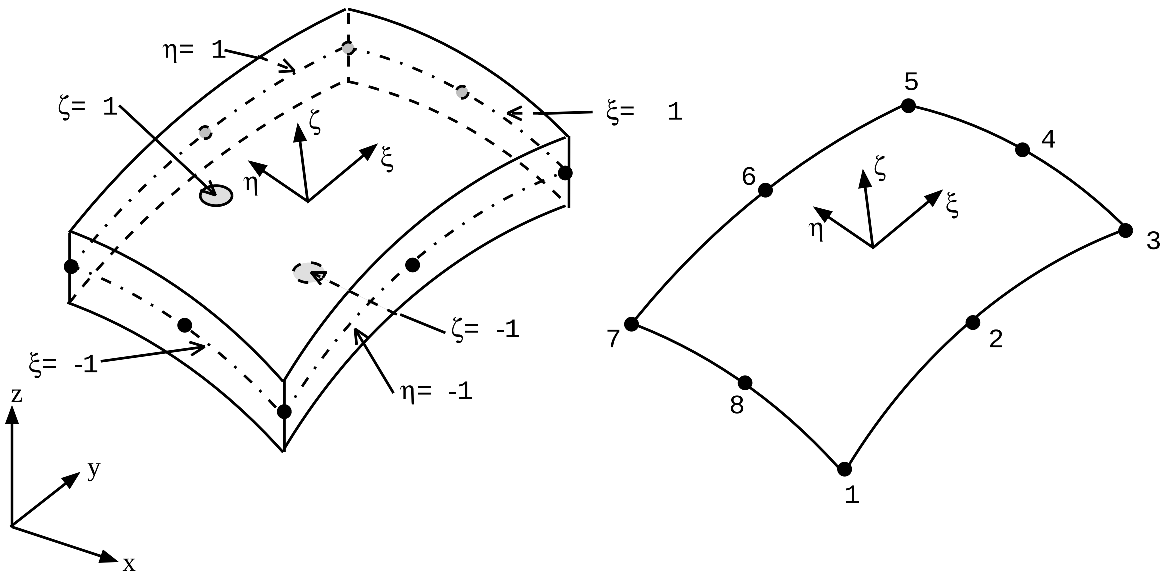


Figure 5-27 Element node numbering. Global Cartesian and local normalized coordinate system.

When line load is specified, the relation between local node numbers and loaded line will go:

SCQS(28)

LINE=1	means line load along the line defined by the nodes 3, 4 and 5
LINE=2	means line load along the line defined by the nodes 2 and 6
LINE=3	means line load along the line defined by the nodes 1, 8 and 7
LINE=4	means line load along the line defined by the nodes 7, 6 and 5
LINE=5	means line load along the line defined by the nodes 8 and 4
LINE=6	means line load along the line defined by the nodes 1, 2 and 3

The orientation of the local nodal coordinate system is related to the nodenumbering sequence (see Figure 5-27). The positive ζ-direction, normal to the element middlesurface, is chosen according to the normal convention of the right hand rule, i.e. the positive ζ-direction is found when the node numbers are followed in ascending order.

The SIDE definition on the BEUSLO records is as follows:

SIDE=1	means that load is given on the element surface where ζ= -1,
SIDE=2	that ζ= 0 is loaded, and
SIDE=3	that ζ= 1 is loaded.

Data types for this element:

GELMNT1	*
GNODE	*
GCOORD	*
GELREF1	*
GELINT	
GELTH	*
GELSTRP	
MISOSEL	* or
MISOPL	* or
MORSSEL	*
MTRSEL	
BEUSLO	
BELLO2	
BEISTE	
BGRAV	
BNACCLO	

*) Mandatory

SCQS(28)

The following restrictions are put on the data types.

GELINT The integration stations must be distributed according to the Gaussian integration scheme, i.e. INTYPE=1. For this element type only the first line of the GELINT specifications is used. N3 ("ζ-direction") is not possible to specify and the value 2 is used. The integration in ζ-direction will be performed analytically if max deviation from mean thickness is 5% and the element is nearly flat.

Stiffness matrix: Legal values for N1 and N2 are 2 and 3.
Default value is 2 for both.

Load calculations: Legal values for N1 and N2 are 2, 3 and 4.
Default value is 2 for both.

Initial strain: Legal values for N1 and N2 are 2 and 3.
Default value is 2 for both.

Mass matrix: Legal values for N1 and N2 are 1, 2, 3 and 4. To ensure positive definite mass matrix N1=N2=4 is recommended.
Default value is N1=N2=4.

GELSTRP The stress points must be distributed according to the Gaussian integration scheme, i.e. STRPTYP=1. The only legal value for N1 and N2 is 2. N3 may be 2, 3 or 4. This gives 4*N3 stress points within each element.

BELLO2 The SIDE-definition is not used.

ELTYP=29: Subparametric Multilayered Curved Quadrilateral Shell (MCQS), for Ref. See SCQS /2/

MCQS(29)

- 8 nodes
- 8 x 6 degrees of freedom
- curved element shape
- isotropic or anisotropic material data
- two or more material layers (sandwich)
- deformations considered:
  bending, shear and translational strain
- parabolically varying element thickness
- element loads:
  - initial strain
  - surface forces
  - line loads
  - line moment load
  - gravitational load
  - general inertia load

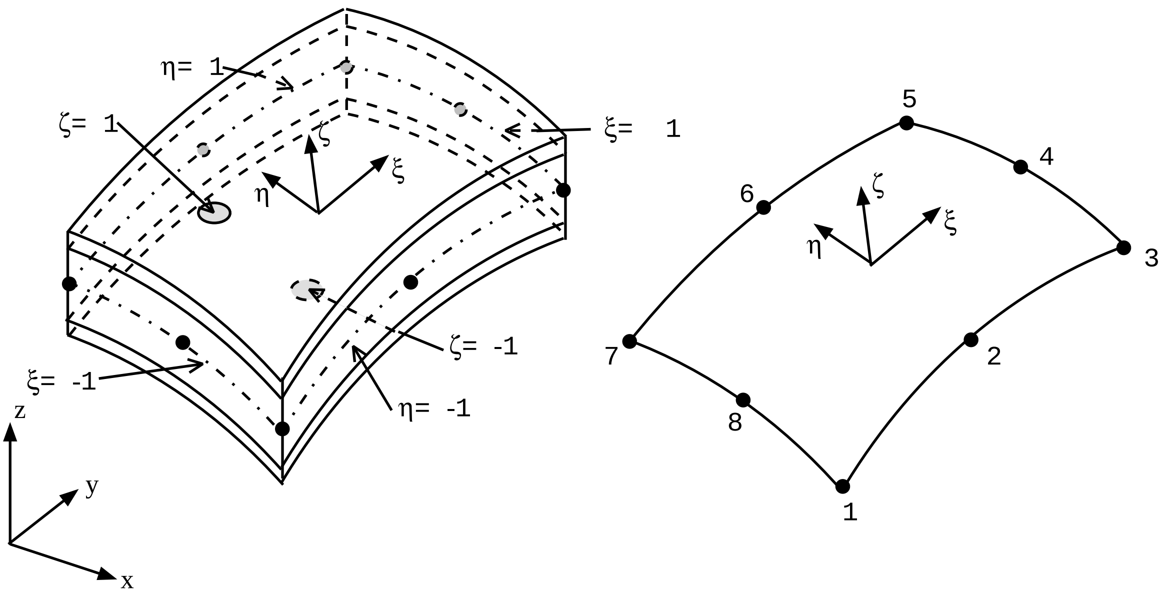


Figure 5-28 Element node numbering. Global Cartesian and local normalized coordinate system. Three layers.

When line load is specified, the relation between local node numbers and loaded line will go:

MCQS(29)

LINE=1	means line load along the line defined by the nodes 3, 4 and 5
LINE=2	means line load along the line defined by the nodes 2 and 6
LINE=3	means line load along the line defined by the nodes 1, 8 and 7
LINE=4	means line load along the line defined by the nodes 7, 6 and 5
LINE=5	means line load along the line defined by the nodes 8 and 4
LINE=6	means line load along the line defined by the nodes 1, 2 and 3

The orientation of the local nodal coordinate system is related to the nodenumbering sequence (see Figure 5-28). The positive ζ-direction, normal to the element middlesurface, is chosen according to the normal convention of the right hand rule, i.e. the positive ζ-direction is found when the node numbers are followed in ascending order, counterclockwise.

The SIDE definition on the BEUSLO records is as follows:

SIDE=1	means that load is given on the element surface where $\zeta = -1$,
SIDE=2	that $\zeta = 0$ is loaded, and
SIDE=3	that $\zeta = 1$ is loaded.

Data types for this element:

GELMNT1	*
GNODE	*
GCOORD	*
GELREF1	*
GELINT	
GELTH	*
GELSTRP	
MORSSEL	*
MTRSEL	
BEUSLO	
BELLO2	
BEISTE	
BGRAV	
BNACCLO	

*) Mandatory

MCQS(29)

The following restrictions are put on the data types.

GELINT The integration stations must be distributed according to the Gaussian integration scheme, i.e. INTYPE=1. For this element type only the first line of the GELINT specifications is used. N3 ("ζ-direction") is not possible to specify and the value 2 is used for each layer. The integration in ζ-direction will be performed analytically if max deviation from mean thickness is 5% and the element is nearly flat.

Stiffness matrix: Legal values for N1 and N2 are 2 and 3.
Default value is 2 for both.

Load calculations: Legal values for N1 and N2 are 2, 3 and 4.
Default value is 2 for both.

Initial strain: Legal values for N1 and N2 are 2 and 3.
Default value is 2 for both.

Mass matrix: Legal values for N1 and N2 are 1, 2, 3 and 4. To ensure positive definite mass matrix N1=N2=4 is recommended.
Default value is N1=N2=4.

GELSTRP The stress points must be distributed according to the Gaussian integration scheme, i.e. STRPTYP=1. The only legal value for N1 and N2 is 2. N3 may be 2, 3 or 4. This gives 4*N3 stress points within each layer of the element.

BELLO2 The SIDE-definition is not used.

ELTYP=30: Isoparametric Prism (IPRI) /2/

IPRI(30)

- 15 nodes
- 15 x 3 degrees of freedom
- curved element sides
- isotropic or anisotropic material data
- deformations considered: translational strain
- element loads:
  - initial strain (temperature load)
  - surface forces
  - line forces
  - gravitational load
  - general inertia load

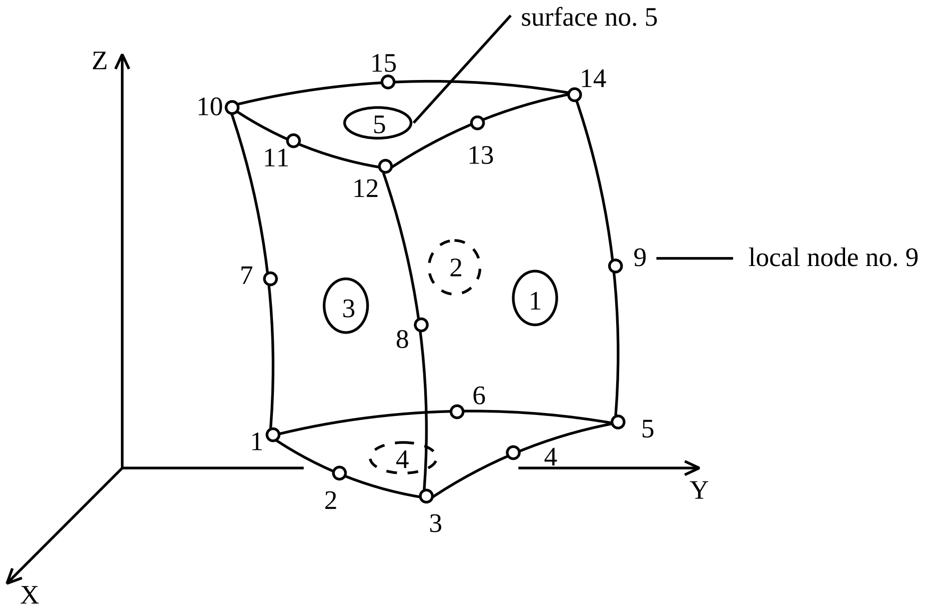


Figure 5-29 Isoparametric triangular prism with local nodenumbering and corresponding surface numbering.

IPRI(30)

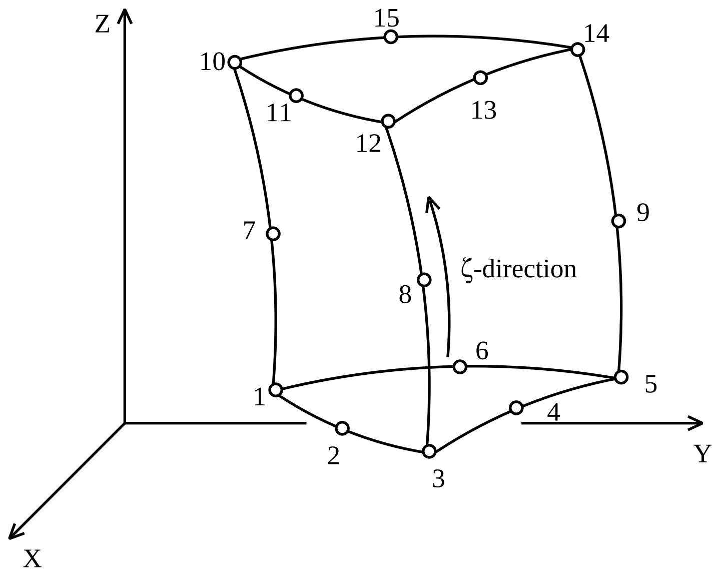


Figure 5-30 Typical isoparametric triangular prism with local node numbering

When surface loads are specified for an element side, the surface numbers shown are used for identification of the surface in question.

The local nodenumbering for each side is defined as follows:

	Node number							
Side no.	1	2	3	4	5	6	7	8
1	3	4	5	9	14	13	12	8
2	5	6	1	7	10	15	14	9
3	1	2	3	8	12	11	10	7
4	1	2	3	4	5	6		
5	14	13	12	11	10	15		

IPRI(30)

When line load is specified, the relation between the local node numbers and the loaded line will be as follows:

Line no.	Node number 1	2	3
1	1	2	3
2	3	4	5
3	5	6	1
4	1	7	10
5	3	8	12
6	5	9	14
7	10	11	12
8	12	13	14
9	14	15	10
10	7	8	
11	2	11	
12	8	9	
13	4	13	
14	9	7	
15	6	15	

Data types used for this element:

GELMNT1 *
GNODE *
GCOORD *
GELREF1 *
GELINT
GELSTRP
MISOSEL * or
MORSSOL *
MTRSOL
BEUSLO
BELLO2
BEISTE
BGRAV
BNACCLO

*) Mandatory

IPRI(30)

The following restrictions are put on the data type.

GELINT — The integration stations must be distributed according to the Gaussian integration scheme, i.e. INTYPE=1. For this element type the GELINT specifications consist of the two first lines. For the triangle plane the integration stations will be distributed according to the usual Gaussian integration scheme. N1 will be employed for the specification of number of integration stations in the triangular plane; N2 for the number of integration stations in the ζ-direction. N3 will be employed for the specification of number of integration stations in the direction perpendicular to the ζ-direction in the four edged surfaces, used in the calculation of surfaces, used in the calculation of surface loads.

Stiffness matrix: Legal values for N1 are 3, 4 and 7, and for N2 legal values are 2, 3 and 4. Default values are N1=7 and N2=3. N3 is not used in this case.

Load calculations: For surface loads N3 will be employed as described above. Legal values for N3 are 1, 2, 3 and 4. Default value is N3=3. For surface loads legal values for N1 are 3, 4 and 7, and for N2 2, 3 and 4. Default values are N1=7 and N2=3.

Initial strain: Only N2 is used in this case. Legal values for N2 are 1, 2, 3 and 4. Default value is N2=3.

Mass matrix: Only N2 is used in this case. Legal values for N2 are 3 and 4. Default value is N2=3.

GELSTRP — The stress points must be distributed according to the same scheme as the integration points in the GELINT specification, i.e. STRPTYP=1. Legal values for N1 are 1, 4 and 7 and for N2 1, 2 and 3. Default values are N1=4 and N2=2. Only the first record of the GELSTRP specification is used for this element type.

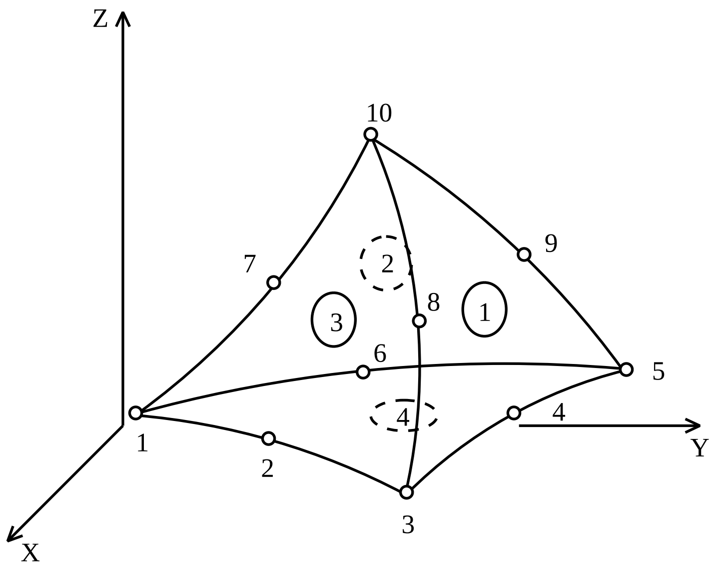
BEUSLO — A element side may only be loaded once for each BEUSLO-record.

BELLO2 — The SIDE definition is not used. The load components are given nodewise in global coordinates.

ELTYP=31: Isoparametric Tetrahedron (ITET) /2/

ITET(31)

- 10 nodes
- 10 x 3 degrees of freedom
- curved element sides
- isotropic or anisotropic material data
- deformations considered: translational strain
- element loads:
  - initial strain (temperature load)
  - surface forces
  - line forces
  - gravitational load
  - general inertia load



In surface No. 1 we have L_1=0 and so on for surface No. 2, 3 and 4. See "volume coordinates" in /3/

Figure 5-31 Isoparametric tetrahedron with local nodenumbering and corresponding surface numbering.

ITET(31)

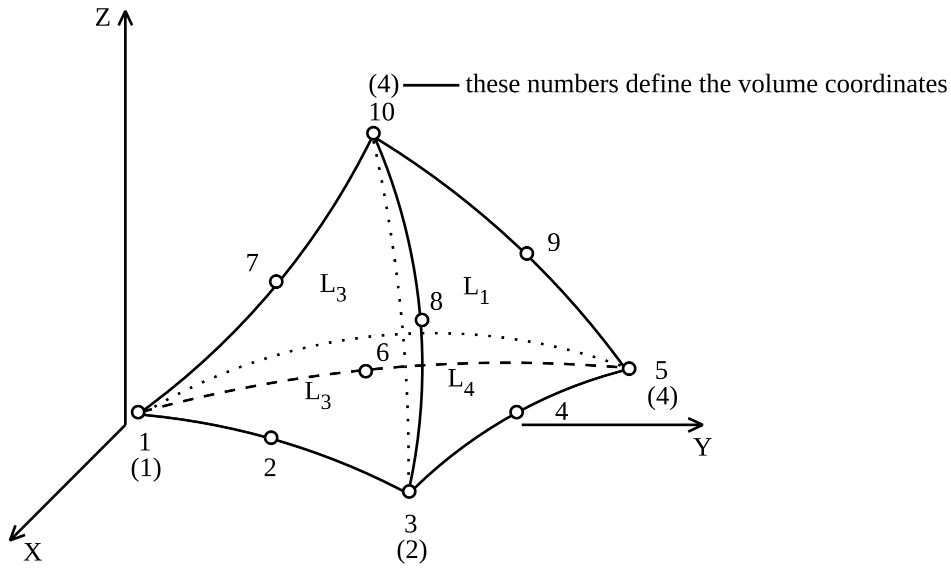


Figure 5-32 Typical isoparametric tetrahedron with node numbering and numbers defining the volume coordinates L_1, L_2, L_3, L_4.

When surface loads are specified for an element side, the surface numbers shown are used for identification of the side in question.

The local nodenumbering for each side is defined as follows:

	Node number					
	1	2	3	4	5	6
Side no.						
1	3	4	5	9	10	8
2	5	6	1	7	10	9
3	1	2	3	8	10	7
4	1	6	5	4	3	2

ITET(31)

When line load is specified, the relation between local node numbers and loaded line will be as follows:

Line no.	Node number 1	2	3
1	1	2	3
2	3	4	5
3	5	6	1
4	1	7	10
5	3	8	10
6	5	9	10

Data types for this element:

GELMNT1 *
GNODE *
GCOORD *
GELREF1 *
GELINT
GELSTRP
MISOSEL * or
MORSSOL *
MTRSOL
BEUSLO
BEISTE
BGRAV
BNACCLO

*) Mandatory

ITET(31)

The following restrictions are put on the data types:

GELINT The integration stations must be distributed according to a scheme similar to the Gaussian integration scheme, i.e. INTYPE=1. Only the first record of the GELINT specification is used for these element types. The number of integration stations specified for N1 covers the whole volume of the tetrahedron. N2 will be used to specify the number of integration points in the triangular surfaces. The specification of integration points in the triangular surfaces is used in surface load calculations.

N1 must always be specified equal to 5.

Load calculations: Legal values for N2 are 1, 2, 3, 4 and 7. Default value is 4.

GELSTRP The stress points must be distributed according to the same scheme as the integration points in the GELINT specification, i.e. STRPTYP=1. Legal values for N1 are 1, 4 and 5. Default value is 4.

BELLO2 The SIDE-definition is not used. The load components are given nodewise in global coordinates.

ELTYP=32: Triangular Prism (TPRI), /2/

TPRI(32)

- 6 nodes
- 6 x 3 degrees of freedom
- linear element sides
- isotropic or anisotropic material data
- deformation considered: translational displacement
- element loads
  - initial strain (temperature loads)
  - volume forces
  - surface forces
  - line forces
  - gravitational load
  - general acceleration load

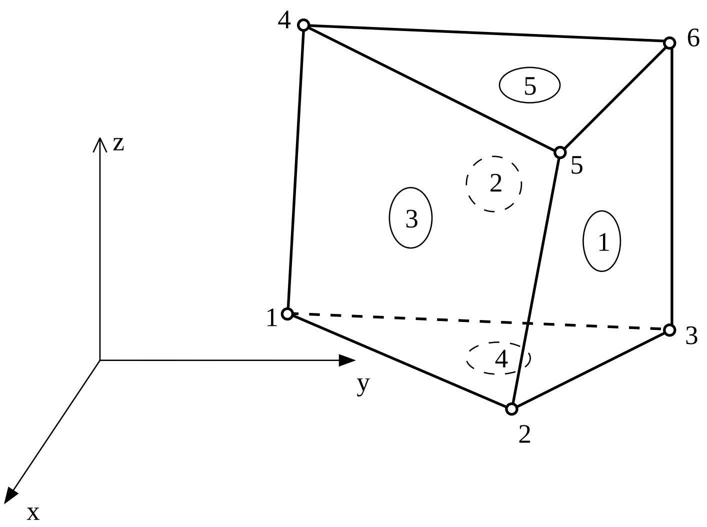


Figure 5-33 Triangular prism solid element with local nodenumbering and corresponding surface numbering.

TPRI(32)

When surface loads are specified for an element side, the surface numbers shown are used for identification of the surface in question.
The local nodenumbering for each side is defined as follows:

	Node number			
	1	2	3	4
Side no.				
1	2	3	6	5
2	3	1	4	6
3	1	2	5	4
4	1	2	3	0
5	6	5	4	0

When line load is specified, the relation between the local node numbers and the loaded line will be as follows:

	Node number	
	1	2
Line no.		
1	1	2
2	2	3
3	3	1
4	1	4
5	2	5
6	3	6
7	4	5
8	5	6
9	6	4

Data types used for this element:

GELMNT1 *
GNODE *
GCOORD *
GELREF1 *
MISOSEL * or
MORSSOL *
MTRSOL
BELLO2
BEUSLO
BEISTE
BGRAV
BNACCLO

*) Mandatory

TPRI(32)

The following restrictions are put on data type:

GELINT The integration stations must be distributed according to the Gaussian integration sceme, i.e. INTYPE=1. For this element type the GELINT specifications consist of only the first line. For the triangular plane the integration stations will be specified in the plane and not along local coordinate axis. In the z-direction, integration stations will be distributed according to the usual Gaussian integration shceme. N1 will be used for specification of number of integration points in the triangular plane, N2 for the number of integration stations in the z-direction.

Stiffness matrix calculation: Legal values for N1 are 3, 4 and 7, for N2, 2, 3 and 4. Default values are N1=4 and N2=3.

Load calculation: For surface loads N1 will not be used. Number of integration stations in z-direction is given by N2 as before. Legal values of N2 are 2, 3 and 4, with 3 as default. Number of integration stations normal to the z-direction is set equal to one less than N2. This gives a default value equal to 2, and with legal values 1, 2 and 3.

Initial strain: Legal values for N1 are 3, 4 and 7, and for N2, 2, 3 and 4. Default values are N1=4 and N2=3.

Mass matrix calculations: The only legal values for N1 and N2 are N1=4 and N2=3.

GELSTRP The stress points must be distributed according to the Gaussian integration scheme, i.e. STRPTYP=1. Number of stress points in the triangular planes is given by N1. Legal values are 1, 3 and 4. The default value of N1 is 1. Number of stress points in the z-direction is specified by N2. The only legal value of N2 is 2.

BEUSLO An element side may only be loaded once for each BEUSLO-record.

BELLO2 The SIDE definition is not used. The load components are given nodewise in global coordinates.

ELTYP=33: Tetrahedron (TETR), /2/

TETR(33)

- 4 nodes
- 4 x 3 degrees of freedom
- linear element sides
- isotropic or anisotropic material data
- deformation considered: translational displacement
- element loads
  - initial strain (temperature loads)
  - volume forces
  - surface forces
  - line forces
  - gravitational load
  - general inertia load

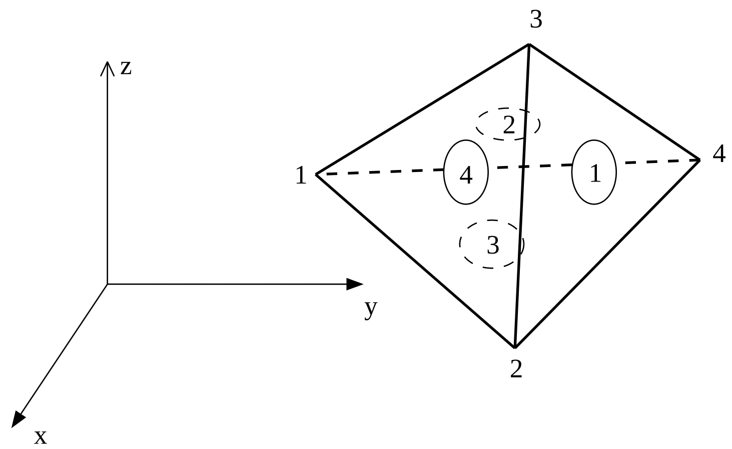


Figure 5-34 Tetrahedron solid element with local node numberieng and corresponding surface numbering.

TETR(33)

When surface loads are specified for an element side, the surface numbers shown are used for identification of the surface in question. The local nodenumbering for each side is defined as follows:

	Node number		
	1	2	3
Side no			
1	3	2	4
2	1	3	4
3	2	1	4
4	1	2	3

When line load is specified, the relation between the local node numbers and the loaded line will be as follows:

	Node number	
	1	2
Line no.		
1	1	2
2	2	3
3	3	1
4	1	4
5	2	4
6	3	4

Data types used for this element:

GELMNT1 *
GNODE *
GCOORD *
GELREF1 *
MISOSEL * or
MORSSOL *
BEUSLO
BEEO2
BEISTE
BGRAV
BNACCLO

*) Mandatory

TETR(33)

The following restrictions are put on data type:

GELINT Only the default values for number of integration points are used. This means that if GELINT is given, N1 must be specified equal to the default value for the calculation type in question:

Stiffness matrix: The centroid of the element is used as the only calculation point.

Load calculation: Constant volume force is only calculated in the centroid of the element. Surface forces in arbitrary direction are calculated in three points on the loaded side, and constant normal pressure is calculated in the midpoint on the loaded side.

Initial strain: The centroid of the element is used as the only calculation point.

Mass matrix: Four integration points are used. These are distributed according to the Gaussian integration scheme.

GELSTRIP Stresses are only calculated in the centroid of the element. If the GELSTRP specification is given, only the first record is used. This must be given with STRPTYP=1 and N1=1. N2 should not be specified.

BEUSLO Only one side can be loaded in each load case. This means that only one side identification can be given in SIDE. The element can only reproduce a constant strain situation. Variation in loads will cause a stress situation which the element is not able to reproduce. Therefore this element should only be used for constant loads, i.e. the load intensity should be the same for all the nodes on the loaded side.

BELLO2 The SIDE definition is not used. The load components are given nodewise in global coordinates.

ELTYP=34: Subparametric Layered Curved Triangular Shell (LCTS), for Ref. See SCTS /2/

LCTS(34)

- 6 nodes
- 6 x 6 degrees of freedom
- curved element shape
- isotropic or anisotropic material data (anisotropic only, in ’plate layers’)
- one or more material layers
- the layers may be eccentric plate layers and / or eccentric stiffener layers with bar stiffeners in one arbitrary direction. Each layer may have different stiffener direction
- deformations considered:
  bending, shear and translational strain
- constant element thickness
- element loads:
  - initial strain
  - surface forces
  - line loads
  - line moment load
  - gravitational load
  - general inertia load

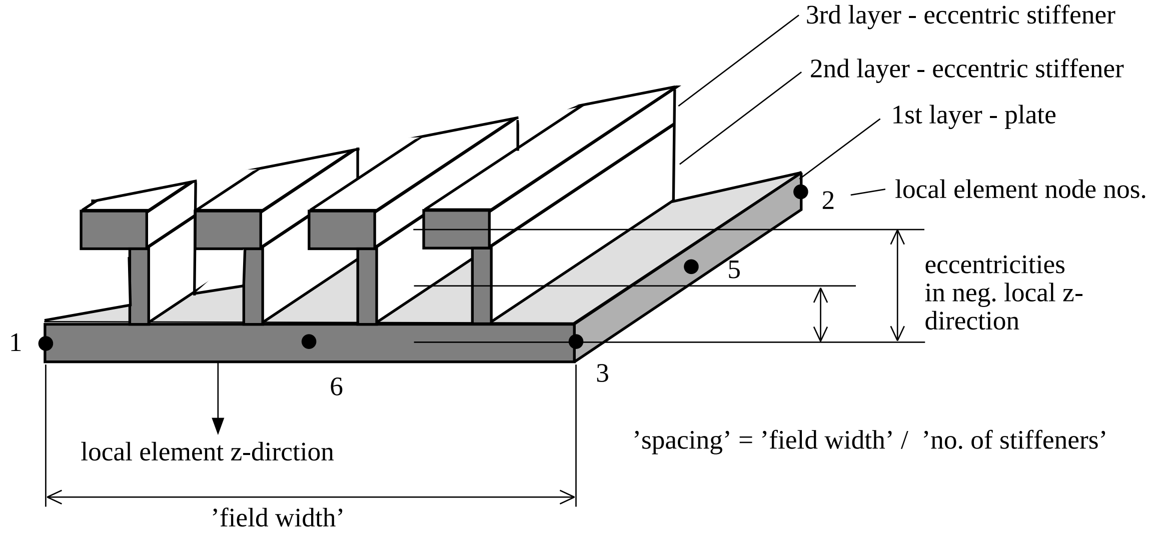


Figure 5-35 Element local node numbering. Three layers - one plate layer and two stiffener layers.

The stiffeners are transformed to layers with no stiffness in the direction lateral to the stiffener direction, and smeared stiffness in the stiffener direction. The direction defining the local element coordinate axes (local x-,

LCTS(34)

y- and z-axes) are specified on a BNTRCOS record for this element. Only the x-direction (first line) in the direction cosine matrix defined on the BNTRCOS record is used.

The projection of this vector onto the middle of the element surface defines the local x-axis in different points on the element. The positive local z-direction, normal to the element middlesurface, is chosen according to the normal convention of the right hand rule, i.e. the positive z-direction is found when the local element node numbers are followed in ascending order. The BNTRCOS record is referred on the GELREF1 record.

The material may be general anisotropic in the plate layer(s) of the element, but if stiffener layers are specified, they must have isotropic material. For anisotropic materials, each layer must have a separate anisotropic material specification (MORSSEL record).

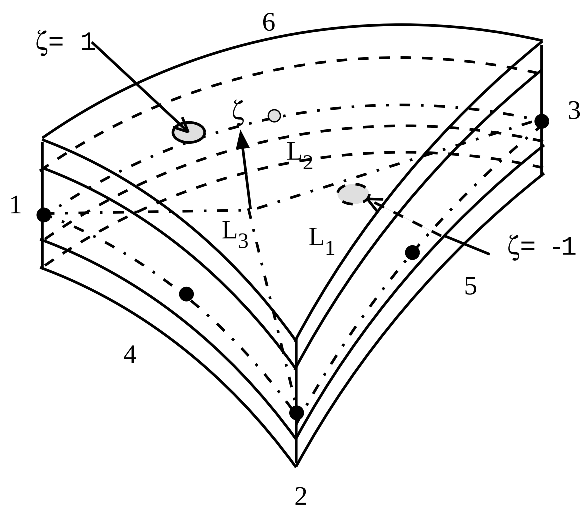


Figure 5-36 Element local node numbering and local normalised coordinate system.

When line load is specified, the relation between local node numbers and loaded line will go:

LINE=1	means line load on the element side defined by nodes 2, 5 and 3
LINE=2	means line load on the element side defined by nodes 1, 6 and 3
LINE=3	means line load on the element side defined by nodes 1, 4 and 2

LCTS(34)

The orientation of the local normalised coordinate system is related to the local node numbering sequence (see Figure 5-36). The positive ζ-direction, normal to the element middlesurface, is chosen according to the normal convention of the right hand rule, i.e. the positive ζ-direction is found when the node numbers are followed in ascending order.

The SIDE definition on the BEUSLO records is as follows:

SIDE=1	means that load is given on the element surface where ζ= -1,
SIDE=2	that ζ= 0 is loaded, and
SIDE=3	that ζ= 1 is loaded.

LCTS(34)

Data types for this element:

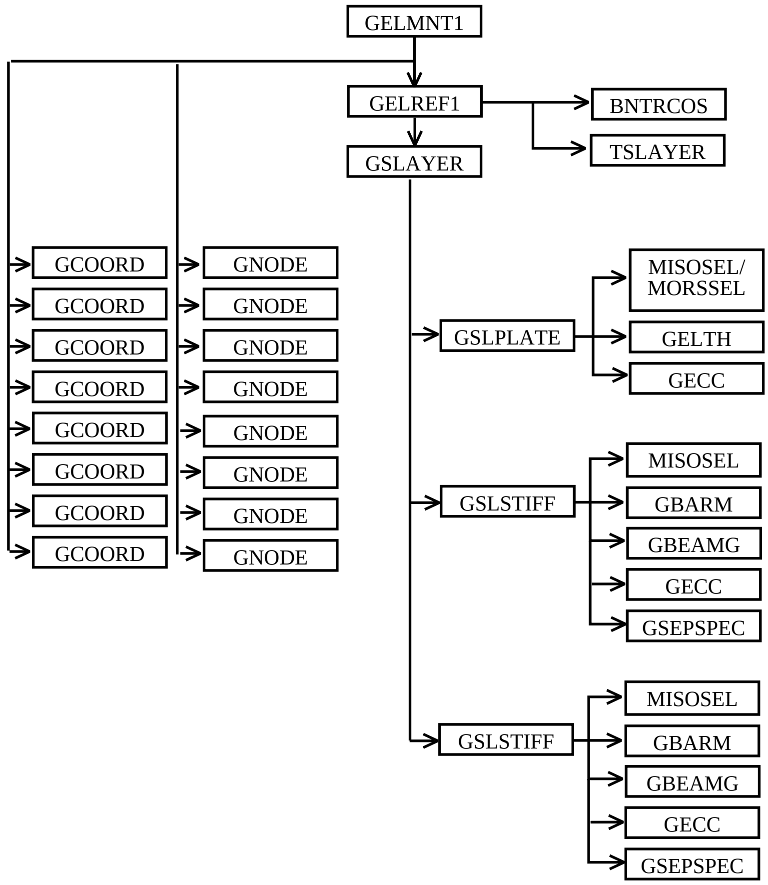


Figure 5-37 Normal data reference for a Subparametric Layered Curved Triangular Thin / Thick Shell . The layered element in the figure is having three layers, one plate layer and two eccentric stiffener layers.

GELMNT1	GELSTRP	BEUSLO
GNODE	GELTH	BELLO2
GCOORD	GSLAYER	BEISTE
GBARM	GSLPLATE	BGRAV
GBEAMG	GSLSTIFF	BNACCLO
GECC	GSEPSPEC	TSLAYER
GELREF1	MISOSEL	
GELINT	MORSSEL	

LCTS(34)

The following restrictions are put on the data types.

GELINT The integration stations must be distributed according to a scheme similar to the Gaussian integration scheme, i.e. INTYPE=1. For this element type the GELINT specifications consist of the first line only. The integration stations will be specified in the triangle planes, and not along local coordinate axes. The value specified for N1 is **not** the number of integration stations but a reference number to specified distributions of integration stations, which may have the same number of integration stations, but different positions in the triangle planes. Therefore, N3 has no meaning for this element type. Legal values for N1 are 1, 2, 3, 4, 5, 6, 7, 8, 9, see description of subroutine HAMC30 in the finite element library, /2/. N2 ("ζ-direction") is not possible to specify and the value 2 is used for each layer. The integration in ζ-direction will be performed analytically if max deviation from mean thickness is 5% and the element is nearly flat.

Stiffness matrix: Default value for N1 is 7.

Load calculations: Default value for N1 is 6 for surface loads.

Initial strain: Default value for N1 is 6.

Mass matrix: N1 should be specified ³ 7 to ensure positive definite mass matrix. Default value is N1=7.

GELSTRP The stress points must be distributed according to the same scheme as the integration points in the GELINT specification, for stress point coordinates in the triangular plane. The stress point coordinates in the ζ-direction are distributed according to the usual Gaussian integration scheme STRPTYP=1. Legal values for N1 are 1, 3, 4, 7, 9, and for N2 2, 3, 4.
Default values for N1 is 3 and for N2 ("z-direction") the default value is 2.
Only the first record of the GELSTRP specification is used for this element type.

BELLO2 The SIDE-definition is not used.

ELTYP=35: Subparametric Layered Curved Quadrilateral Shell (LCQS), for Ref. See SCQS /2/

LCQS(35)

- 8 nodes
- 8 x 6 degrees of freedom
- curved element shape
- isotropic or anisotropic material data (anisotropic only, in ’plate layers’)
- one or more material layers
- the layers may be eccentric plate layers and / or eccentric stiffener layers with bar stiffeners in one arbitrary direction. Each layer may have different stiffener direction
- deformations considered:
  bending, shear and translational strain
- constant element thickness
- element loads:
  - initial strain
  - surface forces
  - line loads
  - line moment load
  - gravitational load
  - general inertia load

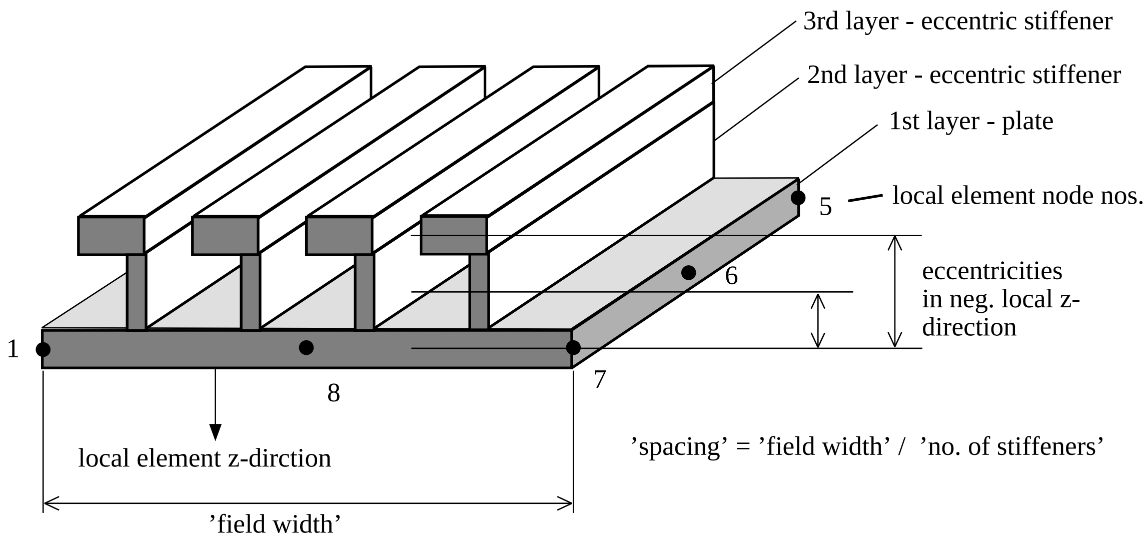


Figure 5-38 Element local node numbering. Three layers - one plate layer and two stiffener layers.

The stiffeners are transformed to layers with no stiffness in the direction lateral to the stiffener direction, and smeared stiffness in the stiffener direction. The direction defining the local element coordinate axes (local x-, y- and z-axes) are specified on a BNTRCOS record for this element. Only the x-direction (first line) in the direction cosine matrix defined on the BNTRCOS record is used.

LCQS(35)

The projection of this vector onto the middle of the element surface defines the local x-axis in different points on the element. The positive local z-direction, normal to the element middlesurface, is chosen according to the normal convention of the right hand rule, i.e. the positive z-direction is found when the local element node numbers are followed in ascending order. The BNTRCOS record is referred on the GELREF1 record.

The material may be general anisotropic in the plate layer(s) of the element, but if stiffener layers are specified, they must have isotropic material. For anisotropic materials, each layer must have a separate anisotropic material specification (MORSSEL record).

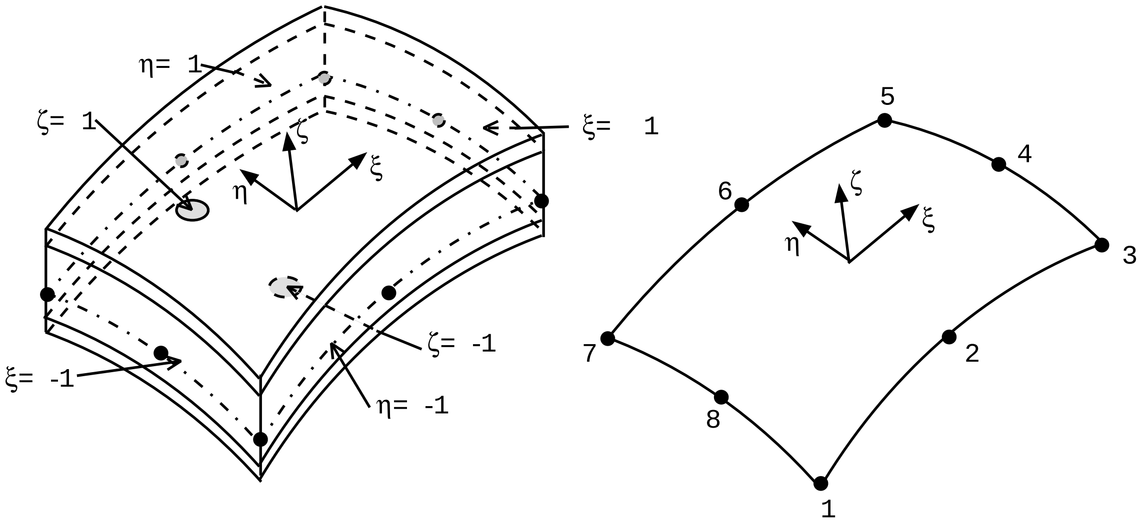


Figure 5-39 Element local node numbering and local normalised coordinate system.

When line load is specified, the relation between local node numbers and loaded line will go:

LINE=1	means line load along the line defined by the nodes 3, 4 and 5
LINE=2	means line load along the line defined by the nodes 2 and 6
LINE=3	means line load along the line defined by the nodes 1, 8 and 7
LINE=4	means line load along the line defined by the nodes 7, 6 and 5
LINE=5	means line load along the line defined by the nodes 8 and 4
LINE=6	means line load along the line defined by the nodes 1, 2 and 3

LCQS(35)

The orientation of the local normalised coordinate system is related to the local node numbering sequence (see Figure 5-39). The positive ζ-direction, normal to the element middlesurface, is chosen according to the normal convention of the right hand rule, i.e. the positive ζ-direction is found when the node numbers are followed in ascending order.

The SIDE definition on the BEUSLO records is as follows:

SIDE=1 means that load is given on the element surface where $\zeta = -1$,
SIDE=2 that $\zeta = 0$ is loaded, and
SIDE=3 that $\zeta = 1$ is loaded.

LCQS(35)

Data types for this element:

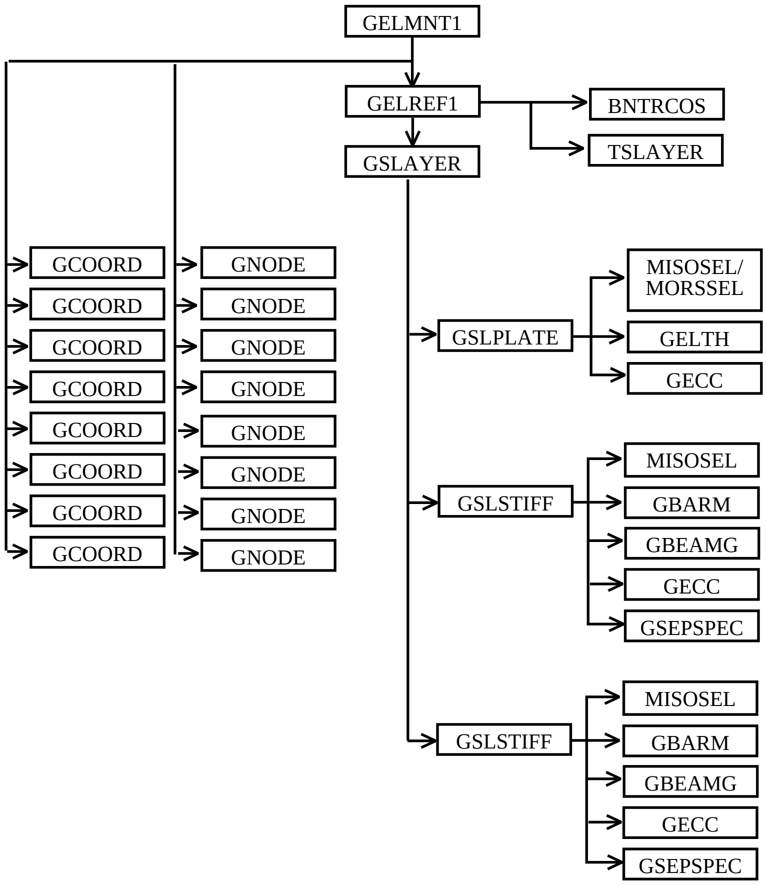


Figure 5-40 Normal data reference for a Subparametric Layered Curved Quadrilateral Thin / Thick Shell . The layered element in the figure is having three layers, one plate layer and two eccentric stiffener layers.

GELMNT1	GELSTRP	BEUSLO
GNODE	GELTH	BELLO2
GCOORD	GSLAYER	BEISTE
GBARM	GSLPLATE	BGRAV
GBEAMG	GSLSTIFF	BNACCLO
GECC	GSEPSPEC	TSLAYER
GELREF1	MISOSEL	
GELINT	MORSSEL	

LCQS(35)

The following restrictions are put on the data types.

GELINT The integration stations must be distributed according to the Gaussian integration scheme, i.e. INTYPE=1. For this element type only the first line of the GELINT specifications is used. N3 ("ζ-direction") is not possible to specify and the value 2 is used for each layer. The integration in ζ-direction will be performed analytically if max deviation from mean thickness is 5% and the element is nearly flat.

Stiffness matrix: Legal values for N1 and N2 are 2 and 3.
Default value is 2 for both.

Load calculations: Legal values for N1 and N2 are 2, 3 and 4.
Default value is 2 for both.

Initial strain: Legal values for N1 and N2 are 2 and 3.
Default value is 2 for both.

Mass matrix: Legal values for N1 and N2 are 1, 2, 3 and 4. To ensure positive definite mass matrix N1=N2=4 is recommended.
Default value is N1=N2=4.

GELSTRP The stress points must be distributed according to the Gaussian integration scheme, i.e. STRPTYP=1. The only legal value for N1 and N2 is 2. N3 may be 2, 3 or 4. This gives 4*N3 stress points within each layer of the element.

BELLO2 The SIDE-definition is not used.

ELTYP=36, 37 or 38: Transition Elements between Solids and Shells (TRSI), /6/

TRSI(36, 37, 38)

- 18, 15 or 12 nodes
- 57, 54 or 51 degrees of freedom
- curved or linear element sides
- parabolically varying element thickness (in relevant nodes of ELTYP=37 and 38 only)
- isotropic or anisotropic material data
- deformations considered: translational strain
- element loads:
    - initial strain (temperature loads)
    - surface forces
    - line forces
    - gravitational load
    - general inertia load

The TRSI elements are described in detail in /6/

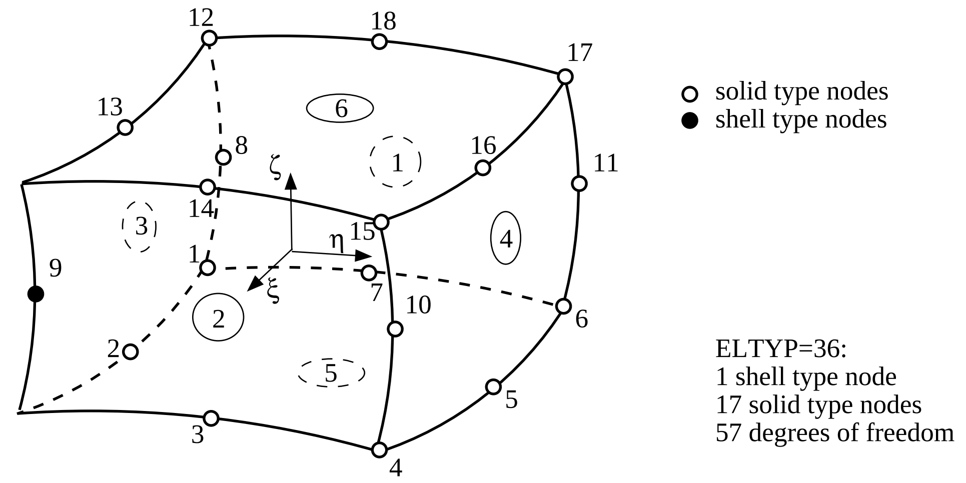
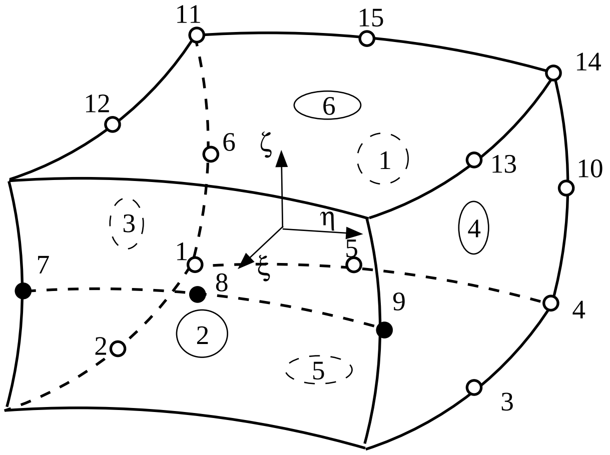


Figure 5-41 Local node numbering and corresponding surface numbering for transition element with one "shell type node", the "shell type node" is node number 9.

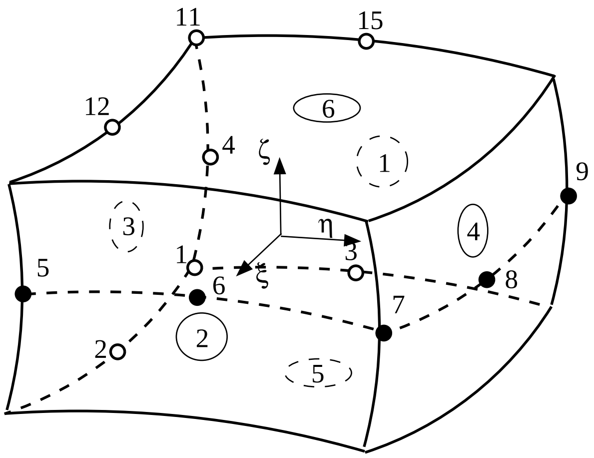
TRSI(36, 37, 38)



solid type nodes
shell type nodes

ELTYP=37:
3 shell type node
12 solid type nodes
54 degrees of freedom

Figure 5-42 Local node numbering and corresponding surface numbering for transition element with three "shell type nodes", the "shell type nodes" is node number 7, 8 and 9.



solid type nodes
shell type nodes

ELTYP=38:
5 shell type node
7 solid type nodes
51 degrees of freedom

Figure 5-43 Local node numbering and corresponding surface numbering for transition element with five "shell type nodes", the "shell type nodes" are nodes number 5 through 9.

TRSI(36, 37, 38)

Loads on the element are specified as if given for an IHEX element (ELTYP=20) (the so-called originating IHEX element) with that element’s number of nodes, type of nodes (3 translational degrees of freedom) and sequence of nodes specifying the originating element. (see the tables and figures below for TRSI(36), TRSI(37) and TRSI(38)).
When surface load is specified for one element side, the load intensities are always given in eigth points on each side, regardless of this beeing a "solid side" or a "shell side". These points are the nodes on the "solid sides", and the points on the upper and lower element side corresponding to the nodes on the "shell sides". The points on the upper and lower shell element side is marked with the same number as the node in the ’shell middle plane’ with a ’ (prime) and " (double prime) to separate them from the ’real nodes’.

With correspondence to Figure 5-41, 5-42 and 5-43 the local node ("point") numbering of each side is defined as follows:

TRSI(36, 37, 38)

It should be noted that the points in the three tables and Figs. 5-41, 5-42 and 5-43 below are in the same topological positions on the sides, but the node (point) numbers are different, since number of 'real nodes' are different. The point numbers are sort of dummy numbers and only used to indicate the sequence of the load intensities to be specified.

TRSI(36)

	Local node ("point") number on side							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Side no.								
1	6	7	1	8	12	18	17	11
2	4	10	15	14	9"	9	9'	3
3	1	2	9'	9	9"	13	12	8
4	6	11	17	16	15	10	4	5
5	6	5	4	3	9'	2	1	7
6	17	18	12	13	9"	14	15	16

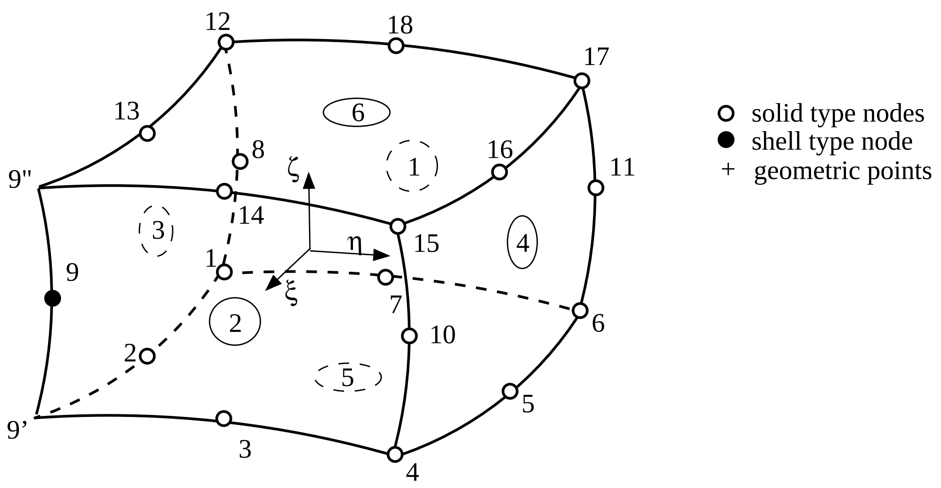


Figure 5-44 Numbering of nodes (points) where surface and line load values are specified for TRSI(36)-elements

TRSI(36, 37, 38)

TRSI(37)

	Local node ("point") number on side							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Side no.								
1	4	5	1	6	11	15	14	10
2	9’	9	9"	8"	7"	7	7’	8’
3	1	2	7’	7	7"	12	11	6
4	4	10	14	13	9"	9	9’	3
5	4	3	9’	8’	7’	2	1	5
6	14	15	11	12	7"	8"	9"	13

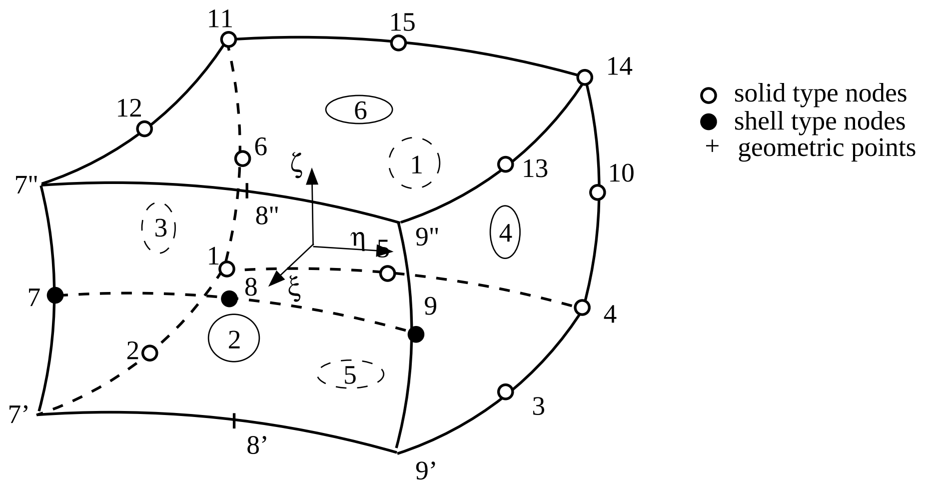


Figure 5-45 Numbering of nodes (points) where surface and line load values are specified for TRSI(37)-elements

TRSI(36, 37, 38)

TRSI(38)

	Local node ("point") number on side							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Side no.								
1	9’	3	1	4	10	12	9"	9
2	7’	7	7"	6"	5"	5	5’	6’
3	1	2	5’	5	5"	11	10	4
4	9’	9	9"	8"	7"	7	7’	8’
5	9’	8’	7’	6’	5’	2	1	3
6	9"	12	10	11	5"	6"	7"	8"

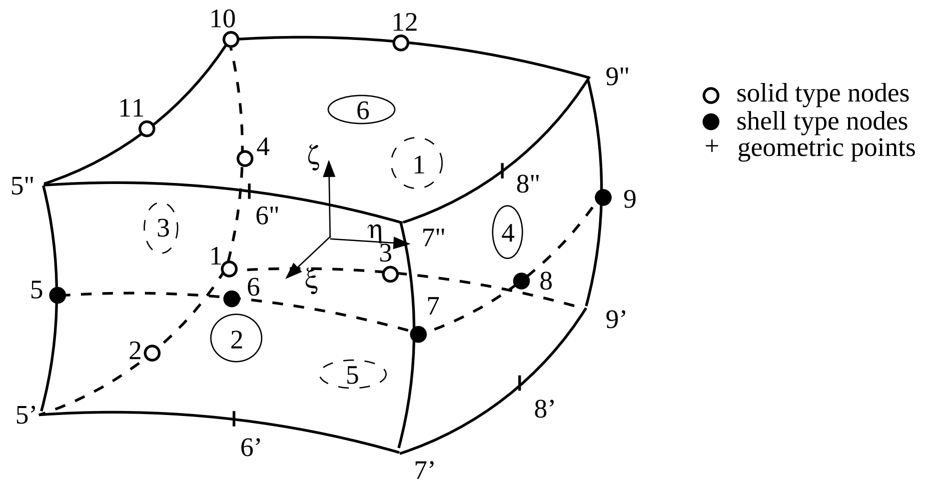


Figure 5-46 Numbering of nodes (points) where surface and line load values are specified for TRSI(37)-elements

TRSI(36, 37, 38)

Line loads are specified in the same manner as surface loads. The load intenisties are always given in points along lines as defined for the IHEX-element (the so-called originating IHEX element). In the table below the numbers without prime and double prime refer to the node numbers of the actual TRSI element. The the nmbers with prime or double prime refers to the geometrical point below or above the TRSI node. With reference to Figs. 5-41, 5-42 and 5-43 the local node (point) numbering for each line is defined as follows:

Local node ("point") number on line:

	TRSI(36)			**TRSI(37)**			**TRSI(38)**		
Line no.:	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
1	1	2	9’	1	2	7’	1	2	5’
2	9’	3	4	7’	8’	9’	5’	6’	7’
3	4	5	6	9’	3	4	7’	8’	9’
4	6	7	1	4	5	1	9’	3	1
5	1	8	12	1	6	11	1	4	10
6	9’	9	9"	7’	7	7"	5’	5	5"
7	4	10	15	9’	9	9"	7’	7	7"
8	6	11	17	4	10	14	9’	9	9"
9	12	13	9"	11	12	7"	10	11	5"
10	9"	14	15	7"	8"	9"	5"	6"	7"
11	15	16	17	9"	13	14	7"	8"	9"
12	17	18	12	14	15	11	9"	12	10
13	7	3		5	8’		3	6’	
14	5	2		3	2		8’	2	
15	8	9		6	7		4	5	
16	2	13		2	12		2	11	
17	9	7		7	9		5	7	
18	3	14		8’	8"		6’	6"	
19	10	11		9	10		7	9	
20	5	16		3	13		8’	8"	
21	11	8		10	6		9	4	
22	7	18		5	15		3	12	
23	18	14		15	8"		12	6"	
24	13	16		12	13		11	8"	

TRSI(36, 37, 38)

Data types used for this element:

GELMNT1 *
GNODE *
GCOORD *
GELREF1 *
GELTH *
GELINT
GELSTRP
MISOSEL * or
MISOPL * or
MORSSOL *
MTRSOL
BEUSLO
BELLO2
BEISTE
BGRAV
BNACCLO

*) Mandatory

TRSI(36, 37, 38)

Restrictions on modelling with transition elements:

The "shell type nodes" have no stiffness connected to the rotational degree of freedom perpendicular to the middle plane. In shell elements this is taken care of by inserting a small stiffness value to avoid a rectangular system. Hence the "shell type nodes" of the transition elements must always be coupled to a shell element in order to avoid a singular stiffness matrix.

Restrictions on data types:

GELREF1	Parameters INTNO, MINTNO, STRANO, STRENO and STREPONO all refer to data groups were the data are specified as if given for an IHEX element (ELTYP=20). The element thickness of the shell type node(s) must be referred to, either directly by GEONO/OPT or indirectly by GEONO(i) (with GEONO/OPT=-1). In the latter case the GEONO(i) for solid type numbers are of no consequence (set equal to zero).
GELINT GELSTRP BEUSLO BEISTE	The data is as if given for an IHEX element (ELTYP=20). When giving nodal values (intensities) they shall refer to a so-called originating IHEX element. See Figure 5-41 above.
GNODE	The values of NDOF and ODOF must be consistent with the type of node: solid type: NDOF=3, ODOF=123 shell type: NDOF=6, ODOF=123456

- 2 nodes
- degrees of freedom, arbitrary (max 12)
- stiffness matrix

Data types used for this element:

GELMNT1 *
GELREF1 *
MSHGLSP *
BNTRCOS

*) Mandatory

LTYP=40: General 2-Noded Spring / Shim Element (GLSH) GLSH(40)

- 2 nodes
- degrees of freedom, arbitrary
- general spring matrix

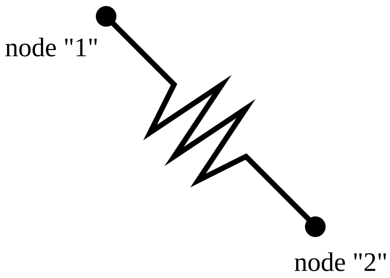


Figure 5-47 General 2-noded spring element

As General Spring it is just a 2-noded spring (12x12 matrix) which may be in a local coordinate system. As a shim element the preprocessor(s) will only insert stiffness in the local x- and y-direction. In the analysis program(s), shim members and general springs are treated exactly in the same manner.

The resulting spring matrix is a full symmetric matrix where all values on and below the main diagonal are stored.

Data types used for this element:

GELMNT1 *
MSHGLSP * (NDOF1 and NDOF2 must be equal to NDOF on data type GNODE for node "1" and node "2")
GELREF1 *
BNTRCOS (Transformation in the two nodes may be different. But NDOF1 = NDOF2 = 3 or 6 is required for transformation).

*) Mandatory

ELTYP=41: Axisymmetric Constant Strain Triangle (AXCS), for Ref. See CSTA in /2/

AXCS(41)

- 3 nodes
- 3 x 3 degrees of freedom
- straight
  - line loads
  - initial strain (temperature load)
  - gravitational load (only in the membrane plane)
  - general inertia load (only in the membrane plane)
- isotropic or anisotropic material data

Local node numbering:

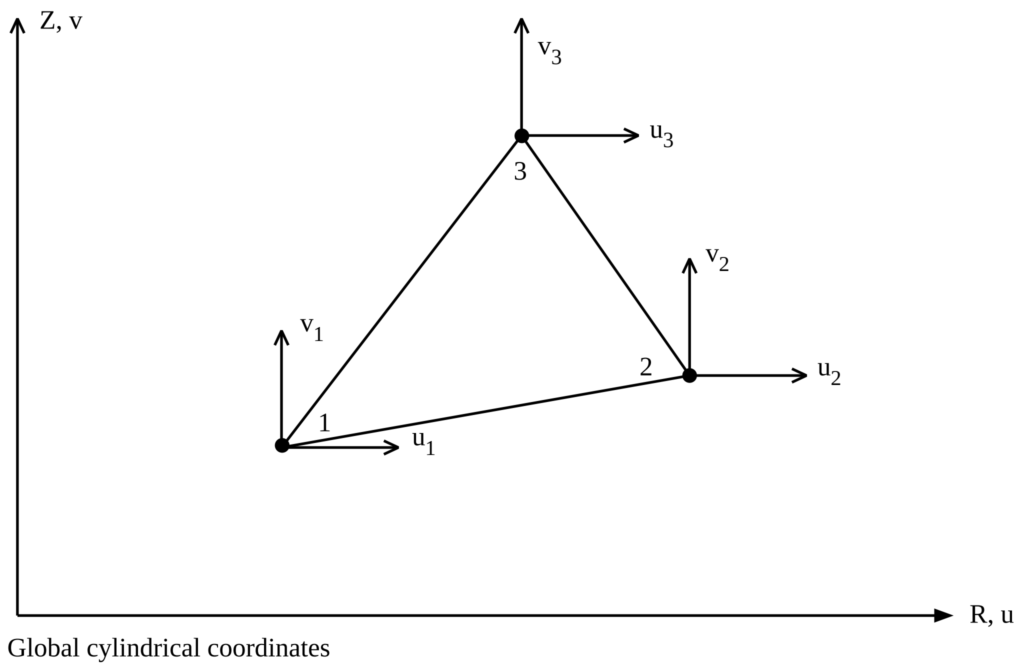


Figure 5-48 Element node numbering. Global cylindrical coordinate system.

When line load is specified, the relation between local node numbers and loaded line will be:

Line 1 means load along the line defined by the nodes 2 and 3.
Line 2 means load along the line defined by the nodes 1 and 3
Line 3 means load along the line defined by the nodes 1 and 2.

The direction of node numbering must be counterclockwise.

AXCS(41)

Data types used for this element:

GELMNT1 *
GELREF1 *
GNODE *
GCOORD *

MISOSEL * or
MORSMEL *
MTRMEL

BELLAX
BEISTE
BGRAV
BNACCLO

*) Mandatory

ELTYP=42: (AXLQ), for ref. see LQUA in /2/

AXLQ(42)

- 4 nodes
- 4 x 3 degrees of freedom
- straight
- element loads
  - line loads
  - initial strain (temperature load)
  - gavitational load (only in the membrane plane)
  - general inertia load (only in the membrane plane)
- isotropic or anisotropic material data
- deformations considered: translational strain

Local node numbering:

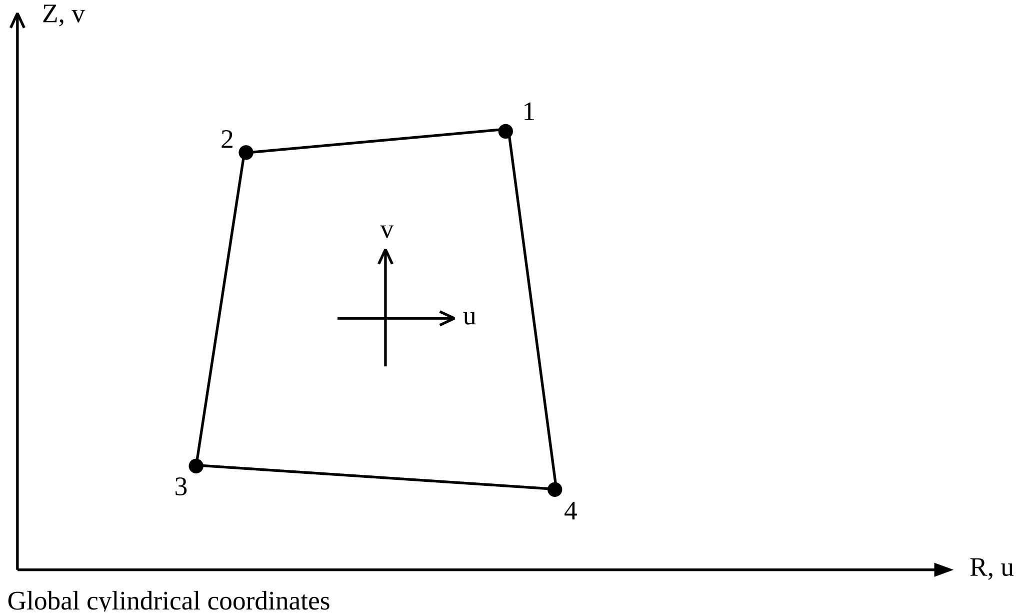


Figure 5-49 Element node numbering. Global cylindrical coordinate system.

When line load is specified, the relation between local node numbers and loaded line will be:

LINE 1 means load along the line defined by the nodes 1 and 2
LINE 2 means load along the line defined by the nodes 2 and 3
LINE 3 means load along the line defined by the nodes 3 and 4
LINE 4 means load along the line defined by the nodes 4 and 1

The direction of node numbering must be counterclockwise.

AXLQ(42)

Data types used for this element:

GELMNT1 *
GELREF1 *
GNODE *
GCOORD *
GELINT

MISOSEL or *
MORSMEL
MTRMEL

BELLAX
BEISTE
BGRAV
BNACCLO

*) Mandatory

The following restrictions are put on data types:

GELINT	The integration stations must be distributed according to the Gaussian integration scheme, i.e. INTYPE =1. For this element type the GELINT specifications consist of the first line. Stiffness matrix: Legal values for N1 and N2 are 2 and 3. N1 and N2 must have the same value. Default value is N1=N2=2. Mass matrix: For mass matrix calculations the number of integration stations will be the same in both coordinate directions and equal to the value specified for N1 for the stiffness matrix.

ELTYP=43: Axisymmetric Linear Strain Triangle

AXLS(43)

(AXLS), for Ref. see ILST in /2/

- 6 nodes
- 6 x 3 degrees of freedom
- curved
- deformations considered: translational strain
- element loads:
    - line loads
    - initial strain (temperature loads)
    - gravitational load (only in the membrane plane)
    - general inertia load (only in the membrane plane)
- isotropic or anisotropic material data

Local node numbering:

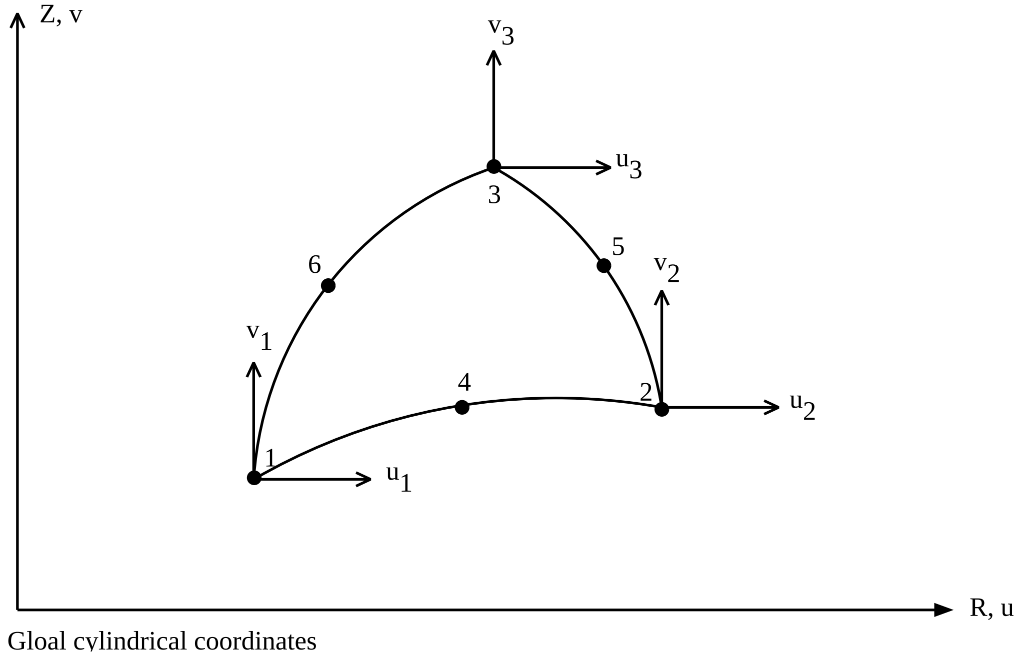


Figure 5-50 Element node numbering. Global cylindrical coordinate system.

When line load is specified, the relation between local node numbers and loaded line will be:

Line 1 means load along the line defined by the nodes 2, 5 and 3.
Line 2 means load along the line defined by the nodes 1, 6 and 3
Line 3 means load along the line defined by the nodes 1, 4 and 2.

The direction of node numbering must be counterclockwise.

AXLS(43)

The following restrictions are put on the data types

GELINT	The integration stations must be distributed according to the Gaussian integration scheme, i.e. INTYPE =1. For this element type the GELINT specifications consist of the first filerecord (line) only. Stiffness matrix: For stiffness matrix calculations the number of integration stations will be equal to the value specified for N1. Legal values are 1, 3, 4 and 7. Default value is 4. Mass matrix: Only possible value and default value is 7. Load vector: Only possible value and default value is 3.

Data types used for this element:

GELMNT1 *
GELREF1 *
GNODE *
GCOORD *
GELINT

MISOSEL or *
MORSMEL
MTRMEL

BELLAX
BEISTE
BGRAV
BNACCLO

*) Mandatory

ELTYP=44: Axisymmetric Linear Strain Quadrilateral (AXQQ), for Ref. see IQQE in /2/

AXQQ(44)

- 8 nodes
- 8 x 3 degrees of freedom
- curved
- deformations considered: translational strain
- element loads:
  - line loads
  - initial strain (temperature loads)
  - gravitational load (only in the membrane plane)
  - general inertia load (only in the membrane plane)
- isotropic or anisotropic material data

Local node numbering:

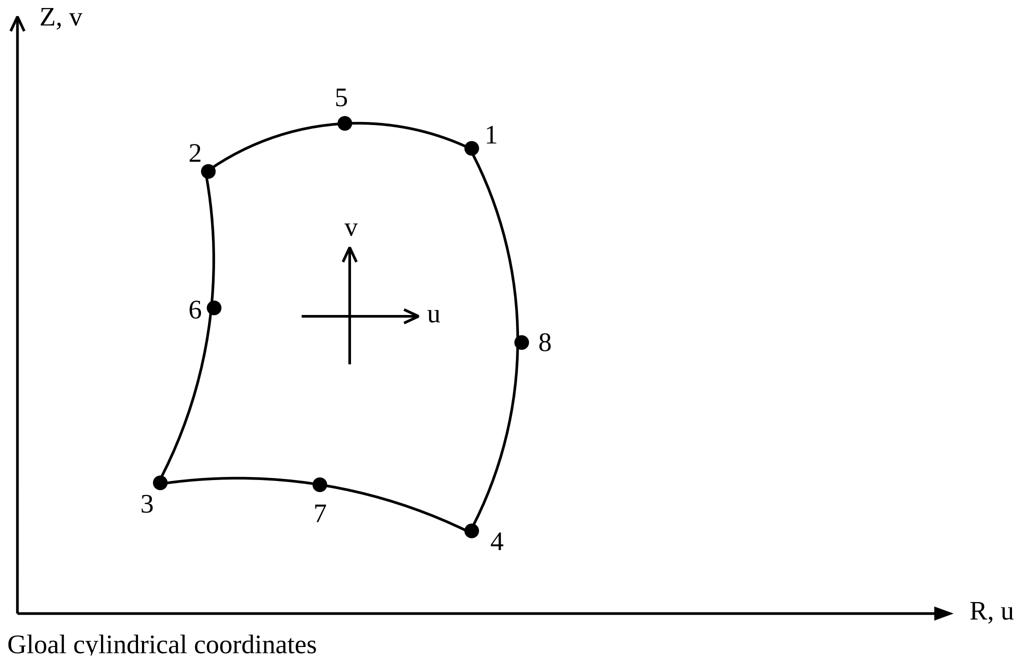


Figure 5-51 Element node numbering. Global cylindrical coordinate system.

When line load is specified, the relation between local node numbers and loaded line will be:

LINE 1 means load along the line defined by the nodes 2, 6 and 3
LINE 2 means load along the line defined by the nodes 5 and 7
LINE 3 means load along the line defined by the nodes 1, 8 and 4
LINE 4 means load along the line defined by the nodes 1, 5 and 2
LINE 5 means load along the line defined by the nodes 8 and 6
LINE 6 means load along the line defined by the nodes 4, 7 and 3

AXQQ(44)

The direction of node numbering must be counterclockwise.

The following restrictions are put on the data types

GELINT The integration stations must be distributed according to the Gaussian integration scheme, i.e.
INTYPE =1. For this element type the GELINT specifications consist of the first filerecord only.

Stiffness matrix: For stiffness matrix calculations the number of integration stations will be the same in both coordinate directions and equal to the value specified for N1.
Legal values are 2 and 3. Default value is 3.

Mass matrix: For mass matrix calculations the number of integration stations will be the same in both coordinate directions and equal to the value specified for N1 for the stiffness martix..

Load vector: 3 is used, the variable is not possible to specify for the user.

BELLO2 LINE = 2 and LINE = 5 is not operative in SESTRA.

Data types used for this element:

GELMNT1 *
GELREF1 *
GNODE *
GCOORD *
GELINT

MISOSEL or *
MORSMEL
MTRMEL

BELLAX
BELLO2
BEISTE
BGRAV
BNACCLO

*) Mandatory

ELTYP=51: 2 noded (1+1) Contact Element

CTCP(51)

- 2 nodes
- 2 x 6 degrees of freedom
- contact material (see the MCNT record)
- deformations considered:
  separation and relative tangential desplacement between surfaces.
- zero thickness.
- element loads:
  - none

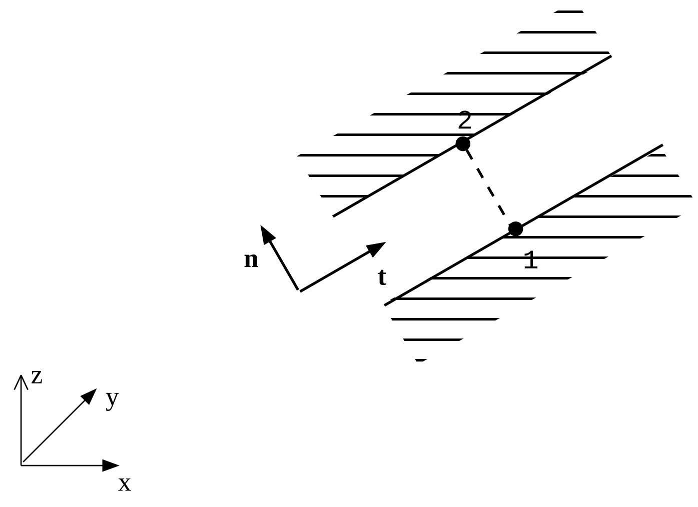


Figure 5-52 Element node numbering.

CTCP(51)

Data types for this element:

GELMNT1 *
GNODE *
GCOORD *
GELREF1 *
GELTH **
GELINT
MCNT *

*) Mandatory
**) If the nodes in the two layers (sides) of the element in the model do not coincide, thickness of the element may be specified by GELTH records.
Any distance between the two layers (sides) which is different from specified thickness is interpreted as initial gap or initial penetration of the contact surface.

ELTYP=52: 4 noded (2+2) Contact Element

CTCL(52)

- 4 nodes
- 4 x 6 degrees of freedom
- linear element shape
- contact material (see the MCNT record)
- deformations considered:
  separation and relative tangential desplacement between surfaces.
- zero thickness.
- element loads:
  - none

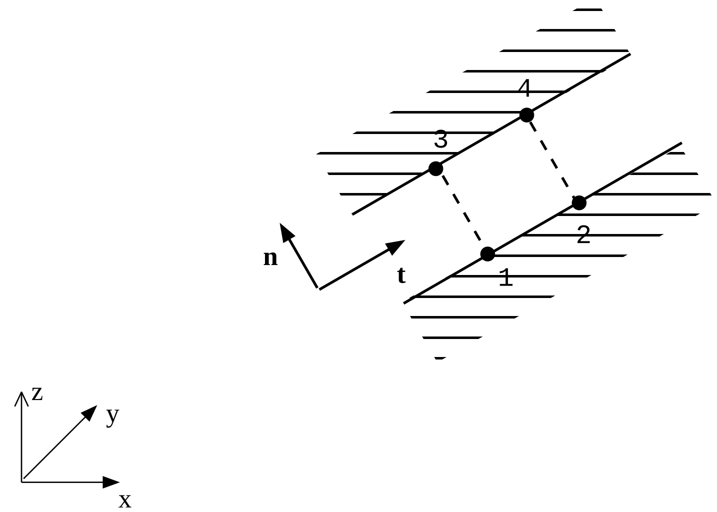


Figure 5-53 Element node numbering.

CTCL(52)

Data types for this element:

GELMNT1 *
GNODE *
GCOORD *
GELREF1 *
GELTH **
GELINT
MCNT *

*) Mandatory
**) If the nodes in the two layers (sides) of the element in the model do not coincide, thickness of the element may be specified by GELTH records.
Any distance between the two layers (sides) which is different from specified thickness is interpreted as initial gap or initial penetration of the contact surface.

ELTYP=53: 4 noded (2+2) Axisymmetric Contact Element CTAL(53)

- 4 nodes
- 4 x 3 degrees of freedom
- linear element shape
- contact material (see the MCNT record)
- deformations considered:
  separation and relative tangential desplacement between surfaces.
- zero thickness.
- element loads:
  - none

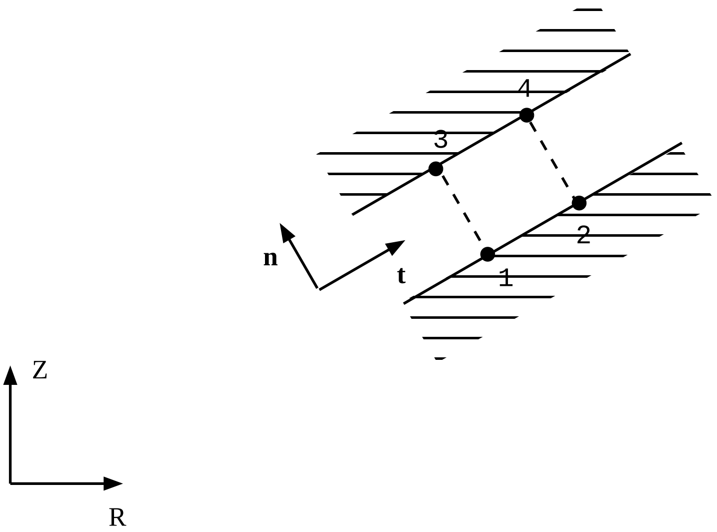


Figure 5-54 Element node numbering.

CTAL(53)

Data types for this element:

GELMNT1	*
GNODE	*
GCOORD	*
GELREF1	*
GELTH	**
GELINT	
MCNT	*

*) Mandatory

**) If the nodes in the two layers (sides) of the element in the model do not coincide, thickness of the element may be specified by GELTH records.

Any distance between the two layers (sides) which is different from specified thickness is interpreted as initial gap or initial penetration of the contact surface.

ELTYP=54: 6 noded (3+3) Contact Element

CTCC(54)

- 6 nodes
- 6 x 6 degrees of freedom
- curved element shape
- contact material (see the MCNT record)
- deformations considered:
  separation and relative tangential desplacement between surfaces.
- zero thickness.
- element loads:
  - none

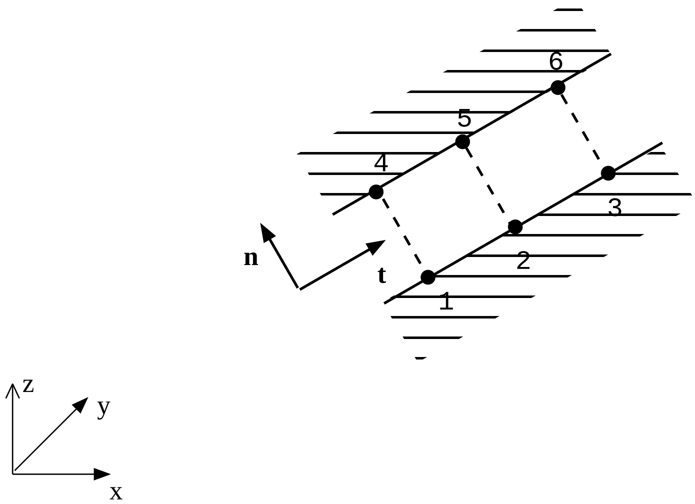


Figure 5-55 Element node numbering.

CTCC(54)

Data types for this element:

GELMNT1	*
GNODE	*
GCOORD	*
GELREF1	*
GELTH	**
GELINT	
MCNT	*

*) Mandatory
**) If the nodes in the two layers (sides) of the element in the model do not coincide, thickness of the element may be specified by GELTH records.
Any distance between the two layers (sides) which is different from specified thickness is interpreted as initial gap or initial penetration of the contact surface.

ELTYP=55: 6 noded (3+3) Axisymmetric Contact Element, /8/ and /9/

CTAQ(55)

- 6 nodes
- 6 x 3 degrees of freedom
- curved element shape
- contact material (see the MCNT record)
- deformations considered:
  separation and relative tangential desplacement between surfaces.
- zero thickness.
- element loads:
  - none

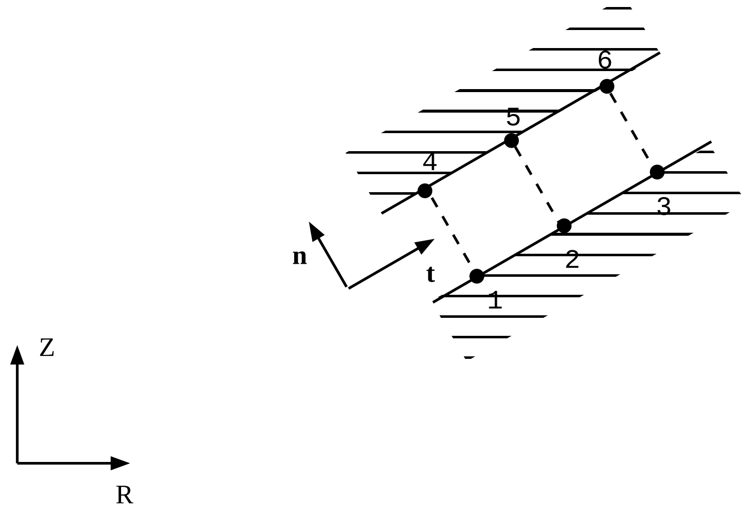


Figure 5-56 Element node numbering.

CTAQ(55)

Data types for this element:

GELMNT1	*
GNODE	*
GCOORD	*
GELREF1	*
GELTH	**
GELINT	
MCNT	*

*) Mandatory
**) If the nodes in the two layers (sides) of the element in the model do not coincide, thickness of the element may be specified by GELTH records.
Any distance between the two layers (sides) which is different from specified thickness is interpreted as initial gap or initial penetration of the contact surface.

ELTYP=56: 8 noded (4+4) Contact Element, /8/ and /9/ CTLQ(56)

- 8 nodes
- 8 x 3 degrees of freedom
- flat elemtent shape
- contact material (see the MCNT record)
- deformations considered:
  penetration prevented
- zero thickness when beeing between two solid elements and linearly varying element thickness according to the adjacent shell elements when connecting two shell elements.
- element loads:
  - none

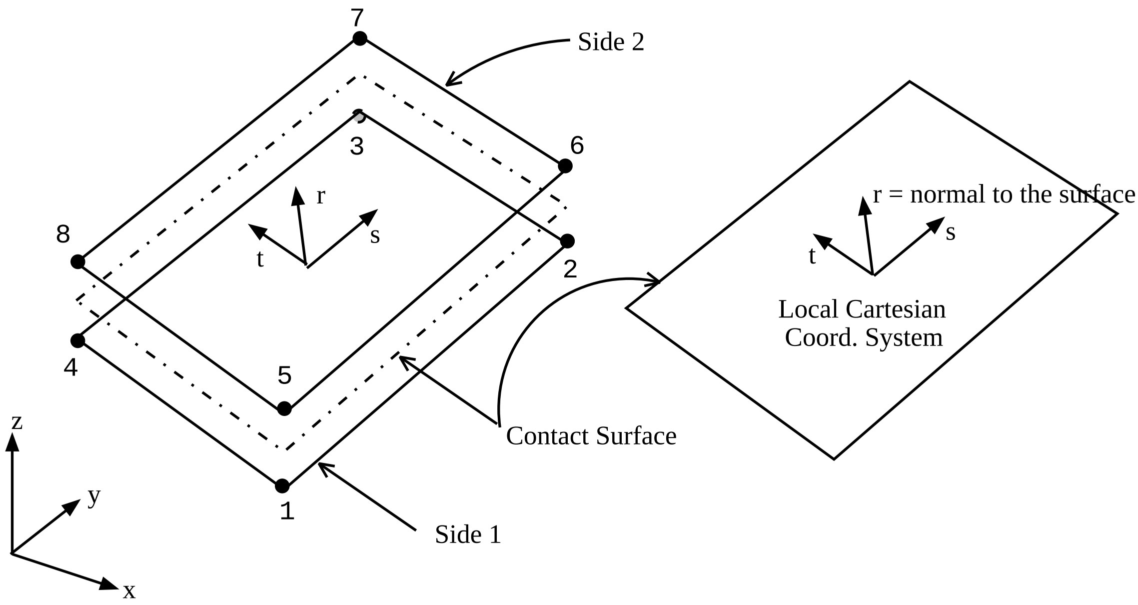


Figure 5-57 Element node numbering. Global Cartesian and local coordinate system.

CTLQ(56)

Line no. definition:

The orientation of the local nodal coordinate system is related to the nodenumbering sequence (see Figure 5-57). The positive r-direction, normal to the element contact surface, is chosen according to the normal convention of the right hand rule, i.e. the positive r-direction is found when the node numbers are followed in ascending order, counterclockwise.

The SIDE definition is as follows:

SIDE=1	means the element surface where r is negative
SIDE=2	means the element surface where r is positive

Data types for this element:

GELMNT1	*
GNODE	*
GCOORD	*
GELREF1	*
GELTH	**
GELINT	
MCNT	*

*) Mandatory

**) If the nodes in the two layers (sides) of the element in the model do not coincide, thickness of the element may be specified by GELTH records.

Any distance between the two layers (sides) which is different from specified thickness is interpreted as initial gap or initial penetration of the contact surface.

ELTYP=57: 16 noded (8+8) Contact Element, /8/ and /9/ **CTCQ(57)**

- 16 nodes
- 16 x 3 degrees of freedom
- curved element shape
- contact material (see the MCNT record)
- deformations considered:
  penetration prevented
- zero thickness when beeing between two solid elements and parabolically varying element thickness according to the adjacent shell elements when connecting two shell elements.
- element loads:
  - none

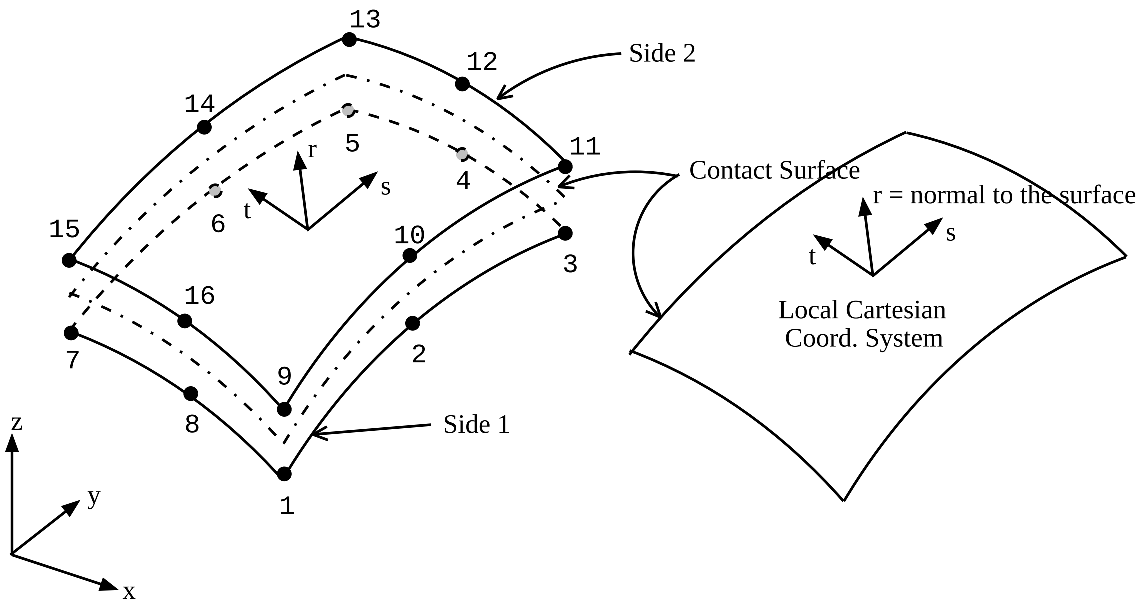


Figure 5-58 Element node numbering. Global Cartesian and local coordinate system.

Line no. definition:

LINE=1 means line defined by the nodes 3, 4 and 5
LINE=2 means line defined by the nodes 2 and 6
LINE=3 means line defined by the nodes 1, 8 and 7
LINE=4 means line defined by the nodes 7, 6 and 5
LINE=5 means line defined by the nodes 8 and 4
LINE=6 means line defined by the nodes 1, 2 and 3

LINE=7 means line defined by the nodes 11, 12 and 13
LINE=8 means line defined by the nodes 10 and 14

CTCQ(57)

LINE=9	means line defined by the nodes 9, 16 and 15
LINE=10	means line defined by the nodes 15, 14 and 13
LINE=11	means line defined by the nodes 16 and 12
LINE=12	means line defined by the nodes 9, 10 and 11

The orientation of the local nodal coordinate system is related to the nodenumbering sequence (see Figure 5-58). The positive r-direction, normal to the element contact surface, is chosen according to the normal convention of the right hand rule, i.e. the positive r-direction is found when the node numbers are followed in ascending order, counterclockwise.

The SIDE definition is as follows:

SIDE=1	means the element surface where r is negative
SIDE=2	means the element surface where r is positive

Data types for this element:

GELMNT1	*
GNODE	*
GCOORD	*
GELREF1	*
GELTH	
GELINT	
MCNT	*

*) Mandatory
**) If the nodes in the two layers (sides) of the element in the model do not coincide, thickness of the element may be specified by GELTH records.
Any distance between the two layers (sides) which is different from specified thickness is interpreted as initial gap or initial penetration of the contact surface.

ELTYP=58: 18 noded (9+9) Contact Element, /8/ and /9/

CTMQ(58)

- 18 nodes
- 18 x 3 degrees of freedom
- curved element shape
- contact material (see the MCNT record)
- deformations considered:
  penetration prevented
- zero thickness when beeing between two solid elements and parabolically varying element thickness according to the adjacent shell elements when connecting two shell elements.
- element loads:
  - none

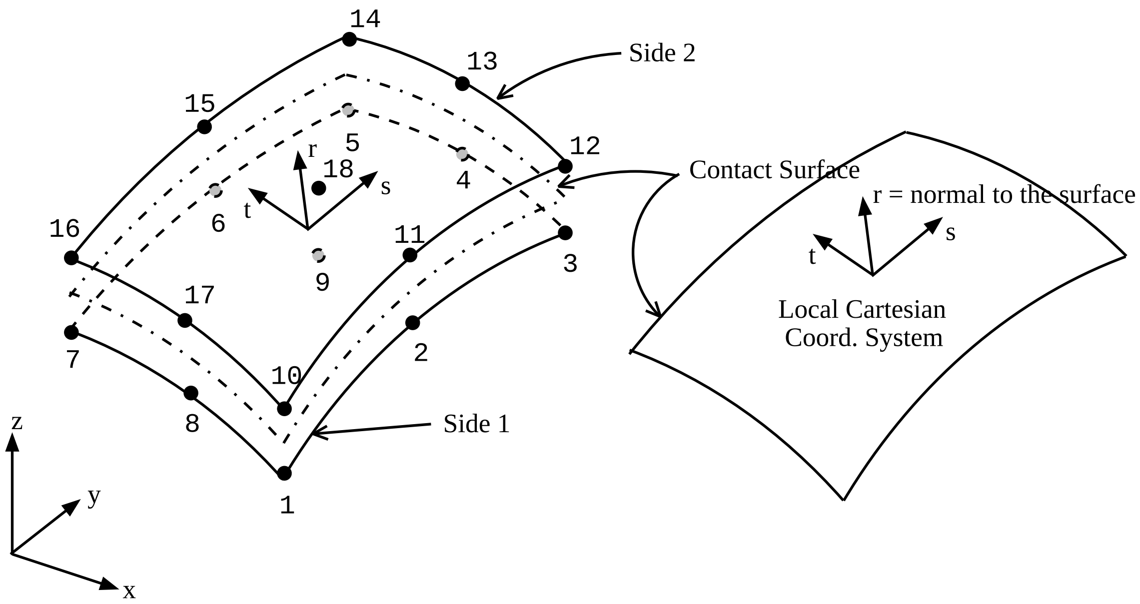


Figure 5-59 Element node numbering. Global Cartesian and local coordinate system.

CTMQ(58)

The orientation of the local nodal coordinate system is related to the nodenumbering sequence (see Figure 5-59). The positive r-direction, normal to the element contact surface, is chosen according to the normal convention of the right hand rule, i.e. the positive r-direction is found when the node numbers are followed in ascending order, counterclockwise.

The SIDE definition is as follows:

SIDE=1 means the element surface where r is negative
SIDE=2 means the element surface where r is positive

Data types for this element:

GELMNT1 *
GNODE *
GCOORD *
GELREF1 *
GELTH
GELINT
MCNT *

*) Mandatory
**) If the nodes in the two layers (sides) of the element in the model do not coincide, thickness of the element may be specified by GELTH records.
Any distance between the two layers (sides) which is different from specified thickness is interpreted as initial gap or initial penetration of the contact surface.

ELTYP=61: Heterosis Curved Quadrilateral Shell (HCQS),

HCQS(61)

- 9 nodes
- 9 x 6 degrees of freedom
- curved element shape
- isotropic or anisotropic material data
- deformations considered:
  bending, shear and translational strain
- parabolically varying element thickness
- element loads:
  - initial strain
  - surface forces
  - line loads
  - gravitational load
  - general inertia load

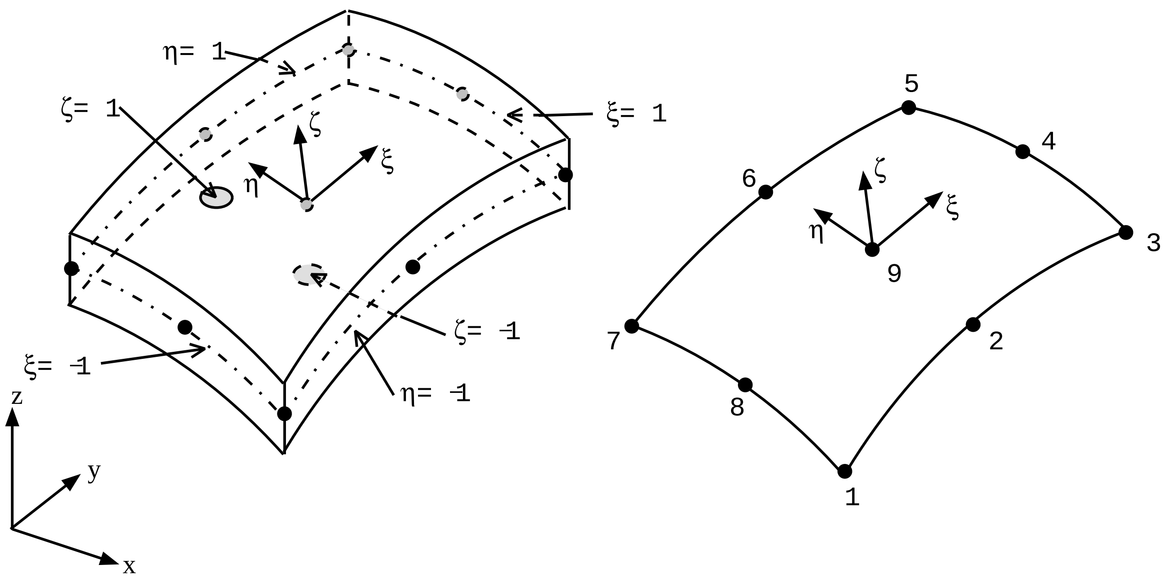


Figure 5-60 Element node numbering. Global Cartesian and local normalized coordinate system.

When line load is specified, the relation between local node numbers and loaded line will go:

HCQS(61)

LINE=1	means line load along the line defined by the nodes 3, 4 and 5
LINE=2	means line load along the line defined by the nodes 2, 9 and 6
LINE=3	means line load along the line defined by the nodes 1, 8 and 7
LINE=4	means line load along the line defined by the nodes 7, 6 and 5
LINE=5	means line load along the line defined by the nodes 8, 9 and 4
LINE=6	means line load along the line defined by the nodes 1, 2 and 3

The orientation of the local nodal coordinate system is related to the nodenumbering sequence (see Figure 5-60). The positive ζ-direction, normal to the element middlesurface, is chosen according to the normal convention of the right hand rule, i.e. the positive ζ-direction is found when the node numbers are followed in ascending order, counterclockwise.

The SIDE definition on the BEUSLO records is as follows:

SIDE=1	means that load is given on the element surface where ζ= -1,
SIDE=2	that ζ= 0 is loaded, and
SIDE=3	that ζ= 1 is loaded.

Data types for this element:

GELMNT1 *
GNODE *
GCOORD *
GELREF1 *
GELINT
GELTH *
GELSTRP
MISOSEL * or
MISOPL * or
MORSSEL *
MTRSEL
BEUSLO
BELLO2
BEISTE
BGRAV
BNACCLO

*) Mandatory

HCQS(61)

The following restrictions are put on the data types.

BELLO2	The SIDE-definition is not used.

ELTYP=70: General Matrix Element (MATR)

MATR(70)

This element is a way of transferring stiffness / damping / mass matrices and / or load / displacement / velocity / acceleration vectors between different models or analysis programs.

- variable number of nodes - maximum 999 nodes
- possible with different number of degrees of freedom in each node
- real or complex matrices and vectors
- possible with e.g. frequency dependent matrices
- stiffness matrix
- damping matrix
- mass matrix
- nodal load vectors
- no element loads
- nodal displ. / velocity / acceleration vectors

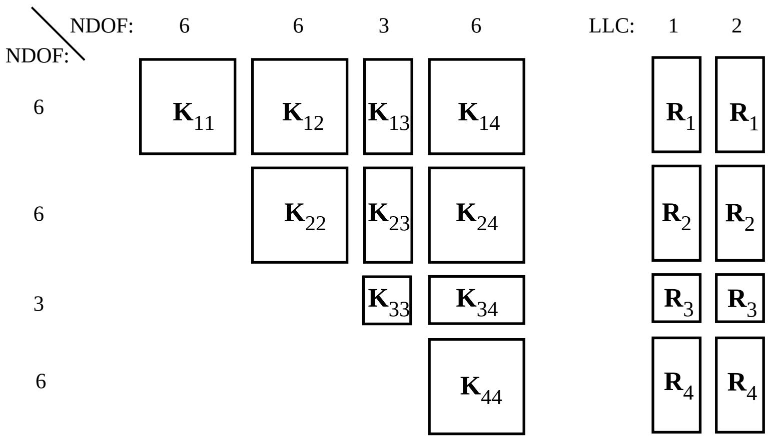


Figure 5-61 Example of 4 noded stiffness and load matrix / vector, with 6, 6, 3 and 6 degrees of freedom in the nodes respectively and 2 loadcases.

MATR(70)

Data types for this element:

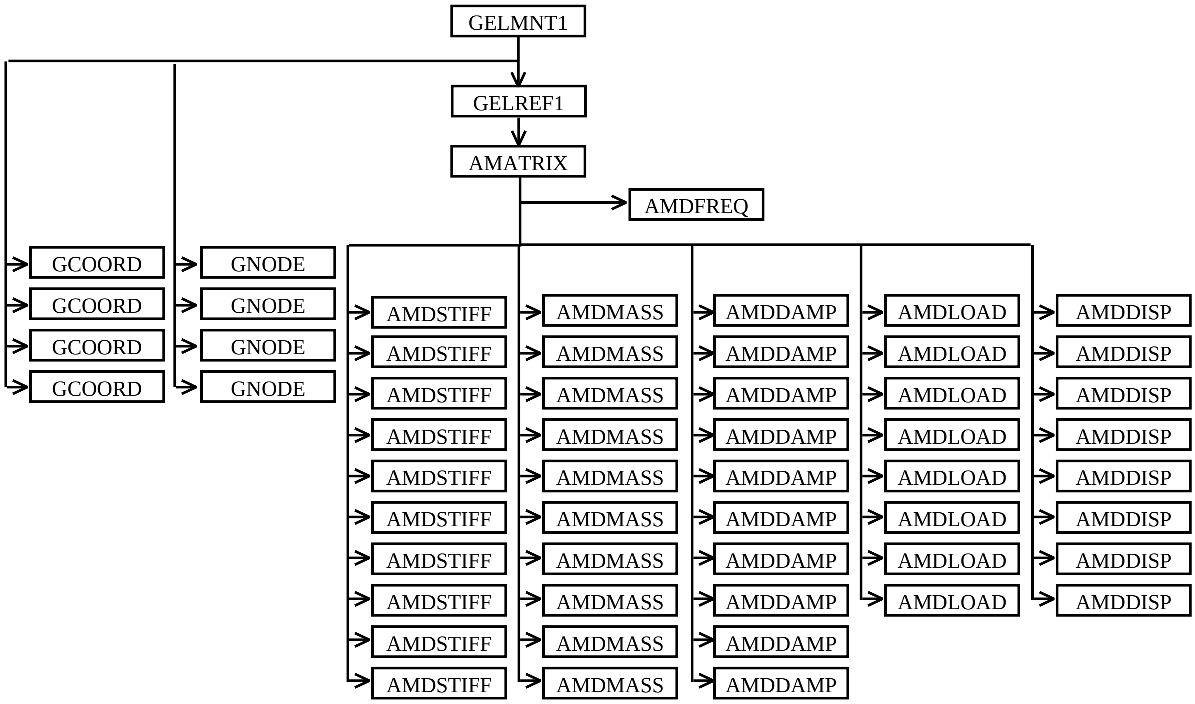


Figure 5-62 Normal data reference for a matrix element with 4 nodes and 2 loadcases. The element is having stiffness, mass, damping, load and resulting displacement matrices / vectors. At least some of the vectors / matrices are also frequency dependent.

AMATRIX [1]	AMDSTIFF [2]
AMDDAMP [2]	AMDMASS [2]
AMDLOAD [2]	AMDDISP [3]
AMDFREQ	AMDVELO [3]
AMDACCL [3]	GCOORD [1]
GELMNT1 [1]	GELMNT2
GELREF1 [1]	GNODE [1]

1 Mandatory

2 At least one of these records must be present.

3 Nodal results may alternatively be defined through records described in 'SIF, Results Interf. File, File Descr.'. See also figure 5-63.

MATR(70)

Below is a figure showing the datatypes for nodal displacement, velocity or acceleration results associated with a matrix element, when using the records described in the 'SIF, Results Interf. File, File Descr.' In the example the results are displacements.

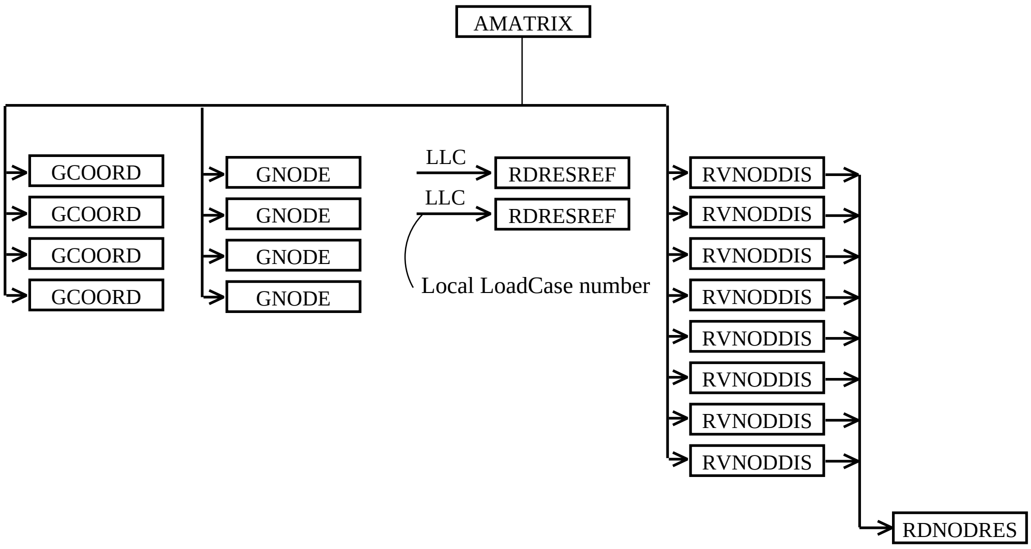


Figure 5-63 Normal data reference for results defined on records described in the 'SIF, Results Interf. File, File Descr.' for a matrix element with 4 nodes and 2 loadcases.

AMATRIX [1]	RDRESREF [1]
GCOORD [1]	RVNODACC[2]
GNODE [1]	RVNODDIS [2]
RDNODRES [1]	RVNODVEL[2]

1 Mandatory.

2 At least one of these records must be present.

ELTYP=100,...163: General Hexahedron (GHEX), /2/

GHEX

- 21 to 27 nodes
- (21 to 27) x 3 degrees of freedom
- curved element sides
- isotropic or anisotropic material data
- deformations considered: translational strain
- element loads:
  - initial strain (temperature load)
  - surface forces
  - line loads
  - gravitational load
  - general inertia load

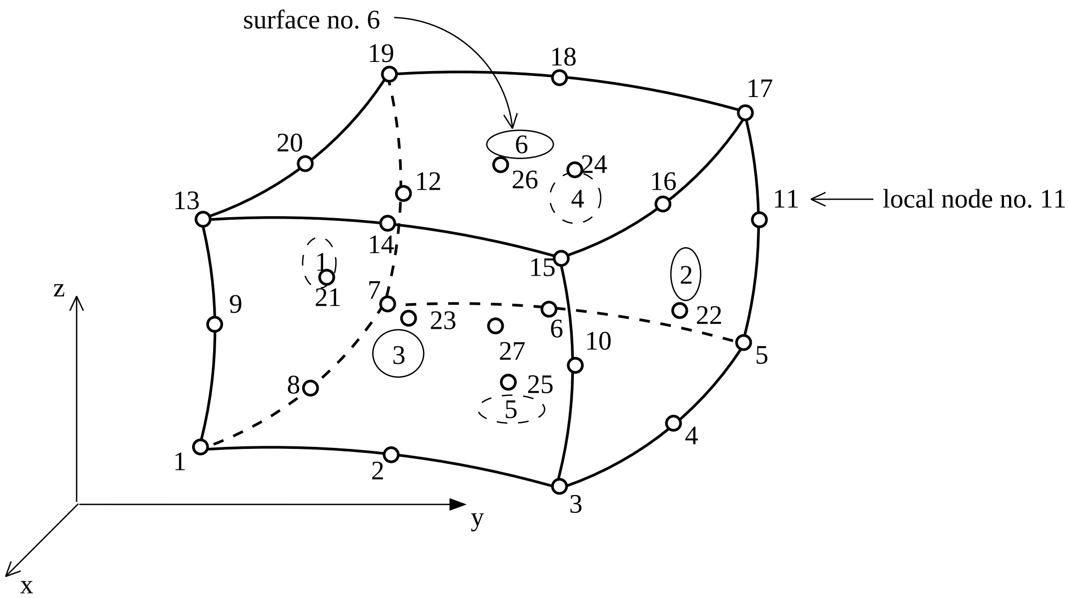


Figure 5-64 General hexahedron with local nodenumbering and corresponding surface numbering

The element may be without some of the nodes. Which nodes are not present is reflected in the element number:

100	The basic element with node 1 to 20 and node 27 present.
101	Nodes 1 to 20, node 21 and node 27 are present.
102	Nodes 1 to 20, node 22 and node 27 are present.
103	Nodes 1 to 20, node 21, node 22 and node 27 are present.

ETC.

GHEX

If node 21 is present, 1 is added to the basic element type number.
If node 22 is present, 2 is added to the basic element type number.
If node 23 is present, 4 is added to the basic element type number.
If node 24 is present, 8 is added to the basic element type number.
If node 25 is present, 16 is added to the basic element type number.
If node 26 is present, 32 is added to the basic element type number.
If more than one of these nodes are present, the sum of the additions above is added.

element type number	Node position contains node number						
Node positions:	21	22	23	24	25	26	27
100	-	-	-	-	-	-	21
101	21	-	-	-	-	-	22
102		21	-	-	-	-	22
103	21	22	-	-	-	-	23
104	-	-	21	-	-	-	22
105	21	-	22	-	-	-	23
106	-	21	22	-	-	-	23
107	21	22	23	-	-	-	24
108	-	-	-	21	-	-	22
109	21	-	-	22	-	-	23
110	-	21	-	22	-	-	23
111	21	22	-	23	-	-	24
112	-	-	21	22	-	-	23
113	21	-	22	23	-	-	24
114	-	21	22	23	-	-	24
115	21	22	23	24	-	-	25
116	-	-	-	-	21	-	22
117	21	-	-	-	22	-	23
118	-	21	-	-	22	-	23
119	21	22	-	-	23	-	24
120	-	-	21	-	22	-	23
121	21	-	22	-	23	-	24
122	-	21	22	-	23	-	24
123	21	22	23	-	24	-	25
124	-	-	-	21	22	-	23
125	21	-	-	22	23	-	24
126	-	21	-	22	23	-	24
127	21	22	-	23	24	-	25
128	-	-	21	22	23	-	24
129	21	-	22	23	24	-	25
130	-	21	22	23	24	-	25
131	21	22	23	24	25	-	26
132	-	-	-	-	-	21	22
133	21	-	-	-	-	22	23
134	-	21	-	-	-	22	23

GHEX

135	21	22	-	-	-	23	24
136	-	-	21	-	-	22	23
137	21	-	22	-	-	23	24
138	-	21	22	-	-	23	24
139	21	22	23	-	-	24	25
140	-	-	-	21	-	22	23
141	21	-	-	22	-	23	24
142	-	21	-	22	-	23	24
143	21	22	-	23	-	24	25
144	-	-	21	22	-	23	24
145	21	-	22	23	-	24	25
146	-	21	22	23	-	24	25
147	21	22	23	24	-	25	26
148	-	-	-	-	21	22	23
149	21	-	-	-	22	23	24
150	-	21	-	-	22	23	24
151	21	22	-	-	23	24	25
152	-	-	21	-	22	23	24
153	21	-	22	-	23	24	25
154	-	21	22	-	23	24	25
155	21	22	23	-	24	25	26
156	-	-	-	21	22	23	24
157	21	-	-	22	23	24	25
158	-	21	-	22	23	24	25
159	21	22	-	23	24	25	26
160	-	-	21	22	23	24	25
161	21	-	22	23	24	25	26
162	-	21	22	23	24	25	26
163	21	22	23	24	25	26	27

GHEX

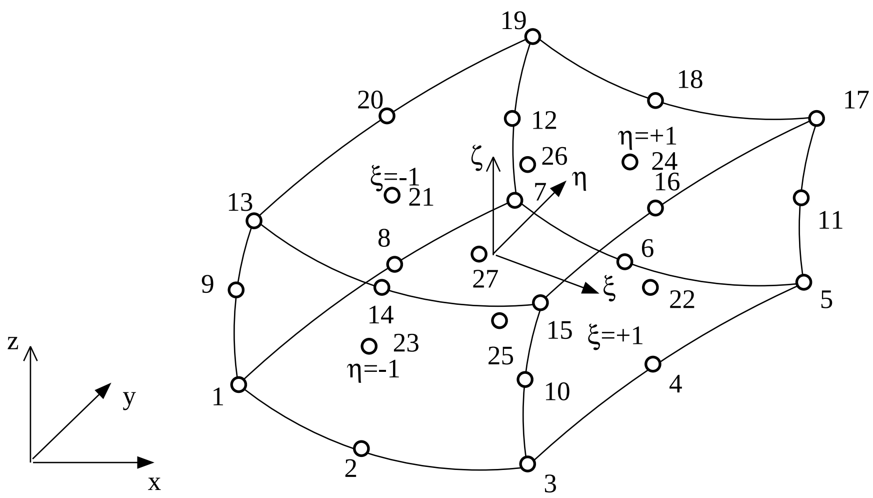


Figure 5-65 Typical general hexahedron

When surface loads are specified for the element side, the surface numbers shown are used for identification of the side in question. The node numbers 21 to 27 signifies the node position number. The actual node number within the actual element is 20 + number of nodes up to node position which are present in the actual element. Which node number shall actually be used in the tables below may be determined by the table of nodes in node position above. If the node position in question is empty the number of nodes on the line or side is one less, and compacted when the line is missing one node.

The local node numbering for each side is defined as follows:

Node number

Side no.	1	2	3	4	5	6	7	8	(9)
1	7	8	1	9	13	20	19	12	(21)
2	5	11	17	16	15	10	3	4	(22)
3	1	2	3	10	15	14	13	9	(23)
4	7	12	19	18	17	11	5	6	(24)
5	7	6	5	4	3	2	1	8	(25)
6	19	20	13	14	15	16	17	18	(26)

GHEX

When line load is specified, the relation between the local node numbers and the loaded line will be as follows:

	Node number		
	1	2	3
Line no.			
1	1	2	3
2	3	4	5
3	5	6	7
4	7	8	1
5	1	9	13
6	3	10	15
7	5	11	17
8	7	12	19
9	13	14	15
10	15	16	17
11	17	18	19
12	19	20	13
13	8	(25)	4
14	6	(25)	2
15	9	(23)	10
16	2	(23)	14
17	10	(22)	11
18	4	(22)	16
19	11	(24)	12
20	6	(24)	18
21	12	(21)	9
22	8	(21)	20
23	20	(26)	16
24	14	(26)	18

GHEX

Data types used for this element:

GELMNT1 *
GNODE *
GCOORD *
GELREF1 *
GELSTRP
MISOSEL * or
MISOPL * or
MORSSOL *
MTRSOL
BEUSLO
BELLO2
BEISTE
BGRAV
BNACCLO

*) Mandatory

The following restrictions are put on the data types

BELLO2	The SIDE definition is not used. The load components are given nodewise in global coordinates.
BEUSLO	Only one side identification can be given in SIDE.

6 FIRST LEVEL DATA

6.1 Additional Element Data

First Level

General Crack Data

ACFD

ACFD	IGLB	ILOK	NEP	IMOD
	MKP	DX	DY	DZ
	I(1)	I(2)	. . .	I(NEP)
	NSIF	ISIF(1)	ISIF(2)	. . .
	ISIF(NSIF)			

A crack is defined by a set of AFCD records on the Interface file. There is one AFCD-record for each crack front node.

IGLB — Sequence numbering of crack front nodes.

ILOK — External node number of the crack front node.

NEP — Perturbation option for nodes to be perturbed.
< 0 Nodes not supplied; use all side nodes closest to the crack tip and nodes coinciding with ILOK.
= 0 Crack tip node only is perturbed.
> 0 Number of nodes supplied. The nodes are perturbed in addition to the crack tip node.

IMOD — Conversion option.
IMOD governs the conversion from crack driving force to stress intensity factor according to:
= 1 $K= \sqrt{(E/(1-\upsilon^2))}*\sqrt{G}$
= 2 $K= \sqrt{(E*G)}$
= 3 $K= \sqrt{(E/(1+\upsilon^2))}*\sqrt{G}$
where K is stress intensity factor, G is crack driving force, E is Young's modulus and υ is Poisson's ratio.

MKP — Perturbation direction option:
= 0 Perturbation direction given in (DX,DY,DZ)
> 0 MKP=external node number of node which defines direction together with ILOK
= -1 Automatic computation by analysis program (only relevant for double crack surface)
= -2 Point (DX,DY,DZ) in crack surface is given.
The perturbation direction must be normal to the crack front and tangential to the crack surface.

DX, DY, DZ — Coordinates (in superelement global coordinate system) as MKP specifies.

I(1:NEP) — If NEP > 0: External node numbers of nodes to be perturbed together with crack front node ILOK. Nodes with the same position as ILOK may be left out of specification.

AFCD

NSIF — Number of associated nodes used in calculation of Stress Intensity Factors (SIF) in node ILOK. NSIF = 0 is treated as NSIF = 4 (four associated nodes).
NSIF = 2, Node ILOK is a midside node
NSIF = 4, Node ILOK is a corner node
NSIF = 0, Node ILOK is a corner node and the last node along crack front.

Note that two crack fronts may be present in a superelement. Separation between the two crack fronts is identified with NSIF = 0. IGLB goes from 1 to the total number of crack front nodes along the two crack fronts.

ISIF(1:NSIF) — External node numbers for nodes in crack surface.

AFCD

Definition of local axis-system:

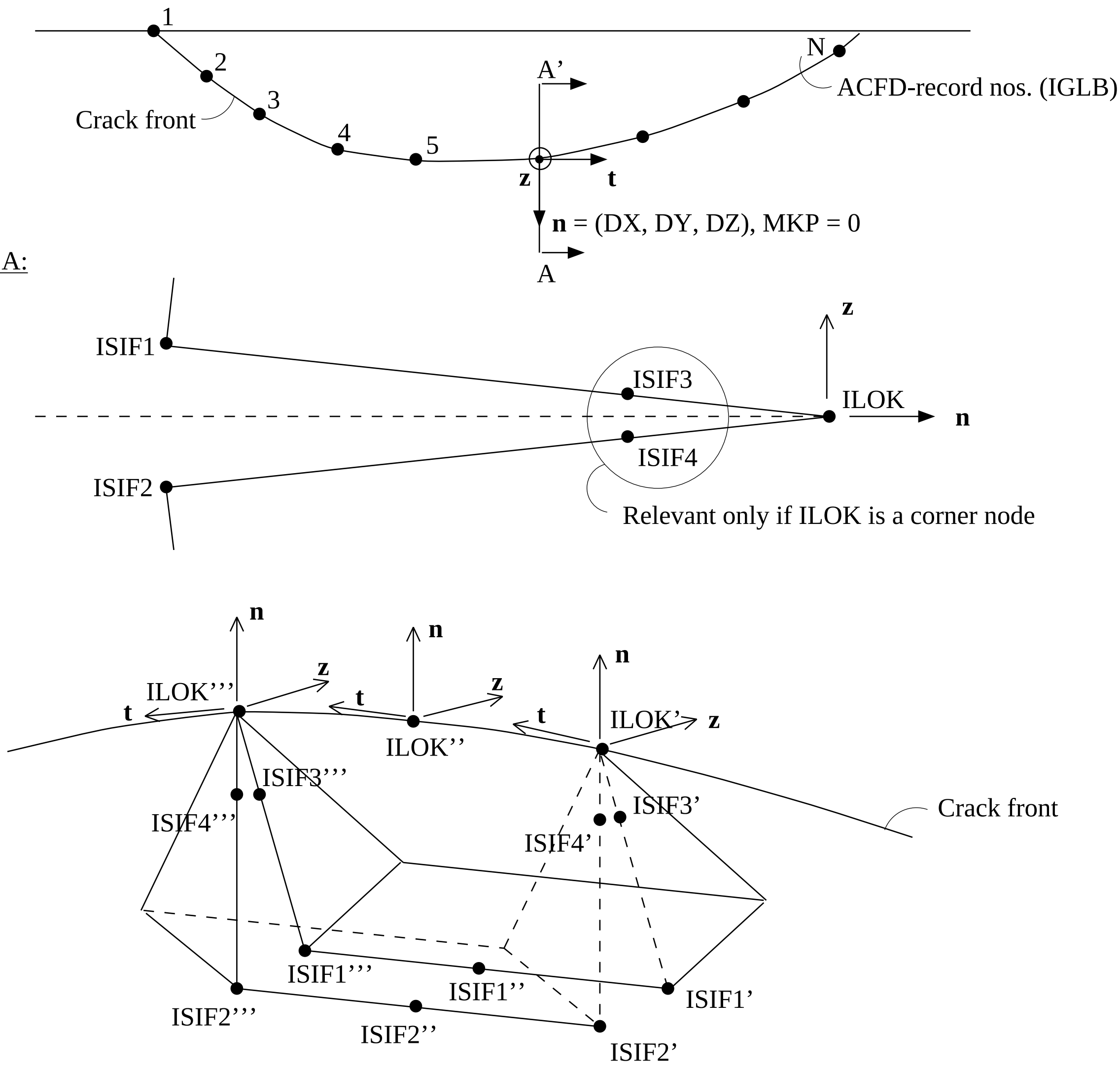


Figure 6-1 Definition of local axis-system.

Additional User defined Basic Element Data

ADDATA

ADDATA	ADDNO	NPAR	PAR1	PAR2
	. . .	. . .	PAR(NPAR)	

ADDNO Additional data type number, i.e. number referring to additional data specifications.

NPAR Number of parameters specified by user.

PAR1 PAR2 Values of the different terms of the additional data. The sequence is according to the conven-
: tion of the analysis program.
PAR(NPAR)

Whenever the analysis program requires data that are particular to a basic element of the superelement type in question (and which are not defined elsewhere) this record type may be employed to assign the data.

The data assigned above are data intended for one or several basic elements of a referenced superelement type. In the record labeled GELREF1 of that particular superelement type an ADDNO must be included which corresponds with the ADDNO of the above record.

The definition of the various parameters are depending on the analysis program to be used and must be revised when switching to another analysis program.

6.2 Boundary Conditions, Loads and Point Masses

First Level

Elements with Initial Strain Due to Thermal Expansion

BEISTE

BEISTE	LLC	LOTYP		TOP
	ELNO	NNOD	INTNO	$T1_1$
	$T2_1$	. . .	$T(NNOD)_1$	$T1_2$
	$T2_2$	. . .	$T(NNOD)_2$	

LLC Local load case number (positive integer number).

LOTYP Load type.
= 1 For all element types including shell elements with constant temperature across element thickness.
= 2 For shell elements with temperature difference across element thickness

TOP Option to temperature difference specification.
= 1 Only one temperature difference is specified. It will be the same for all nodes.
= 2 Temperature differences will be specified in all nodes.

ELNO Internal element number (generated by the program).

NNOD Number of nodes in element.

INTNO Integration station reference number. Referring to record GELINT. This reference is usually not used (=0). It means that the program performing the load calculation chooses integration points.

$T1_1$ Temperature difference at node 1, referred to element surface where z=-1.

$T2_1$ Temperature difference at node 2, referred to element surface where z=-1 etc.

$T1_2$ Temperature difference at node 1, referred to element surface where z=1 etc.

Reference to element side is used for shell elements with temperature difference across thickness. For all other situations only one temperature difference has to be specified in each node. By "temperature difference at node 1" is meant the difference between the present temperature and a reference temperature where no initial strain is acting at the node.

Flexible Joint/Hinge

BELFIX

BELFIX	FIXNO	OPT	TRANO	void
	A(1)	A(2)	A(3)	A(4)
	A(5)	A(6)		

FIXNO Fixation number to a node.
FIXNO is referenced to from GELREF.

OPT = 1 A(i) = a_i is a value between 0 and 1, and gives the degree of fixation (connectivity) to degree of freedom number i in the node. The extreme values of a is described by:
a = 0, fully released
a = 1, fully connected

= 2 A(i) = C_i is the interelement elastic spring stiffness to degree of freedom number i in the node. The degrees of freedom which are neither flexible nor free will be given $C_i = -1$ (instead of $C_i = \infty$). The relation between C_i and a_i is

$$a_i = C_i \;/\; (k_{ii} + C_i) \;\geq 0.0$$

where k_{ii} is the diagonal term of the element stiffness matrix corresponding to degree of freedom number i of the current node.

TRANO = -1 The fixation/flexibility (=A(i)) is given in the superelement coordinate system.
= 0 A(i) is given in the local element coordinate system
> 0 A(i) is given in a local coordinate system defined by TRANO, which refers to a transformation matrix given on record BNTRCOS. The transformation matrix is defined by
transformation from global to local system.

A(i) See above (under the explanation of OPT).

Surface Load on Axisymmetric Solids

BELLAX

BELLAX	LLC	LOTYP	COMPLX	
	ELNO	NDOF	INTNO	LINE
	LD	IZERO	NFF	NFL
	NFS	NF	FC(1,1)	FC(1,2)
	. . .	FC(1,NDOF)	FC(2,1)	FC(2,2)
	. . .	FC(2,NDOF)	. . .	FC(NF,1)
	. . .	FC(NF,NDOF)		

LLC Local load case number (positive integer number).

LOTYP Load type. Usually not of interest to linear programs.
= 0 not decided whether conservative or non-conservative load
= 1 conservative load
=-1 non-conservative load

COMPLX Phase shift definition.
= 0 no phase shift
= 1 phase shift
Currently not used.

ELNO Internal element number (generated by the program).

NDOF Total number of degrees of freedom along the given load line = 3 * the number of nodes.

INTNO Integration stations reference number. Referring to datatype GELINT.
Currently not used.

LINE Line specification.
See element description in Chapter 6.

LD = 1 if loading is symmetric with respect to the q=0 axis.
= 2 if loading is antisymmetric with respect to the q=0 axis.
= 3 if loading is not symmetric with respect to the q=0 axis.
q is the angle coordinate of the cylindrical coordinate system (r, z, q).

BELLAX

IZERO	= 0	if the zero harmonic is NOT included in the Fourier expansion.
	= 1	if the zero harmonic is included in the Fourier expansion.

NFF The first nonzero harmonic in the Fourier expansion of the load.

NFL The last nonzero harmonic in the Fourier expansion of the load.

NFS The harmonic increment in the Fourier expansion of the load.

NF The total number of coefficients of the Fourier expansion.
Axisymmetric load: NF=1
Non-axisymmetric load:
If LD = 1 or 2: NF = (NFL - NFF) / NFS + 1 + IZERO
If LD = 3: NF = 2 * ((NFL - NFF) / NFS + 1) + IZERO

FC(1, 1) The Fourier coefficient for the radial (R) degree of freedom of the first node for the first harmonic.

FC(1, 2) The Fourier coefficient for the tangential (q) degree of freedom of the first node for the first harmonic.

FC(1, 3) The Fourier coefficient for the axial (Z) degree of freedom of the first node for the first harmonic.

FC(1, 4) The Fourier coefficient for the radial (R) degree of freedom of the second node for the first harmonic.
:
FC(1, NDOF) The Fourier coefficient for the axial (Z) degree of freedom of the last node for the first harmonic.

FC(2,1)
FC(2,2)
: The Fourier coefficients for the degrees of freedom of the load line for the second harmonic.
FC(2,NDOF)

:

FC(NF,1)
FC(NF,2)
: The Fourier coefficients for the degrees of freedom of the load line for the last harmonic.
FC(NF,NDOF)

BELLAX

E.g. SYMMETRIC LOAD

Consider a load line with 3 nodes each with RADIAL (R), TANGENTIAL (q) and AXIAL (Z) degrees of freedom. The loads are described using the zero, first, second and third harmonics.

NDOF = 9
LD = 1
IZERO = 1

NFF = 1
NFL = 3
NFS = 1
NF = 4

FC(1,1) . . FC(1,9) : Fourier coefficients for the zero harmonic
FC(2,1) . . FC(2,9) : Fourier coefficients for the first harmonic
FC(3,1) . . FC(3,9) : Fourier coefficients for the second harmonic
FC(4,1) . . FC(4,9) : Fourier coefficients for the third harmonic

The loads for the three d.o.f.s of the first node on the load line are thus given by

P_{RADIAL} = FC(1,1) + FC(2,1)cosq + FC(3,1)cos2q + FC(4,1)cos3q
$P_{TANGENTIAL}$ = FC(1,2) + FC(2,2)sinq + FC(3,2)sin2q + FC(4,2)sin3q
P_{AXIAL} = FC(1,3) + FC(2,3)cosq + FC(3,3)cos2q + FC(4,3)cos3q

Similarly the loads for the second and third node on the load line are described using the values 4, 5, 6 and 7, 8, 9 respectively for the last index of FC.

SYMMETRIC loads (LD=1) of the RADIAL and AXIAL d.o.f.s are described using coefficients of COSINE, while the TANGENTIAL d.o.f.s are described using coefficients of SINE.

E.g. ANTISYMMETRIC LOAD

Consider a load line with 2 nodes, each with 3 degrees of freedom.
The first node has load in RADIAL(R)- and AXIAL(Z)-direction. The second node has load in RADIAL(R)- and TANGENTIAL(q)-direction. The loads are described using the second, fifth and eighth harmonics.

NDOF = 6
LD = 2
IZERO = 0
NFF = 2
NFL = 8
NFS = 3
NF = 3

BELLAX

FC(1,1) . . FC(1,6) : second harmonics
FC(2,1) . . FC(2,6) : fifth harmonics
FC(3,1) . . FC(3,6) : eighth harmonics

The loads for the first node on the load line are thus given by:

P_{RADIAL} = FC(1, 1) sin 2q + FC(2, 1) sin 5q + FC(3,1) sin 8q
P_{AXIAL} = FC(1, 3) sin 2q + FC(2, 3) sin 5q + FC(3,3) sin 8q

FC(1, 2) = FC(2, 2) = FC(3, 2) = 0.0 (no tangential load)

The loads for the second node on the load line is thus given by:

P_{RADIAL} = FC(1, 4) sin 2q + FC(2, 4) sin 5q + FC(3, 4) sin 8q
$P_{TANGENTIAL}$ = FC(1, 5) cos 2q + FC(2, 5) cos 5q + FC(3, 5) cos 8q

FC(1, 6) = FC(2, 6) = FC(3, 6) = 0.0 (no axial load)

Totally NDOF x NF = 6 x 3 = 18 coefficients will be written.

ANTISYMMETRIC loads of the RADIAL and AXIAL d.o.f.s are described using coefficients of SINE, while the TANGENTIAL d.o.f.s are described using coefficients of COSINE.

E.g. NONSYMMETRIC LOAD
Not implemented in SESTRA.

Consider 3 nodes on a load line each with RADIAL(R), AXIAL(Z) and TANGENTIAL(q) degrees of freedom. The loads are described using the zero, first and second harmonics

NDOF = 9
LD = 3
IZERO = 1
NFF = 1
NFL = 2
NFS = 1
NF = 3

FC(1,1) . . FC(1,9) : Fourier coefficients for the zero harmonic
FC(2,1) . . FC(2,9) : Fourier coefficients for the first COSINE harmonic
FC(3,1) . . FC(3,9) : Fourier coefficients for the first SINE harmonic
FC(4,1) . . FC(4,9) : Fourier coefficients for the second COSINE harmonic
FC(5,1) . . FC(5,9) : Fourier coefficients for the second SINE harmonic

BELLAX

The loads for the 3 d.o.f. of the first node on the load line is thus given by.

P_{RADIAL} = FC(1,1) + FC(2,1)cosq + FC(3,1)sinq + FC(4,1)cos2q + FC(5,1)sin2q
$P_{TANGENTIAL}$ = FC(1,2) + FC(2,2)cosq + FC(3,2)sinq + FC(4,2)cos2q + FC(5,2)sin2q
P_{AXIAL} = FC(1,3) + FC(2,3)cosq + FC(3,3)sinq + FC(4,3)cos2q + FC(5,3)sin2q

Similarly the load for the second and third node on the load line is described using the values 4, 5, 6 and 7, 8, 9 respectively for the last index of FC.

Elements with Line Loads, Solid, 3-D Shell, 2-D Shell-, Membrane and Curved Beam Elements

BELLO2

BELLO2	LLC	LOTYP	COMPLX	LAYER
	ELNO	NDOF	INTNO	LINE
	SIDE	RLOAD1	RLOAD2	. . .
	. . .	RLOAD(NDOF)	ILOAD1	ILOAD2
	. . .	. . .	ILOAD(NDOF)	

LLC Local load case number (positive integer number).

LOTYP Load type - decision of load being force or moment and if it is conservative or non-conservative. Conservative or non-conservative is usually not of interest to linear programs.
= 0 not decided whether conservative or non-conservative force per length
= 1 conservative force per length
=-1 non-conservative force per length
= 3 conservative moment per length
=-3 non-conservative moment per length

COMPLX Phase shift definition.
= 0 no phase shift
= 1 phase shift

LAYER Layer number for elements with more than one layer. If LAYER equals 0, the line load will be positioned in the shell layer (in opposition to a stiffener layer). If more than one shell layer and LAYER equals 0, the programs shall stop and give an error message. For elements which are treated as one layer in the load calculations (e.g. the sandwich element in SESTRA), LAYER does not have any meaning.

ELNO Internal element number (generated by the program).

NDOF Number of translational degrees of freedom along the given load line for line force. For line moment the variable is specifying number of rotational degrees of freedom along the given load line.

INTNO Integration stations reference number. Referring to datatype GELINT.

LINE Line specification.
See element description in Chapter 5.

BELLO2

SIDE Element side definition
See element description in Chapter 5.

RLOAD1 Real part of the load with respect to the first degree of freedom.
:
RLOAD(NDOF) Real part of the load with respect to the last degree of freedom.

ILOAD1 Imaginary part of the load with respect to the first degree of freedom.
:
ILOAD(NDOF) Imaginary part of the load with respect to the last degree of freedom.

If phase shift is not specified, i.e. COMPLX = 0, the fields or positions ILOAD1, ILOAD2, etc. are left out.

For quadrilateral membrane elements line loads can only be specified along element sides.

It will make no sense to specify line moment for membrane and solid type of elements.

Beams with Line Loads

BELOAD1

BELOAD1	LLC	LOTYP	COMPLX	OPT
	ELNO	L1	L2	EDOF
	INTNO	RINT1	RINT2	. . .
	. . .	RINT(EDOF)	IINT1	IINT2
	. . .	. . .	. . .	IINT(EDOF)

LLC — Local load case number (positive integer number).

LOTYP — Load type - decision of load being force or moment and if it is conservative or non-conservative. Conservative or non-conservative is usually not of interest to linear programs.
- = 0 not decided whether conservative or non-conservative load
- = 1 True distributed force, conservative load
- = 2 Simulated concentrated force, conservative load
- = 3 True distributed moment, conservative load
- = 4 Simulated concentrated moment, conservative load
- =-1 True distributed force, non-conservative load
- =-2 Simulated concentrated force, non-conservative load
- =-3 True distributed moment, non-conservative load
- =-4 Simulated concentrated moment, non-conservative load

COMPLX — Phase shift definition.
- = 0 no phase shift
- = 1 phase shift

OPT — Option for reference of L1 and L2 (see below).
- = 0 L1 and L2 are distances measured from the ends of the flexible part of the beam
- = 1 L1 and L2 are distances measured along the beam axis from the projection of the end nodes on the beam axis

ELNO — Internal element number (generated by the program).

L1 — Distance along the beam from end node 1 to position on beam where the line load starts acting. The distance is in the interval [0, length-of-beam].

L2 — Distance along the beam from end node 2 to position on beam where the line load ends acting.

EDOF — Product of last degree of freedom with specified load and the number of nodes of the beam in question (= 3*NNOD for 3-dimensional beams)

BELOAD1

INTNO	Integration station reference number. Referring to record GELINT.
RINT1	The real part of the intensity with respect to the first degree of freedom of the first load point.
RINT2 :	The real part of the global intensity with respect to the second degree of freedom of the first load point.
RINT(EDOF)	The real part of the global intensity with respect to the last degree of freedom with load of the last load point.
IINT1	The imaginary part of the global intensity with respect to the first degree of freedom of the first load point.
IINT2 :	The imaginary part of the global intensity with respect to the second degree of freedom of the first load point.
IINT(EDOF)	The imaginary part of the global intensity with respect to the last degree of freedom with load of the last load point.

The legal degrees of freedom are the translational components, given in the global coordinate system.

The imaginary numbers follow immediately after the real numbers, i.e. there are no blank fields between the last real part and the first imaginary part.

For the two noded beam element BEAS, the line of action of the load will be the axes through the shear center.

In order to clearify the meaning of EDOF, imagine a beam element with three nodal points. If translatory loads are applied in the global y- and z-direction, the last degree of freedom to have load specified is the third degree of freedom. EDOF will therefore in this case be 3 x 3 = 9. The load intensity for the x-direction will be included, but with the value zero of course.

If the line of application of the line load does not match the node positioning along the beam, the following example will hopefully explain how this problem is solved on the interface file. Node1 (see Figure 6-2) will have the intensity zero, whereas node2 will have the intensity corresponding to the correct intensity at the starting point of the line load. The real point of application (used in the integration process) of course is governed by L1.

BELOAD1

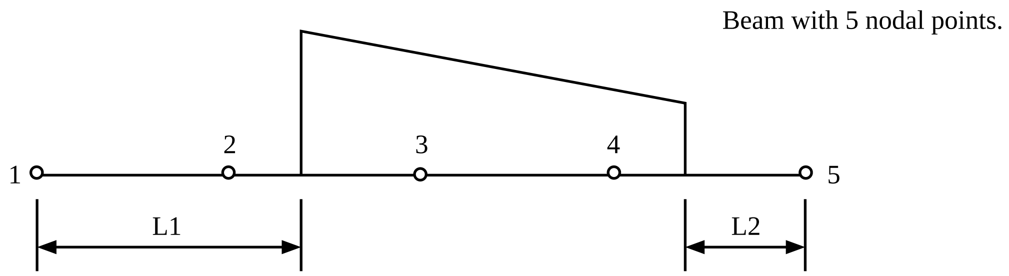


Figure 6-2 The sequence of the record is arbitrary. Much time will be saved in SESTRA if all loads belonging to the same element are in sequence and in ascending order.

Hydrodynamic Drag and Damping from Wave Load Program

BEDRAG1

BEDRAG1		ELNO		NP
	XI(1)	XI(2)	. . .	XI(NP)
	DRG(1,1)	DRG(2,1)	DRG(3,1)	DRG(1,2)
	. . .	DRG(3,NP)		

ELNO	Program defined (internal) element number.
NP	Number of points.
XI(i)	(Distance from end 1 to load point "i") / LTOT
DRG(j, i)	Drag or Damping intensity for the j'th d.o.f. in member local coordinate system as defined by relevant GUNIVEC record at point "i".

The data type BEDRAG1 is generated by WAJAC. This data type may only be used for element type BEAS(15), with no user defined local coordinate system. The data type should not be used for new applications.

Hydrodynamic added Mass from Wave Load Program

BEMASS1

BEMASS1		ELNO		NP
	XI(1)	XI(2)	. . .	XI(NP)
	AM(1,1)	AM(2,1)	AM(3,1)	AM(1,2)
	. . .	AM(3,NP)		

ELNO Program defined (internal) element number.

NP Number of points.

XI(i) (Distance from end 1 to load point "i") / LTOT

AM(j, i) Added mass intensity for the j'th d.o.f. in member local coordinate system as defined by relevant GUNIVEC record at point "i".

The data type BEMASS1 is generated by WAJAC and WADAM and may only be read by SESTRA. This data type may only be used for element type BEAS(15), with no user defined local coordinate system. The data type should not be used for new applications.

Elements with Surface Loads

BEUSLO

BEUSLO	LLC	LOTYP	COMPLX	LAYER
	ELNO	NDOF	INTNO	SIDE
	$RLOAD_1$	$RLOAD_2$	. . .	. . .
	RLOAD(NDOF)	$ILOAD_1$	. . .	ILOAD(NDOF)

LLC Local load case number (positive integer number).

LOTYP Load type.
= 1 normal pressure, conservative load
= 2 load given in component form, conservative load
= 3 dummy hydro pressure, used to indicate the direction of hydrostatic / hydrodynamic pressure to be computed by a hydrodynamic load program.
=-1 normal pressure, non-conservative load
=-2 load given in component form, non-conservative load

COMPLX Phase shift definition.
= 0 no phase shift
= 1 phase shift

LAYER Layer number for elements with more than one layer. If LAYER equals 0, the surface load will be positioned in the shell layer (in opposition to a stiffener layer). If more than one shell layer and LAYER equals 0, the programs shall stop and give an error message. For elements which are treated as one layer in the load calculations (e.g. the sandwich element in SESTRA), LAYER does not have any meaning.

ELNO Internal element number (generated by the program).

NDOF If LOTYP = 1 number of nodes of the specified element side
If LOTYP = 2 number of translational degrees of freedom of the specified element side
If LOTYP = 3 NDOF= 1

INTNO Integration station reference number. Referring to record GELINT. This reference is usually not used (=0). It means that the program performing the load calculation chooses integration points.

SIDE Side definition
For shell elements:
= 1 loads referred to element side where z=-1
= 2 loads referred to element side where z= 0
= 3 loads referred to element side where z= 1
For solid elements:

BEUSLO

SIDE will be a six figures number for a hexahedron, a five figures number for a prism and a four figures number for a tetrahedron, consisting of zeroes with 1 for the side with load. For instance 000100 for a hexahedron means load on side no. 4.
For further description, see Chapter 5.2.

RLOAD1 The real part of the load with respect to the first degree of freedom or first node of the element side if normal pressure.

RLOAD2 The real part of the load with respect to the second degree of freedom or second node of the element side.
:
RLOAD(NDOF) The real part of the load with respect to the last degree of freedom or last node of the element side.

ILOAD1 The imaginary part of the load with respect to the first degree of freedom or first node of the element side.

ILOAD2 The imaginary part of the load with respect to the second degree of freedom or second node of the element side.
:
ILOAD(NDOF) The imaginary part of the load with respect to the last degree of freedom or last node of the element side.

If LOTYP= 3, RLOAD= ±1.0 indicating which side the element pressure comes from. (+1 indicates shell element SIDE= 1(z=-1), -1 indicates shell element SIDE= 3 (z=1)). For solids when LOTYP = 3, RLOAD must be +1.0.

If phase shift is not specified, i.e. COMPLX = 0, the fields or positions ILOAD1, ILOAD2, etc. are left out.

Normal pressure means that only one pressure component is specified for each node, and this pressure component is acting normal to the surface.

For volume elements a positive value means normal pressure directed into the element. For shell elements, a positive value means normal pressure in the local z-direction.

Elements with Volume Forces, 3-D Solid, 2-D Shell and Membrane Elements

BEUVLO

BEUVLO	LLC	LOTYP	COMPLX	
	ELNO	NDOF	INTNO	RLOAD1
	. . .	RLOAD(NDOF)	ILOAD1	. . .
	ILOAD(NDOF)			

LLC Local load case number (positive integer number).

LOTYP Load type. Usually not of interest to linear programs.
= 0 not decided whether conservative or non-conservative load
= 1 loads given as nodal accelerations, conservative load
= 2 loads given as nodal force intensities, conservative load
=-1 loads given as nodal accelerations, non-conservative load
=-2 loads given as nodal force intensities, non-conservative load

COMPLX Phase shift definition.
= 0 no phase shift
= 1 phase shift

ELNO Internal element number (generated by the program).

NDOF Number of translational degrees of freedom.

INTNO Integration station reference number. Referring to record GELINT.

RLOAD1 The real part of the load with respect to the first degree of freedom.
:
RLOAD(NDOF) The imaginary part of the load with respect to the last degree of freedom.

If phase shift is not specified, i.e. COMPLX = 0, the fields or positions ILOAD1, ILOAD2, etc. are left out.

Note: This data type is *not* available in SESAM.

Wave Kinematics

BEWAKIN

BEWAKIN	LLC	ELNO	COMPLX	NP
	LTOT	L(1)	L(2)	. . .
	L(NP)	η(1)	VX(1)	VY(1)
	VZ(1)	AX(1)	AY(1)	AZ(1)
	η(2)	VX(2)	VY(2)	. . .
	AY(NP)	AZ(NP)		

LLC	Local load case number (positive integer number).
ELNO	Internal element number (generated by the program).
COMPLX	Complex data flag (= 1 if complex data, = 0 if real data).
NP	Number of points.
LTOT	Total element length.
L(i)	Distance from end 1 to point "i".
η(i)	Sea surface position above point "i".
VX(i)	Wave particle velocity in X-direction
VY(i)	Wave particle velocity in Y-direction
VZ(i)	Wave particle velocity in Z-direction
AX(i)	Wave particle acceleration in X-direction
AY(i)	Wave particle acceleration in Y-direction
AZ(i)	Wave particle acceleration in Z-direction

Elevation, particle velocity and particle acceleration are given in the coordinate system of the superelement in question.

The datatype BEWAKIN may optionally be generated by WAJAC, and should not be used for new applications.

Element Loads from Wave Load Program

BEWALO1

BEWALO1	LLC	ELNO	COMPLX	NP
	LTOT	L(1)	L(2)	. . .
	L(NP)	FR(1, 1)	FR(2, 1)	FR(3, 1)
	FR(1, 2)	. . .	FR(3, NP)	FI(1, 1)
	FI(2, 1)	. . .	FI(3, NP)	

LLC Local load case number (positive integer number).

ELNO Internal element number (generated by the program).

COMPLX Complex loads flag (=1 if complex loads, =0 if real loads).

NP Number of load points.

LTOT Total element length.

L(i) Distance from end 1 to load point "i".

FR(j, i) Real component of force for the j’th d.o.f. atload point "i". Here j Î [1,3] for the and Y or Z direction respectively.

FI(j, i) Imaginary component of force for the j’th d.o.f. at load point "i".Here j Î [1,3] for the and Y or Z direction respect

Forces are given in the coordinate system of the superelement in question.

When unformatted the records are packed in the following manner:

The first record contains 6 words (as for all other record types).

The next record contains the rest of the information, and the variable record length must be computed as:

NW = 1 + (4 + COMPLX*3)*NP
or NW = 1 + 4*NP if real loads
and NW = 1 + 7*NP if complex loads

The data type BEWALO1 is only generated by WAJAC and may only be read by SESTRA. The data type should not be used for new applications.

Gravitational Load (Constant of Gravity)

BGRAV

BGRAV	LLC			OPT
	GX	GY	GZ	

LLC Local load case number (positive integer number).

OPT Option for weight contribution of stiff ends for beam element.
= 0 only flexible part of the beam contributes to the gravitational load
= 1 stiff ends also contribute to the gravitational load.

GX Component of constant of gravity in the global x-direction.

GY Component of constant of gravity in the global y-direction.

GZ Component of constant of gravity in the global z-direction.

Only the constant of gravity is stored on the Interface File. The actual gravitational load is computed in the analysis program where the element routines are available.

Nodes with Linear Dependence

BLDEP

BLDEP	NODENO	CNOD	NDDOF	NDEP
	$DEPDOF_1$	$INDEPDOF_1$	$b_{DEP1,INDEP1}$	
	$DEPDOF_2$	$INDEPDOF_2$	$b_{DEP2,INDEP2}$	
	. . .	. . .	. . .	
	$DEPDOF_{NDEP}$	$INDEPDOF_{NDEP}$	$b_{DEPn,INDEPn}$	

NODENO Internal node number of the dependent node.

CNOD Internal node number of an independent node.

NDDOF Number of dependent degrees of freedom of node NODENO. When not specified, NDDOF is equal to NDEP.

NDEP Number of triplets with DEPDOF, INDEPDOF and $b_{i,j}$

DEPDOF[1] Dependent node's degree of freedom.

INDEPDOF[1] Independent node's degree of freedom.

$b_{i,j}$ The contribution of the j'th degree of freedom of the independent node to the i'th degree of freedom of the dependent node.

Each line specifies one dependent degree of freedom which is dependent on the independent node's specified degree of freedom with the factor $b_{i,j}$. The degrees of freedom must also be specified on BNBCD-records as linear dependent (3) for the dependent node, and as retained (4) for the independent node.

A node may be dependent on many nodes. For each combination of NODENO and CNOD a new record, starting with the identifier BLDEP, is given.

The same combination of NODENO and CNOD may occur only once.

When node transformations have been specified for any of the nodes implied in the linear dependence, the degrees of freedom refers to the transformed local coordinate system.

1DEPDOF and
one degree of f
dom is the z-tra

BLDEP

Multipoint constraints (2nd and higher order dependence) may be specifed through more BLDEP records with the same linear dependent node and different independent nodes. The factors $b_{i,j}$ may be found as Lagrange multiplicators or coefficients (Lagrange interpolation polynomial). For 2nd order dependence this may as well be specified on one BQDP record.

Nodes with Acceleration Load

BNACCLO

BNACCLO	LLC	LOTYP	COMPLX	
	NODENO	NDOF	RLOAD1	RLOAD2
	. . .	. . .	RLOAD(NDOF)	ILOAD1
	ILOAD2		. . .	. . .
	. . .	ILOAD(NDOF)		

LLC Local load case number (positive integer number).

LOTYP Load type. Not used.

COMPLX Phase shift definition.
= 0 no phase shift
= 1 phase shift

NODENO Program defined node number.

NDOF Number of degrees of freedom at the node NODENO.

RLOAD1 The real part of the acceleration with respect to the first degree of freedom.

RLOAD2 The real part of the acceleration with respect to the second degree of freedom.
:
RLOAD(NDOF) The real part of the acceleration with respect to the last degree of freedom.

ILOAD1 The imaginary part of the acceleration with respect to the first degree of freedom (Only if COMPLX = 1).

ILOAD2 The imaginary part of the acceleration with respect to the second degree of freedom.
:
ILOAD(NDOF) The imaginary part of the acceleration with respect to the last degree of freedom.

The imaginary numbers follow immediately after the real numbers, i.e. there are no blank fields between the last real part and the first imaginary part.

If phase shift is not specified, i.e. COMPLEX = 0, the fields or positions ILOAD1, ILOAD2, etc. are left out.

Note that acceleration value (not inertia load) is given.

Nodes with Boundary Conditions

BNBCD

BNBCD	NODENO	NDOF	FIX1	FIX2
	. . .	. . .	FIX(NDOF)	

NODENO Internal node number of nodes with specified boundary condition.

NDOF Number of degrees of freedom.

FIX1
FIX2
:
:
FIX(NDOF)

Specification of boundary condition codes of relevant degrees of freedom.

The codes of FIX1, FIX2 ....., FIX(NDOF) are explained below:

FIX1	= 0	free to stay
FIX2	= 1	fixed at zero displacement, temperature, etc.
:	= 2	prescribed displacement, temperature, different from zero
:	= 3	linearly dependent
FIX(NDOF)	= 4	retained degree of freedom.

The code FIX = 2 just indicates specified condition for the relevant degree of freedom. Whether it is displacement, first time derivative of the displacement etc. is definde on the BNDISPL record. Degrees of freedom with FIX = 2 which are not defined on the BNDISPL record will be fixed (have zero displacement, velocity and acceleration).

The nodes (degrees of freedom) with FIX = 4 are called supernodes (super degrees of freedom). The supernode sequence numbering is according to the increasing order of their internal node number.

Nodes with Prescribed Displacements and Accelerations **BNDISPL**

BNDISPL	LLC	DTYPE	COMPLX	
	NODENO	NDOF	RDISP1	RDISP2
	. . .	. . .	. . .	RDISP(NDOF)
	IDISP1	IDISP2	. . .	. . .
	. . .	IDISP(NDOF)		

LLC Local load case number (positive integer number).

DTYPE Type of boundary condition.
= 1 specified displacement
= 3 specified acceleration

COMPLX Phase shift definition.
= 0 no phase shift
= 1 phase shift

NODENO Program defined node number.

NDOF Number of degrees of freedom at the node NODENO.

RDISP1 The real part of the specified boundary condition with respect to the first degree of freedom.

RDISP2 The real part of the specified boundary condition with respect to the second degree of freedom.
:
RDISP(NDOF) The real part of the specified boundary condition with respect to the last degree of freedom.

IDISP1 The imagenary part of the specified boundary condition with respect to the first degree of freedom.

IDISP2 The imaginary part of the specified boundary condition with respect to the second degree of freedom.
:
IDISP(NDOF) The imaginary part of the specified boundary condition with respect to the last degree of freedom.

RDISP and IDISP refer to the transformed coordinate system if the node NODENO is transformed, else to the global coordinate system of the superelement.

The imaginary numbers follow immediately after the real numbers, i.e. there are no blank fields between the last real part and the first imaginary part.

BNDISPL

If phase shift is not specified, the fields or positions IDISP1, IDISP2, etc. are left out.

Nodes with Transformation

BNDOF

BNDOF	NODENO	TRANSNOD	TRANSNOR	

NODENO Program defined node number.

TRANSNOD Reference number to the transformed coordinate system of the displacements, defined on data type BNTRCOS.

TRANSNOR Reference number to the transformed coordinate system of the rotations, defined on data type BNTRCOS.

If no reference number is given, no transformation is relevant to the relevant type of degree of freedom, i.e. translations or rotations.

Nodes with Initial Conditions If Arbitrary Time Dependent Loading

BNINCO

BNINCO	INCONO	DTYPE		
	NODENO	NDOF	RDISP1	RDISP2
	RDISP3	RDISP4	RDISP5	RDISP6

INCONO Initial condition number.

DTYPE Type of condition.
=1 Displacement
=2 Velocities
Both initial displacements and velocities may be specified, but on separate BNINCO records.

NODENO Internal node number.

NDOF Number of degrees of freedom for node.

RDISP1
RDISP2
: Values in the degrees of freedom.
RDISP(NDOF)

Nodes with Loads

BNLOAD

BNLOAD	LLC	LOTYP	COMPLX	
	NODENO	NDOF	RLOAD(1)	RLOAD(2)
	. . .	. . .	RLOAD(NDOF)	ILOAD(1)
	ILOAD(2)		. . .	. . .
	. . .	ILOAD(NDOF)		

LLC Local load case number (positive integer number).

LOTYP Load type at node NODENO. Usually not of interest to linear programs.
= 0 not decided whether conservative or non-conservative load
= 1 conservative load
=-1 non-conservative load

COMPLX Phase shift definition.
= 0 no phase shift
= 1 phase shift

NODENO Program defined node number.

NDOF Number of degrees of freedom at the node NODENO.

RLOAD(1) The real part of the load with respect to the first degree of freedom.

RLOAD(2) The real part of the load with respect to the second degree of freedom.
:
RLOAD(NDOF) The real part of the load with respect to the last degree of freedom.

ILOAD(1) The imaginary part of the load with respect to the first degree of freedom. (Only if COMPLX=1).

ILOAD(2) The imaginary part of the load with respect to the second degree of freedom.
:
ILOAD(NDOF) The imaginary part of the load with respect to the last degree of freedom.

The imaginary numbers follow immediately after the real numbers, i.e. there are no blank fields between the last real part and the first imaginary part.

If phase shift is not specified, i.e. COMPLX = 0, the fields or positions ILOAD1, ILOAD2, etc. are left out.

Nodes with Loads (Line Load) for Axisymmetric Solids

(Proposal)

BNLOAX

BNLOAX	LLC	LOTYP	COMPLX	
	NODENO	NDOF		
	LD	IZERO	NFF	NFL
	NFS	NF	FC(1,1)	FC(1,2)
	. . .	FC(1,NDOF)	FC(2,1)	FC(2,2)
	. . .	FC(2,NDOF)	. . .	FC(NF,1)
	. . .	FC(NF,NDOF)		

LLC — Local load case number (positive integer number).

LOTYP — Load type at node NODENO. Usually not of interest to linear programs.
= 0 not decided whether conservative or non-conservative load
= 1 conservative load
=-1 non-conservative load

COMPLX — Phase shift definition.
= 0 no phase shift
= 1 phase shift
Currently not used.

NODENO — Program defined node number.

NDOF — Number of degrees of freedom at the node NODENO.

LD — = 1 if loading is symmetric with respect to the q=0 axis.
= 2 if loading is antisymmetric with respect to the q=0 axis.
= 3 if loading is not symmetric with respect to the q=0 axis.
q is the angle coordinate of the cylindrical coordinate system (r, z, q).

IZERO — = 0 if the zero harmonic is NOT included in the Fourier expansion of the load.
= 1 if the zero harmonic is included in the Fourier expansion of the load.

NFF — The first nonzero harmonic in the Fourier expansion.

BNLOAX

NFL The last nonzero harmonic in the Fourier expansion.

NFS The harmonic increment in the Fourier expansion.

NF The total number of harmonics of the Fourier expansion.
Given by

$$NF = (NFL - NFF) / NFS + 1 + IZERO$$

FC(1,1)
FC(1,2)
: The Fourier coefficients for the degrees of freedom of the node, for the first harmonic.
FC(1,NDOF)

FC(2,1)
FC(2,2)
: The Fourier coefficients for the degrees of freedom of the node, for the second harmonic.
FC(2,NDOF)

:

FC(NF,1)
FC(NF,2)
: The Fourier coefficients for the degrees of freedom of the node, for the last harmonic.
FC(NF,NDOF)

Please see the BELLAX record for examples.

Nodes with Point Masses

BNMASS

BNMASS	NODENO	NDOF	MASS1	MASS2
	. . .	. . .	MASS(NDOF)	

NODENO	Program defined node number.
NDOF	Number of degrees of freedom.
MASS1	Mass with respect to the first degree of freedom.
MASS2	Mass with respect to the second degree of freedom.
:	
MASS(NDOF)	Mass with respect to the last degree of freedom (NDOF).

MASS refer to the transformed coordinate system if the node NODENO is transformed, else to the global coordinate system of the superelement.

A more general method for specifying mass is the mass element GMAS(11), specified with the GELMNT1 and the MGMASS record.

Nodes with Temperatures and Derivatives for Temperatures

BNTEMP

BNTEMP	LLC	DTYPE	COMPLX	
	NODENO	NDOF	RTEMP(1)	RTEMP(2)
	. . .	. . .	. . .	RTEMP(NDOF)
	ITEMP(1)	ITEMP(2)	. . .	. . .
	. . .	ITEMP(NDOF)		

LLC Local load case number (positive integer number).

DTYPE Type of boundary condition.
= 1 specified temperature
= 2 specified first time derivative of the temperature
= 3 specified second time derivative of the temperature

COMPLX Phase shift definition.
= 0 no phase shift
= 1 phase shift

NODENO Program defined node number.

NDOF Number of degrees of freedom at the node NODENO.

RTEMP(1) The real part of the specified boundary condition with respect to the first degree of freedom.

RTEMP(2) The real part of the specified boundary condition with respect to the second degree of freedom.
:
RTEMP(NDOF) The real part of the specified boundary condition with respect to the last degree of freedom.

ITEMP(1) The imaginary part of the specified boundary condition with respect to the first degree of freedom.

ITEMP(2) The imaginary part of the specified boundary condition with respect to the second degree of freedom.
:
ITEMP(NDOF) The imaginary part of the specified boundary condition with respect to the last degree of freedom.

BNTEMP

The imaginary numbers follow immediately after the real numbers, i.e. there are no blank fields between the last real part and the first imaginary part.

If phase shift is not specified, the fields or positions ITEMP(1), ITEMP(2), etc. are left out.

Note: This data type is *not* available in SESAM.

Transformation from Global to Local Coordinate System, Direction Cosines

BNTRCOS

BNTRCOS	TRANSNO	C11	C21	C31
	C12	C22	C32	C13
	C23	C33	0	0

TRANSNO Reference number to the transformed coordinate system.

C11
C21
C31
: Terms (9 direction cosines) of the transformation matrix (rotation).
C23 For 2-D models all 9 values should be given and the program reading the record must extract
C33 the values C11, C21, C12 and C22 from this matrix.

The transformation matrix **c** describes the tranformation defined by

r’ = **c r**

where **r’** refers to the local coordinate system and **r** to the global (superelement) coordinate system.

The GUNIVEC records are used for beam elements only, i.e. basic element types 2, 15 and 23. Other basic element types may refer to BNTRCOS records. No ambiguity thus exists if both a GUNIVEC and BNTRCOS record have same TRANSNO, but they should preferrably have separate numbering (TRANSNO) to avoid possible program problems.

Node Loads from Wave Load Program

BNWALO

BNWALO	LLC	NODENO	COMPLX	NDOF
	FR(1)	. . .	FR(NDOF)	FI(1)
	. . .	FI(NDOF)		

LLC Local load case number (positive integer number).

NODENO Program defined node number.

COMPLX Complex loads flag (=1 if complex loads).

NDOF Number of d.o.f.s for which loads are given.

FR(j) Real component of force for the j'th d.o.f.

FI(j) Imaginary component of force for the j'th d.o.f.

When unformatted the records are packed in the following manner:

The first record contains 6 words.

The next record contains the rest of the information:
NW = (1 + COMPLX)*NDOF
or NW = NDOF if real loads
and NW = 2*NDOF if complex loads

All other record types on the interface file are written with 6 words on each record, where the first two words are reserved for the character string identifier. These positions are blank on the second and following images, until the beginning of a new record is reached.

The data type BNWALO is only generated by WAJAC and may only be read by SESTRA. The data type should not be used for new applications.

Rigid Body Acceleration

BRIGAC

BRIGAC	LLC		COMPLX	
	XCOORD	YCOORD	ZCOORD	
	$RACCL_1$	$RACCL_2$	$RACCL_3$	$RACCL_4$
	$RACCL_5$	$RACCL_6$	$IACCL_1$	$IACCL_2$
	$IACCL_3$	$IACCL_4$	$IACCL_5$	$IACCL_6$

This record describes an acceleration of a point in a rigid body. It is to be used for calculation of forces of inertia. The position of the point is specified by its coordinates on the record. All rotations are in radians.

LLC — Local load case number (positive integer number).

COMPLX — Phase shift definition. If COMPLX is 0, only the real parts of the acceleration values will be stored. This means that number of data fields on this record (including embedded blank fields) then will be 14 instead of 20.
= 0 no phase shift
= 1 phase shift

XCOORD, YCOORD, ZCOORD — Cartesian X-, Y- and Z-coordinates of the point of acceleration. The coordinates are defined relative to the superelement global coordinate system.

$RACCL_n$ — The real part of the rigid body acceleration with respect to degree of freedom no. 'n'. The three first degrees of freedom are translational accelerations and the next three are angular accelerations (in radians per second squared).

$IACCL_n$ — The imaginary part of the rigid body acceleration with respect to degree of freedom no. 'n'. The imaginary parts are given only if COMPLX= 1. The three first degrees of freedom are translational accelerations and the next three are angular accelerations (in radians per second squared).

Rigid Body Displacement

BRIGDI

BRIGDI	LLC		COMPLX	
	XCOORD	YCOORD	ZCOORD	
	$RDISP_1$	$RDISP_2$	$RDISP_3$	$RDISP_4$
	$RDISP_5$	$RDISP_6$	$IDISP_1$	$IDISP_2$
	$IDISP_3$	$IDISP_4$	$IDISP_5$	$IDISP_6$

This record describes a displacement of a point in a rigid body. The position of the point is specified by its coordinates on the record. All rotations are in radians.

LLC — Local load case number (positive integer number).

COMPLX — Phase shift definition. If COMPLX is 0, only the real parts of the displacement values will be stored. This means that number of data fields on this record (including embedded blank fields) then will be 14 instead of 20.
= 0 no phase shift
= 1 phase shift

XCOORD YCOORD ZCOORD — Cartesian X-, Y- and Z-coordinates of the point of displacement. The coordinates are defined relative to the superelement global coordinate system.

$RDISP_n$ — The real part of the rigid body displacement with respect to degree of freedom no. 'n'. The three first degrees of freedom are translations and the next three are rotations (in radians).

$IDISP_n$ — The imaginary part of the rigid body displacement with respect to degree of freedom no. 'n'. The imaginary parts are given only if COMPLX= 1. The three first degrees of freedom are translations and the next three are rotations (in radians).

Rigid Body Velocity

BRIGVE

BRIGVE	LLC		COMPLX	
	XCOORD	YCOORD	ZCOORD	
	$RVELO_1$	$RVELO_2$	$RVELO_3$	$RVELO_4$
	$RVELO_5$	$RVELO_6$	$IVELO_1$	$IVELO_2$
	$IVELO_3$	$IVELO_4$	$IVELO_5$	$IVELO_6$

This record describes a displacement, velocity and an acceleration of a point in a rigid body. The rotational part of the velocity yields centrifugal forces of inertia. The position of the point is specified by its coordinates on the record. All rotations are in radians.

LLC — Local load case number (positive integer number).

COMPLX — Phase shift definition. If COMPLX is 0, only the real parts of the velocity values will be stored. This means that number of data fields on this record (including embedded blank fields) then will be 14 instead of 20.
= 0 no phase shift
= 1 phase shift

XCOORD YCOORD ZCOORD — Cartesian X-, Y- and Z-coordinates of the point of velocity. The coordinates are defined relative to the superelement global coordinate system.

$RVELO_n$ — The real part of the rigid body velocity with respect to degree of freedom no. 'n'. The three first degrees of freedom are translational velocities and the next three are rotational (in radians per second).

$IVELO_n$ — The imaginary part of the rigid body velocity with respect to degree of freedom no. 'n'. The imaginary parts are given only if COMPLX= 1. The three first degrees of freedom are translational velocities and the next three are angular (in radians per second).

Nodes with Simple Quadratic Dependence

BQDP

BQDP	NODENO	DDOF		
	CNOD1	$CDOF_1$	$BETA_1$	$CDOF_2$
	$BETA_2$	. . .	. . .	$CDOF_{DDOF}$
	$BETA_{DDOF}$			
	CNOD2	. . .	. . .	. . .
	CNOD3	. . .	. . .	. . .

NODENO — Program defined node number of the dependent node.

DDOF — Dependent degrees of freedom of NODENO. (Must correspond with the number of degrees of freedom with the code FIX = 3 referenced in BNBCD for the very same node.)

CNOD1 — Node number of the first independent node.

$CDOF_1$ — The first relevant degree of freedom of CNOD1 which is coupled to the corresponding dependent degree of freedom of NODENO.

$BETA_1$ — The corresponding contribution of the first relevant degree of freedom of CNOD1 to the quadratic dependence of the corresponding dependent degree of freedom of NODENO.

$CDOF_2$ — The second relevant degree of freedom of CNOD1 which is coupled to the corresponding dependent degree of freedom of NODENO.

$BETA_2$ — The corresponding contribution of the second relevant degree of freedom of CNOD1 to the quadratic dependence of the corresponding dependent degree of freedom of NODENO.

:

$CDOF_{DDOF}$ — The last relevant degree of freedom of CNOD1 which is coupled to the corresponding dependent degree of freedom of NODENO.

$BETA_{DDOF}$ — The corresponding contribution of the last relevant degree of freedom of CNOD1 to the quadratic dependence of the corresponding dependent degree of freedom of NODENO.

CNOD2 — As above for the second independent node.

:

CNOD3 — As above for the third and last independent node.

Note: This data type is *not* available in SESAM.

6.3 Nodal Data and Element Geometry Definition

First Level

Cross Section Type Massive Bar

GBARM

GBARM	GEONO	HZ	BT	BB
	SFY	SFZ	NLOBY	NLOBZ

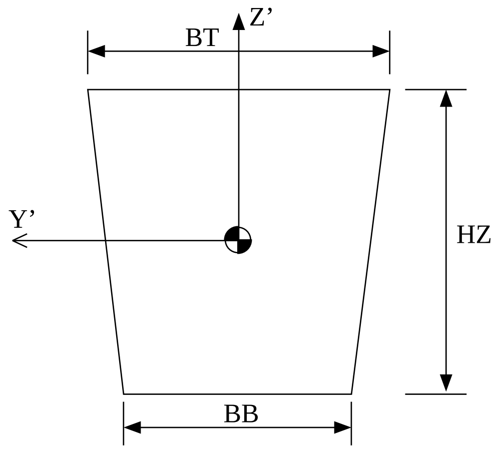


Figure 6-3 Massive bar

GEONO	Geometry type number, i.e. reference number used for element data definition of geometry properties (Cross sectional properties) of beams.
HZ	Height of beam.
BT	Width of bar at top. For massive bars which are not able to have different widths at top and bottom this variable is used as the width of the beam.
BB	Width of bar at bottom.
SFY, SFZ	Factors modifying the shear areas calculated by the preprocessor program such that the modified shear areas are respectively SHARY(MOD) = SHARY(PROG) · SFY SHARZ(MOD) = SHARZ(PROG) · SFZ (The shear areas on GBEAMG are SHARY(MOD) and SHARZ(MOD)).
NLOBY	Number of integration points in Y' direction (optional)
NLOBZ	Number of integration points in Z' direction (optional)

General Beam Element Data

GBEAMG

GBEAMG	GEONO	void	AREA	IX
	IY	IZ	IYZ	WXMIN
	WYMIN	WZMIN	SHARY	SHARZ
	SHCENY	SHCENZ	SY	SZ

The succeding data concern the cross section at a specific local node.

GEONO	Geometry number, referenced to on GELREF1
AREA	Cross section area
IX	Torsional moment of inertia about the shear center
IY	Moment of inertia about the y axis = $\int z^2\,dA$
IZ	Moment of inertia about the z axis= $\int y^2\,dA$
IYZ	Product of inertia about y and z axis= $\int yz\,dA$
WXMIN	Minimum torsional section modulus about shear center (=IX/rmax for a PIPE element)
WYMIN	Minimum sectionmodulus about y axis = IY/zmax
WZMIN	Minimum sectionmodulus about z axis = IZ/ymax
SHARY	Shear area in the direction of y axis. If zero, shear is not included.
SHARZ	Shear area in the direction of z axis. If zero, shear is not included.
SHCENY	Shear center location y component
SHCENZ	Shear center location z component
SY	Static area moment about y-axis = $\int z\,dA$
SZ	Static area moment about z-axis = $\int y\,dA$

If GBEAMG is used for ELTYP 10 (Truss element) only the first record may be on the interface.

Cross Section Type Box Beam

GBOX

GBOX	GEONO	HZ	TY	TB
	TT	BY	SFY	SFZ
	NLOBY	NLOBZ		

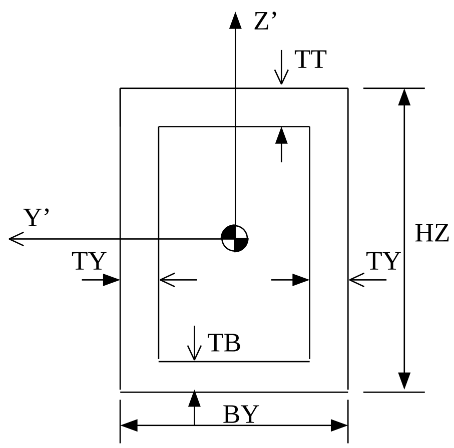


Figure 6-4 Box beam

GEONO	Geometry type number, i.e. reference number used for element data definition of geometry properties (Cross sectional properties) of beams.
HZ	Height of beam at current location
TY	Thickness of vertical walls (webs) of box section
TB	Thickness of bottom flange
TT	Thickness of top flange
BY	Width of box beam
SFY, SFZ	Factors modifying the shear areas calculated by the preprocessor program such that the modified shear areas are respectively, SHARY(MOD) = SHARY(PROG) · SFY SHARZ(MOD) = SHARZ(PROG) · SFZ (The shear areas on GBEAMG are SHARY(MOD) and SHARZ(MOD)).

GBOX

NLOBY	Number of integration points in each horizontal wall (flange) of beam (optional)
NLOBZ	Number of integration points in each vertical wall (web) of beam (optional)

Cross Section Type Channel Beam

GCHAN

GCHAN	GEONO	HZ	TY	BY
	TZ	SFY	SFZ	
	K	NLOBY	NLOBZ	

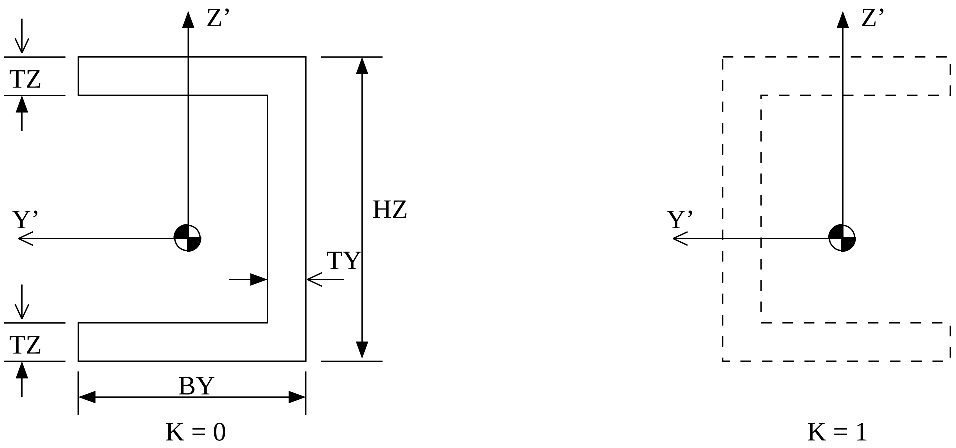


Figure 6-5 Channel beam

GEONO — Geometry type number, i.e. reference number used for element data definition of geometry properties (cross sectional properties) of beams.

HZ — Height of beam at current location.

TY — Thickness of beam web.

BY — Width of top and bottom flange.

TZ — Thickness of top and bottom flange.

SFY,SFZ — Factors modifying the shear areas calculated by the preprocessor program such that the modified shear areas are respectively,

SHARY(MOD) = SHARY(PROG) · SFY
SHARY(MOD) = SHARZ(PROG) · SFZ

(The shear areas on GBEAMG are SHARY(MOD) and SHARZ(MOD)).

GCHAN

K	Web orientation: =0 web located in the negative local y-direction (and consequently flange in the postitive y’-direction) =1 web located in the positive local y-direction (and consequently flange in the negative y’-direction)
NLOBY	Number of integration points in each flange (optional)
NLOBZ	Number of integration points in beam web (optional)

Cross Section Type Channel Beam with Inside Curvature **GCHANR**

GCHANR	GEONO	HZ	TY	BY
	TZ	SFY	SFZ	
	K	R	NLOBY	NLOBZ

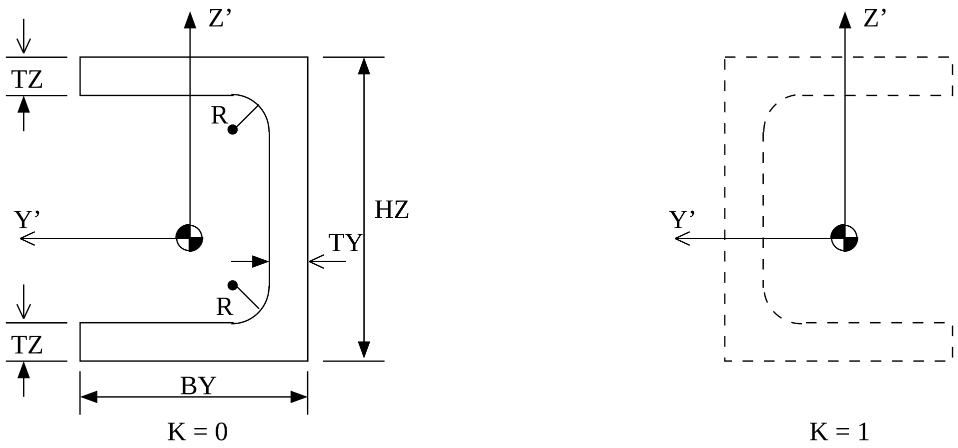


Figure 6-6 Channel beam with inside curvature

GEONO Geometry type number, i.e. reference number used for element data definition of geometry properties (cross sectional properties) of beams.

HZ Height of beam at current location.

TY Thickness of beam web.

BY Width of top and bottom flange.

TZ Thickness of top and bottom flange.

SFY,SFZ Factors modifying the shear areas calculated by the preprocessor program such that the modified shear areas are respectively,

SHARY(MOD) = SHARY(PROG) · SFY

SHARY(MOD) = SHARZ(PROG) · SFZ

(The shear areas on GBEAMG are SHARY(MOD) and SHARZ(MOD)).

GCHANR

K	Web orientation: =0 web located in the negative local y-direction (and consequently flange in the postitive y’-direction) =1 web located in the positive local y-direction (and consequently flange in the negative y’-direction)
R	Radius of inside curvature.
NLOBY	Number of integration points in each flange (optional)
NLOBZ	Number of integration points in beam web (optional)

Nodal Coordinates

GCOORD

GCOORD	NODENO	XCOORD	YCOORD	ZCOORD

NODENO Program defined (internal) node number

XCOORD
YCOORD Cartesian X-, Y- and Z-coordinates of node NODENO.
ZCOORD

There will be one record with the identifier GCOORD for each node. The sequence of the records must correspond to the internal node numbering.

Specification of Integration Points

GCROINT

GCROINT	CROINO	INTYPE	N1	N2
	N3	Y(1)	Z(1)	W(1)
	. . .	. . .	Y(N3)	Z(N3)
	W(N3)			

For definition of an integration point, see record GELINT (specification of integration stations). This record should only be given for 1- and 2-dimensional elements.

CROINO Integration point number, referenced to on record GELINT

INTYPE Integration type number, i.e. information on how to distribute the integration points.

= 0: The coordinates and weights of the points are given, see below. The parameters N1, N2 and N3 have the following interpretation:

- N1 =0: The succeeding coordinates are specified in curvelinear form (natural coordinates)
- =1: The succeeding coordinates are specified in absolute form.
- N2 Not employed, i.e. vacant position
- N3 Number of integration points

> 0: The number of integration points is given and they should be distributed according to the Gaussian integration scheme if INTYPE=1, and the Lobatto integration scheme if INTYPE =2. The parameters N1, N2 and N3 have the following interpretation for a 2-dimensional element:

- N1 Number of points to be distributed across the thickness.
- N2 and N3 Not employed, i.e. vacant positions.

N1, N2 and N3 will have the following interpretation for a 1-dimensional (beam or bar) element:

- N1 Specification of number of points in two directions of the cross section. For a tube:
- N2 circumferential and radial direction respectively. For other cross sections along local element y-axis and z-axis respectively.
- N3 Number of integration points. Note that N3 not necessarily will be the product of N1 and N2 (e.g. for an I-section).

N1 N2 N3 See explanation of INTYPE above.

Y(i) Z(i) Coordinates of integration point No. i. Note that Y(i) will not be used, i.e. a vacant position, for 2-dimensional elements. Both Y(i) and Z(i) are omitted if INTYPE > 0.

W(i) Weight of integration point No. i. Omitted if INTYPE > 0.

Section Type Double Bottom

GDOBO

GDOBO	GEONO	HZ	TY	BY
	TT	TB	SFY	SFZ
	NLOBY	NLOBZ		

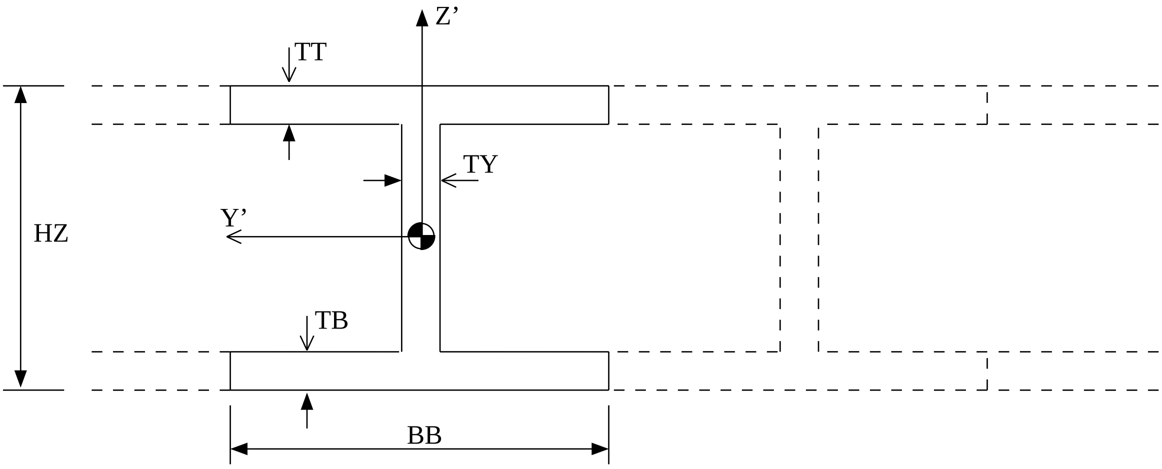


Figure 6-7 Double bottom

GEONO Geometry type number, i.e. reference number used for element data definition of geometry properties (Cross sectional properties) of beams.

HZ Height of beam.

TY Thickness of beam web.

BY Effective width of plates.

TT Thickness of top plate.

TB Thickness of bottom plate.

SFY Factors modifying the shear areas calculated by the preprocessor program such that the modified shear areas is

SHARY(MOD) = SHARY(PROG) · SFY

(The shear area on GBEAMG is the modified value SHARZ(MOD)).

GDOBO

SFZ	Factors modifying the shear areas calculated by the preprocessor program such that the modified shear areas is SHARZ(MOD) = SHARZ(PROG) · SFZ (The shear area on GBEAMG is the modified value SHARZ(MOD)).
NLOBY	Number of integration points in each flange (optional)
NLOBZ	Number of integration points in beam web (optional)

Local Eccentricities

GECC

GECC	ECCNO	IOPT	EX / EZ	(EY)
	(EZ)			

ECCNO — Eccentricity number. The same ECCNO number may not be on both a GECC- and a GECCEN-record for a superelement.

IOPT — Option for number of eccentricity components specified.
= 1: Only local Z-component of eccentricity specified. X and Y components are 0.0
= 2: Local X, Y and Z component of eccentricity specified.

EX
EY
EZ — Eccentricity in element local coordinates. Positive eccenricity is going from the system node to the ’element node’ (for the specific layer, if more layers).

Eccentricities

GECCEN

GECCEN	ECCNO	EX	EY	EZ

ECCNO Eccentricity number, referenced to on record GELREF1.

EX
EY
EZ
Eccentricity vector given in superelement coordinate system, the vector points from the global node towards the local element node.

Specification of Integration Stations

GELINT

GELINT	INTNO	INTYPE	N1	N2
	N3	CROINO(1)	. . .	CROINO(N2)
	X(1, 1)	. . .	X(1,N3)	. . .
	. . .	X(N2, 1)	. . .	X(N2, N3)

An integration station is defined as:

- an assembly of integration points over a cross section of a 1-dimensional (beam or a bar) element,
- an assembly of integration points on a line through the thickness of a two-dimensional element,
- one single integration point for a three-dimensional element.

An integration station comprises the properties of the integration points connected to it, and is used to calculate the element matrices (See Figure 6-8).

INTNO — Integration station reference number, referenced to on record GELREF1, and records for load description

INTYPE — Integration type number, i.e. information on how to distribute the integration stations.
= 0: The coordinates of the stations are given, see parameter x below. The parameters N1, N2 and N3 have the following interpretation:
N1 = 0: the coordinates are specified in curvelinear form.
= 1: the coordinates are specified in absolute form.
N2 Number of integration stations
N3 Number of coordinate components needed for the definition of an integration station.
>0: The number of integration stations is given and they should be distributed according to the Gaussian integration scheme if INTYPE=1, and the Lobatto integration scheme if INTYPE=2. The parameters N1, N2 and N3 have the following interpretation:
N1 number of stations to be distributed along the 1st local element axis
N2 number of stations to be distributed along the 2nd local element axis (only 2- and 3-dimensional elements).
N3 number of stations to be distributed along the 3rd local element axis (only 3-dimensional elements).

N1, N2, N3 — Number of integration points in each direction. See also explanation of INTYPE above. For the 3-dimensional 20 noded hexahedron elements the values may be 2, 3, 4, 32 or 42. A two digit number means that different number of integration points are used for normal strain stiffness terms, and shear stiffness terms to avoid ’shear locking’.

GELINT

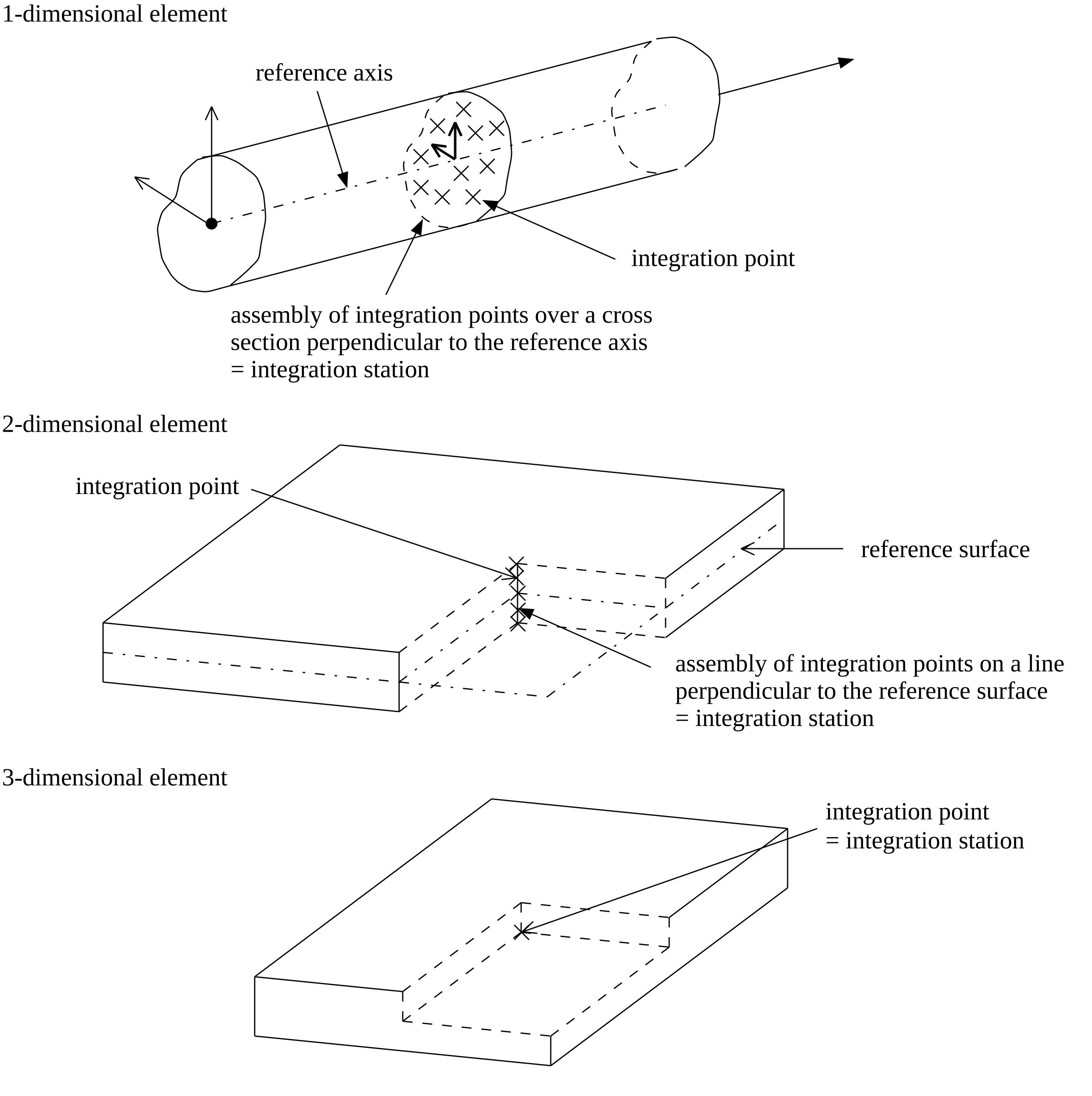


Figure 6-8 Illustration of an integration point and an integration station.

CROINO(1) If INTYPE=0: Integration point number, i.e. number referring to specification of integration points in integration station No. 1.
If INTYPE>0: As above, only for all integration stations.
CROINO(2),...,CROINO(N2) are omitted.

CROINO(N2) Integration point number, i.e. number referring to specification of integration points in integration station No. N2 (the last).
Omitted if INTYPE > 0.

GELINT

X(i,j) Coordinate component No. J for integration station No. i.
Omitted if INTYPE > 0.

Note that for 3-dimensional elements CROINO will have no meaning and should be left vacant.

Element Data Definition

GELMNT1

GELMNT1	ELNOX	ELNO	ELTYP	ELTYAD
	NODIN1	NODIN2	. . .	. . .
	. . .	NODIN(N)		

ELNOX External element number (specified or controlled by user).

ELNO Internal element number (generated by program)

ELTYP Element type number. Refer to chapter 5 for description of legal type no. For element type no. 70 ('matrix element') all relevant element data are stored as stiffness, mass, damping matrices a.s.o. See the AMATRIX record for more information.

ELTYAD Additional information related to element type:

For membrane elements used to specify plane stress / plane strain conditions
= 0 Plane stress
= 1 Plane strain
For two noded beam elements used to specify structural / non-structural elements:
= 0 Structural beam
= 1 Non structural beam
For general matrix element (elem. type 70) used to specify number of nodes
= NNOD Number of nodes on the matrix element

NODIN1
NODIN2
: Internal node numbers in the assembly, to which this element is connected. The sequence of the
: node numbers is in accordance with the local node numbering of the basic element.
NODIN(N)

By 'internal node numbers' is meant the node numbering of the entire superelement of which the element ELNOX is a part. The internal node number refers to the node number generated by the program.

The program-defined element number ranges from 1 up to number of elements.

The sequence of the records will correspond to the program-defined element numbering, ELNO.

Reference to Element Data

GELREF1

GELREF1	ELNO	MATNO	ADDNO	INTNO
	MINTNO	STRANO	STRENO	STREPONO
	GEONO/OPT	FIXNO/OPT	ECCNO/OPT	TRANSNO/OPT
	GEONO(1)	. . .	GEONO(N)	FIXNO(1)
	. . .	FIXNO(1)	ECCNO(1)	. . .
	ECCNO(N)	TRANSNO(1)	. . .	TRANSNO(N)

Shortest version:

GELREF1	ELNO	MATNO	ADDNO	INTNO
	MINTNO	STRANO	STRENO	STREPONO
	GEONO/OPT	FIXNO/OPT	ECCNO/OPT	TRANSNO/OPT

ELNO Internal element number (generated by the program).

MATNO Material number
= 0 no material data attached to the element

ADDNO Additional data type number, i.e. number referring to additional data specification
= 0 no additional data attached to the element

INTNO Integration station reference number for stiffness matrix, i.e. number referring to the specification of integration stations. An integration station is defined as:
- an assembly of integration points over a cross section of a 1-dimensional (beam or bar)
element,
- an assembly of integration points on a line through the thickness of a 2-dimensional element,
- one single integration point for a 3-dimensional element. For further explanation see record GELINT.

INTNO = 0: Default values of the analysis program are employed.

GELREF1

MINTNO Integration station reference number for mass and damping matrices. Integration station, see INTNO.
MINTNO = 0: Default values of the analysis program are employed.

STRANO Initial strain number, i.e. number referring to the specification of initial strains. The data type containing these data is not yet defined.

STRENO Initial stress number, i.e. number referring to the specification of initial stresses. The data type containing these data is not yet defined.

STREPONO Stresspoint specification reference number. See record GELSTRP for further information.

GEONO/OPT Geometry reference number or option for geometry reference number specified later in this record sequence.
>0: The geometry reference number (the same for all nodes in the element). GEONO(1),...,
GEONO(N) will not be specified.
=0: No geometry data is given, i.e. neither here nor on GEONO(1), ..., GEONO(N).
=-1: Reference numbers to geometry data are specified later in this record sequence for all nodes, i.e. all GEONO(1), ..., GEONO(N) will be given.

FIXNO/OPT Fixation reference number or option for fixation reference numbers specified later in this record sequence. The meaning assigned to the values of FIXNO/OPT corresponds to those for GEONO/OPT.

ECCNO/OPT Eccentricity reference number or option for eccentricity reference numbers specified later in this record sequence. The meaning assigned to the values of ECCNO/OPT corresponds to those for GEONO/OPT.

TRANSNO/OPT Reference number for local coordinate system specification or option for specification of local nodal coordinate systems later in this record sequence. Refers to GUNIVEC or BNTRCOS record. The meaning assigned to the values of TRANSNO/OPT corresponds to those for GEONO/OPT.

GEONO(1) Geometry reference number, i.e. number referring to thickness or cross sectional specification. Not employed for 3-dimensional elements. GEONO(1) is the reference number for the 1st local node of the element, GEONO(i) will be the reference number for the i'th local node.

GEONO(N) Geometry reference number for the last local node of the element.

FIXNO(1) Number referring to the specification of degree of fixation (Data type BELFIX).
FIXNO(1) is the reference number for the 1st local node of the element, FIXNO(i) will be the reference number for the i'th local node.

FIXNO(N) Degree of fixation reference number for the last local node of the element.

GELREF1

ECCNO(1)	Eccentricity number for the first local node of the element, i.e. number referring to the specification of eccentricities.
ECCNO(N)	As ECCNO(1) only for the last local node.
TRANSNO(1)	Number referring to the specification of the local element coordinate system for the 1st local node of the element. Refers to BNTRCOS or GUNIVEC record depending on element type.
TRANSNO(N)	As TRANSNO(1) only for the last local node.

N is the number of local nodes of the element.
NOTE: Parameters appear in succeeding order from third line.

The sequence of the records will be in the program-defined element numbering, ELNO.

Specification of Stress Points

GELSTRP

GELSTRP	STREPONO	STRPTYP	N1	N2
	N3	X(1, 1)	. . .	X(1, N3)
	. . .	. . .	X(N2, 1)	. . .
	X(N2, N3)			

STREPONO Stress point specification reference number, referenced to on GELREF1

STRPTYP Type of stress point specification

=0: The coordinates of the stress points are given, see below

N1 =0: the coordinates are specified in curvelinear form

=1: the coordinates are specified in absolute form

N2: number of stress points in the element

N3: number of coordinate components needed for the definition of a stress point

>0: The number of stress points is given, and they should be distributed according to the Gaussian integration scheme if STRPTYP=1 and the Leobatto integration scheme if STRPTYP=2, i.e. the stress points coincide with the integration points. If STRP-TYP=3 the stress points are distributed according to the default method for the element type considered.

N1: number of stress points along 1st local element axis

N2: number of stress points along 2nd local element axis (only 2- and 3-dimensional elements).

N3: number of stress points along the 3rd local element axis. (only for 3-dimensional elements).

X(i,j) Coordinate component no. j for station no. i. Omitted if STRPTYP > 0.

Thickness of Two-dimensional Elements

GELTH

GELTH	GEONO	TH	NINT	

GEONO Geometry type number, i.e. referenced to by GELREF1

TH Thickness of the element, measured in a specific node

NINT Number of integration points through thickness

Cross Section Type I or H Beam

GIORH

GIORH	GEONO	HZ	TY	BT
	TT	BB	TB	SFY
	SFZ	NLOBYT	NLOBYB	NLOBZ

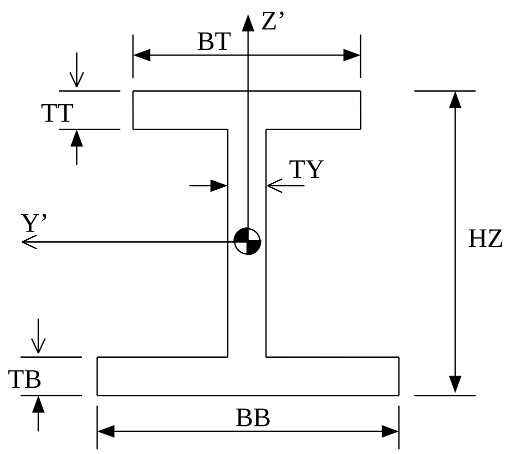


Figure 6-9 I or H beam

GEONO Beam stress type number, i.e. reference number used for element data definition of cross sectional properties of beams.

HZ Height of beam at current location

TY Thickness of beam web

BT Width of top flange

TT Thickness of top flange

BB Width of bottom flange

TB Thickness of bottom flange

SFY, SFZ Factors modifying the shear areas calculated by the preprocessor program such that the modified shear areas are respectively

SHARY(MOD) = SHARY(PROG) · SFY

SHARZ(MOD) = SHARZ(PROG) · SFZ

(The shear areas on GBEAMG are SHARY(MOD) and SHARZ(MD)).

GIORH

NLOBYT	Number of integration points in top flange (optional)
NLOBYB	Number of integration points in bottom flange (optional)
NLOBZ	Number of integration points in beam web (optional)

Cross Section Type I or H Beam with Inside Curvature

GIORHR

GIORHR	GEONO	HZ	TY	BT
	TT	BB	TB	SFY
	SFZ	RT	RB	NLOBYT
	NLOBYB	NLOBZ		

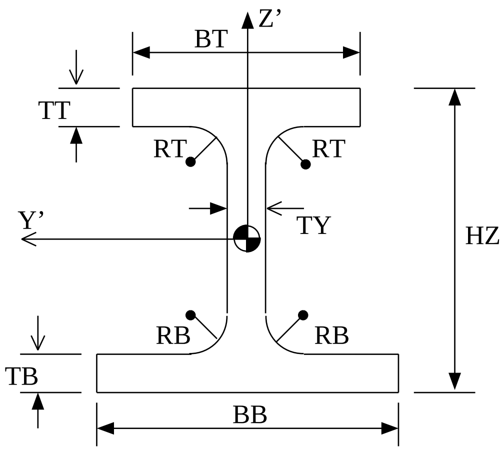


Figure 6-10 I or H beam with inside curvature.

GEONO	Beam stress type number, i.e. reference number used for element data definition of cross sectional properties of beams.
HZ	Height of beam at current location
TY	Thickness of beam web
BT	Width of top flange
TT	Thickness of top flange
BB	Width of bottom flange
TB	Thickness of bottom flange

GIORHR

SFY, SFZ	Factors modifying the shear areas calculated by the preprocessor program such that the modified shear areas are respectively SHARY(MOD) = SHARY(PROG) · SFY SHARZ(MOD) = SHARZ(PROG) · SFZ (The shear areas on GBEAMG are SHARY(MOD) and SHARZ(MOD)).
RT	Radius of inside curvature at top
RB	Radius of inside curvature at bottom
NLOBYT	Number of integration points in top flange (optional)
NLOBYB	Number of integration points in bottom flange (optional)
NLOBZ	Number of integration points in beam web (optional)

Modification of Diagonal Mass Matrices

GLMASS

GLMASS	RFAC			

RFAC	Factor by which the rotational masses of the lumped diagonal mass matrix are multiplied.

Default value = 0.01

Cross Section Type L-Section

GLSEC

GLSEC	GEONO	HZ	TY	BY
	TZ	SFY	SFZ	K
	NLOBY	NLOBZ		

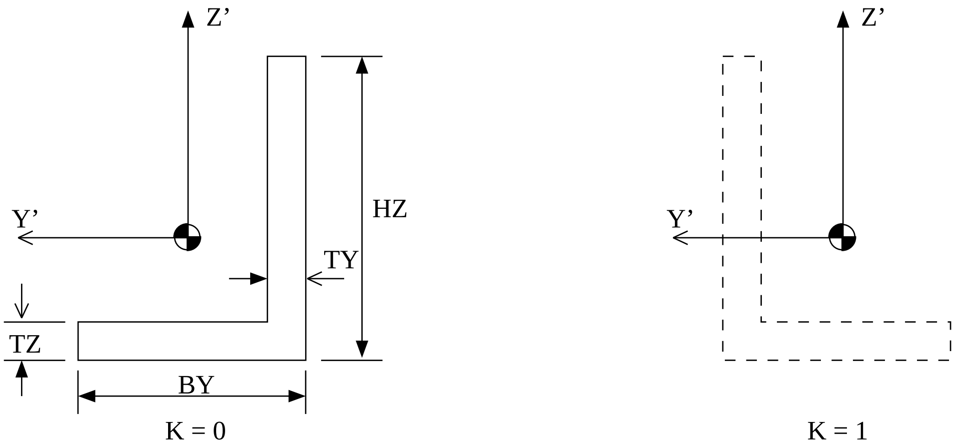


Figure 6-11 L-section

GEONO — Geometry type number, i.e. reference number used for element data definition of geometry properties (Cross sectional properties) of beams.

HZ — Height of beam at current location.

TY — Thickness of beam web.

BY — Width of flange.

TZ — Thickness of flange.

SFY, SFZ — Factors modifying the shear areas calculated by the preprocessor program such that the modified shear areas are respectively

SHARY(MOD) = SHARY(PROG) · SFY

SHARZ(MOD) = SHARZ(PROG) · SFZ

(The shear areas on GBEAMG are SHARY(MOD) and SHARZ(MOD)).

GLSEC

K	Web orientation: =0 web located in the negative local y-direction (and consequently flange in the postitive y’-direction) =1 web located in the positive local y-direction (and consequently flange in the negative y’-direction)
NLOBY	Number of integration points in beam flange (optional)
NLOBZ	Number of integration points in beam web (optional)

Cross Section Type L-Section with Inside Curvature **GLSECR**

GLSECR	GEONO	HZ	TY	BY
	TZ	SFY	SFZ	K
	R	NLOBY	NLOBZ	

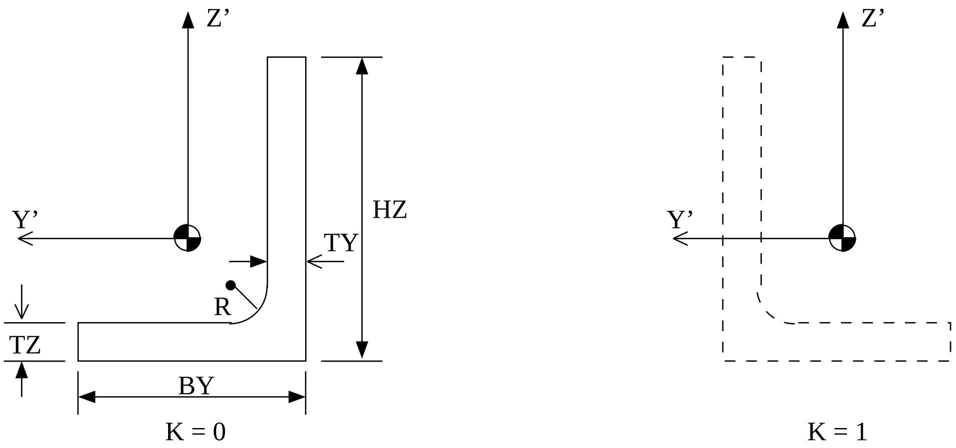


Figure 6-12 L-section with inside curvature

GEONO — Geometry type number, i.e. reference number used for element data definition of geometry properties (Cross sectional properties) of beams.

HZ — Height of beam at current location.

TY — Thickness of beam web.

BY — Width of flange.

TZ — Thickness of flange.

SFY, SFZ — Factors modifying the shear areas calculated by the preprocessor program such that the modified shear areas are respectively

SHARY(MOD) = SHARY(PROG) · SFY

SHARZ(MOD) = SHARZ(PROG) · SFZ

(The shear areas on GBEAMG are SHARY(MOD) and SHARZ(MOD)).

GLSECR

K	Web orientation: = 0 web located in the negative local y-direction (and consequently flange in the postitive y'-direction) = 1 web located in the positive local y-direction (and consequently flange in the negative y'-direction)
R	Radius of inside curvature
NLOBY	Number of integration points in beam flange (optional)
NLOBZ	Number of integration points in beam web (optional)

Correspondence between External and Internal Node Numbering and Number of Degrees of Freedom of Each Node

GNODE

GNODE	NODEX	NODENO	NDOF	ODOF

NODEX — External node number (specified or controlled by user).

NODENO — Internal node number defined by the program (may be generated by internal node numbering optimalizer). The internal node numbers range from 1 up to number of nodes.

NDOF — Number of degrees of freedom of nodal point NODENO.

ODOF — Order of degrees of freedom. NDOF digits.
Example NDOF=3, ODOF=135 means 3 degrees of freedom in x, z and Ry direction respectively in the superelement's coordinate system, unless a local nodal coordinate system is specified (see the BNDOF and BNTRCOS record).

There will be one record with the identifier GNODE for each node. The sequence of the records will correspond to the internal node number, NODENO.

Cross Section Type Tube

GPIPE

GPIPE	GEONO	DI	DY	T
	SFY	SFZ	NCIR	NRAD

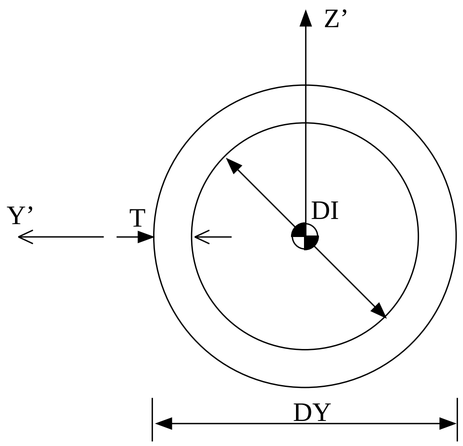


Figure 6-13 Tube

GEONO Geometry type number, i.e. reference number used for element data definition of geometry properties (Cross sectional properties) of beams.

DI Inner diameter of tube.

DY Outer diameter of tube (mandatory).

T Thickness of tube (not necessary if DI is given).

SFY, SFZ Factors modifying the shear areas calculated by the preprocessor program such that the modified shear areas are respectively,

SHARY(MOD) = SHARY(PROG) · SFY

SHARZ(MOD) = SHARZ(PROG) · SFZ

(The shear areas on GBEAMG are SHARY(MOD) and SHARZ(MOD)).

NCIR, NRAD Number of integration points in circumferential and radial direction respectively (optional)

Separation Description **GSEPxxxx**

GSEPxxxx	SEPARID			

The separation description data type is only a super-type. Currently only one sub-type is defined - 'Specified Separation', which also may specify uniform separation. Some data shall be present in all separation descriptions, these are shown here.

GSEPxxxx All sub-types of the separation description data type are named GSEPxxxx, where 'xxxx' may be different for the sub-types.

SEPARID Identification of the separation description. A unique integer value among all the separation description data types (including all sub-types) in the super-element. This number is referenced from the SEPARID number on the GSLSTIFF record.

Specified Separation Description

GSEPSPEC

GSEPSPEC	SEPARID	OPTION	NDIST	$DISTANCE_0$
	$DISTANCE_1$	. . .	$DISTANCE_n$	

The ’specified separation’ data type is a sub-type of the ’separation’ data type. Specified separation type may also specify uniform separation type.

SEPARID — Identification of the separation description. A unique integer value among all the separation description data types (including all sub-types) in the super-element. This number is referenced from the SEPARID number on the GSLSTIFF record.

OPTION — Usage of $DISTANCE_0$.
= 0, $DISTANCE_0$ is not specified. Any value of $DISTANCE_0$ is equally good (not used).
= 1, $DISTANCE_0$ is specified.

NDIST — Number of different distances between stiffeners.
= 1, indicates that all separations are equal (uniform separation).

$DISTANCE_0$ — The distance to the first stiffener from the start of the plate. The start of the plate is the point on the plate which has the smallest y-values (usually negative), where y is in the local beam coordinate systems.

$DISTANCE_i$ — The distance between stiffener number ’i’ and stiffener number ’i+1’. $i \in [\ 1, NDIST\ ]$

For a uniform separation with $DISTANCE_0$ not specified, it will for a stiffener layer result in a smearing (multiplication) factor (F_s) in the stiffener direction for Young’s modulus (E_1). This factor is relative to a plate layer with the same heigth as the stiffener layer.

$F_s = b / d_1$

where:
b = width of each stiffener
$d_1 = DISTANCE_1$

In the other direction, Young’s modulus (E_2) will be taken equal to zero.

Set (group) of Nodes or Elements (Members) — GSETMEMB

GSETMEMB	NFIELD	ISREF	INDEX	ISTYPE
	ISORIG	$IRMEMB_1$	$IRMEMB_2$	$IRMEMB_3$
	$IRMEMB_4$	. . .	$IRMEMB_{NMEMB}$	

This record together with the name and description of a set record (TDSETNAM) constitutes the set (group) datatype.

NFIELD Number of data fields on this record (maximum is 1024)

ISREF Internal set identification number as defined on the name and description of a set record (TDSETNAM).

INDEX Sequential record number for current set (ISREF). Each set may consist of one or more GSETMEMB records with same set identification number (ISREF). INDEX must be strictly increasing from 1 and upwards till number of GSETMEMB records for this set of members (nodes or elements).

ISTYPE Set type
= 1, set of nodes
= 2, set of elements
See also table 6.1 below.

ISORIG Set origin type
= 0, undefined origin
= 1, point
= 2, line (or curve)
= 3, surface
= 4, body

$IRMEMB_1$ First set member on this record

$IRMEMB_2$ Second set member on this record

.
.
.

$IRMEMB_{NMEMB}$ Set member number NMEMB on this record.
NMEMB is number of set members on the current record. NMEMB = NFIELD - 5

GSETMEMB

Table 6.1 Set Type (ISTYPE) and interpretation of Set Member Number (IRMEMB)

ISTYPE:	Description:	Interpretation of IRMEMB:
1	Set of Nodes	Internal Node Number (IINOD)
2	Set of Elements	Internal Element Number (IIELNO)

Comments:
The set datatype consists of one name and description of set record (TDSETNAM) and one or more set member records (GSETMEMB).

It should be noted that a set may have its set members distributed over several set member records (GSETMEMB) all having the same set identification number (ISREF) and consequently also the same TDSETNAM record. The total number of set members will then be the sum of the number of set members (NMEMB) for each of the set records.

Restrictions:

- Only one set type (ISTYPE) for same set identification number (ISREF) is allowed.

- If several records for the same set identification number (ISREF), record numbering must be strictly sequential;
  1 < INDEX < NINDEX, where NINDEX is number of records per set.

- A set member (number) should only be included once in the list.

General Eccentric Sandwich Element **GSLAYER**

GSLAYER	GEONO	NLAYER	$LAYERID_1$	$LAYERID_2$
	$LAYERID_3$	. . .	$LAYERID_n$	

There are never more than one GSLAYER record for an element. The GSLAYER record is referenced from the GELREF1 record for each element. When this layer 'stack' record is referenced from the GELREF1 record, there is no need to refer to any material in the GELREF1 record.

GEONO — Geometry reference number for this general sandwich (layered) element. This number is referenced from the geometry reference number on the GELREF1 record.

NLAYER — Number of layers in the general eccentric sandwich (layered) element.

$LAYERID_i$ — Identification of layer no. 'i'. $LAYERID_i$ refers to a GSLPLATE or GSLSTIFF record with identification $LAYERID_i$. It is a unique integer value among all layers in the super-element. $i \in [\ 1,NLAYER\ ]$

Layer Description

GSLxxxxx

GSLxxxxx	LAYERID	MATNO	SHFACT	NECCNO
	$ECCNO_1$	. . .	$ECCNO_n$	

Layer description data type is only a super-type. Current sub-types are plate layer and stiffener layer. Some data shall be present in all layer descriptions, these are shown here.

GSLxxxxx All sub-types of the layer description data type are named GSLxxxxx, where ’xxxxx’ may be different for the sub-types.

LAYERID Identification of the layer. A unique integer value among all the layers in the super-element. This number is referenced from the LAYERID numbers on the GSLAYER records.

MATNO Reference to the material.

SHFACT A factor for calculation of the shear deflection. A commonly used value for square cross sections and plates is 1.2.

NECCNO Number of eccentricity data for this layer (=1 or number of element nodes).

$ECCNO_i$ Reference to eccentricity description for the layer (=0 if there is no eccentricity for this layer). $ECCNO_i$ refers to a GECC or GECCEN record. $i \in [\ 1,NECCNO\ ]$

Plate Layer Description

GSLPLATE

GSLPLATE	LAYERID	MATNO	SHFACT	NECCNO
	$ECCNO_1$	. . .	$ECCNO_n$	NTHICKID
	$THICKID_1$	. . .	$THICKID_n$	

Plate Layer is a sub-type of layer. It identifies that the layer is a plate, i.e. shell element, and references possible eccentricities and mandatory element or element node thickness(es) of the plate.

LAYERID — Identification of the layer. A unique integer value among all the layers in the super-element. This number is referenced from the LAYERID numbers on the GSLAYER records.

MATNO — Reference to the material. For plate layers, the material may be isotropic or anisotropic. The material record referenced can only specify **one** material.

SHFACT — A factor for calculation of the shear deflection. A commonly used value for square cross sections and plates is 1.2.

NECCNO — Number of eccentricity data for this layer (=1 or number of element nodes).

$ECCNO_i$ — Reference to eccentricity description for the layer (=0 if there is no eccentricity for this layer). $ECCNO_i$ refers to a GECC or GECCEN record. $i \in [1, NECCNO]$

NTHICKID — Number of thickness data for this layer (=1 or number of element nodes).

$THICKID_i$ — Reference to the thickness for the plate or the plate nodes. $THICKID_i$ refers to a GELTH record (in this case GEONO on the GELTH record should read $THICKID_i$, since the GELREF1 record does not reference the GELTH record directly for the general eccentric sandwich element). $i \in [1, NTHICKID]$

Stiffener Layer Description

GSLSTIFF

GSLSTIFF	LAYERID	MATNO	SHFACT	NECCNO
	$ECCNO_1$	. . .	$ECCNO_n$	NSECTID
	$SECTID_1$	. . .	$SECTID_n$	SEPARID
	ANGLE			

Stiffener Layer is a sub-type of layer. It identifies that this layer is a stiffener layer, i.e. beam elements, and specifies the additional information for the beams.

LAYERID Identification of the layer. A unique integer value among all the layers in the super-element. This number is referenced from the LAYERID numbers on the GSLAYER records.

MATNO Reference to the material. For stiffener layers, the material may only be **isotropic** . The material record referenced can only specify **one** material.

SHFACT A factor for calculation of the shear deflection. A commonly used value for square cross sections and plates is 1.2.

NECCNO Number of eccentricity data for this layer (=1 or number of beam element nodes).

$ECCNO_i$ Reference to eccentricity description for the layer (=0 if there is no eccentricity for this layer). $ECCNO_i$ refers to a GECC or GECCEN record. $i \in [1, NECCNO]$

NSECTID Number of section references for this layer (=1 or number of beam element nodes).

$SECTID_i$ Reference to the section for the beam or the beam nodes. $SECTID_i$ refers to a GBARM and a GBEAMG record (in this case GEONO on the GBARM and GBEAMG record should read $SECTID_i$, since the GELREF1 record does not reference the GBARM and GBEAMG record directly for the general eccentric sandwich element). $i \in [1, NSECTID]$

SEPARID Reference to the separation data description (GSEPxxxx). The separation is the distance between stiffeners in the plane of the element, but orthogonal to the stiffener direction.

ANGLE Angle with respect to the element's reference direction (local x-axis). The angle is specified in **degrees**. This angle and the local x-axis of the eccentric sandwich element determines the direction of the local x-axis of the stiffeners. The reference direction (local x-axis) of the eccentric sandwich element are determined by the direction cosine matrix from the BNTRCOS record, referenced on the GELREF1 record for this element. The direction determined from the first line of this direction cosine matrix is projected down on the element plane and this gives the element's reference direction (local x-axis).

Cross Section T on Plate

GTONP

GTONP	GEONO	HZ	TY	BT
	TT	BP	TP	SFY
	SFZ	NLOBYT	NLOBYB	NLOBZ

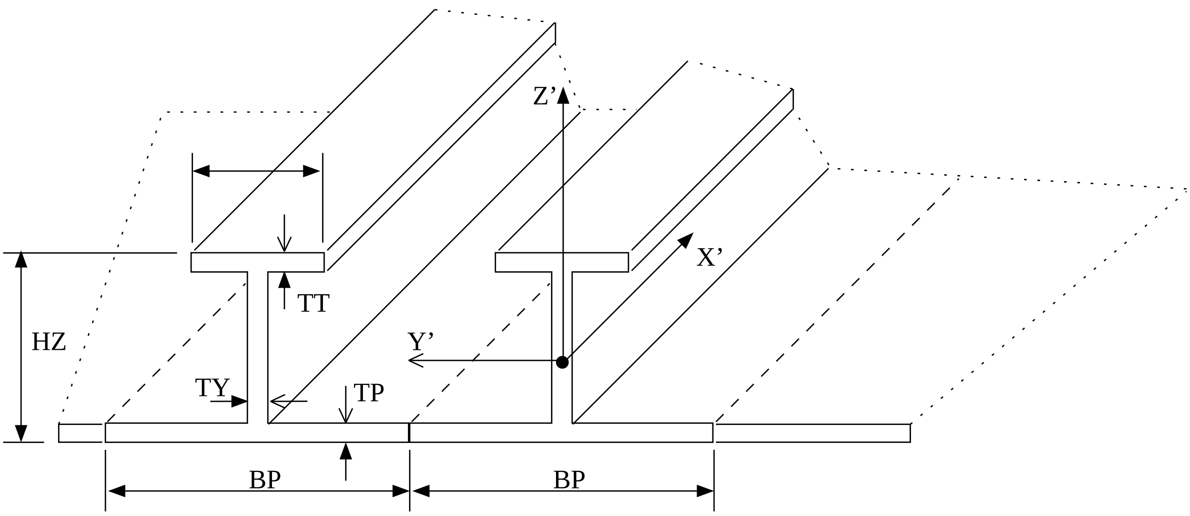


Figure 6-14 T on plate

GEONO Geometry type number, i.e. reference number used for element data definiton of geometry properties (Cross sectional properties) of beams.

HZ Height of beam

TY Thickness of beam web.

BT Width of top flange.

TT Thickness of top flange.

BP Effective width of plate.

TP Thickness of plate.

GTONP

SFY	Factors modifying the shear areas calculated by the preprocessor program such that the modified shear areas is SHARY(MOD) = SHARY(PROG) · SFY (The shear area on GBEAMG is the modified value SHARZ(MOD)).
SFZ	Factors modifying the shear areas calculated by the preprocessor program such that the modified shear areas is SHARZ(MOD) = SHARZ(PROG) · SFZ (The shear area on GBEAMG is the modified value SHARZ(MOD)).
NLOBYT	Number of integration points in top flange (optional)
NLOBYB	Number of integration points in bottom flange (optional)
NLOBZ	Number of integration points in beam web (optional)

Specification of Local Element Coordinate System **GUNIVEC**

GUNIVEC	TRANSNO	UNIX	UNIY	UNIZ

TRANSNO Unit vector number, referenced to on record GELREF1.

UNIX
UNIY
UNIZ
Unit vector given in superelement coordinate system along the local z-axis (reference axis in z-direction) of the element in the particular node.

The GUNIVEC records are used for beam elements only, i.e. basic element types 2, 15 and 23. Other basic element types may refer to BNTRCOS records. No ambiguity thus exists if both a GUNIVEC and BNTRCOS record have same TRANSNO, but they should preferably have separate numbering (TRANSNO) to avoid possible program problems.

Cross Section Type Unsymmetrical I-Beam

GUSYI

GUSYI	GEONO	HZ	TY	BT
	B1	TT	BB	B2
	TB	SFY	SFZ	NLOBYT
	NLOBYB	NLOBZ		

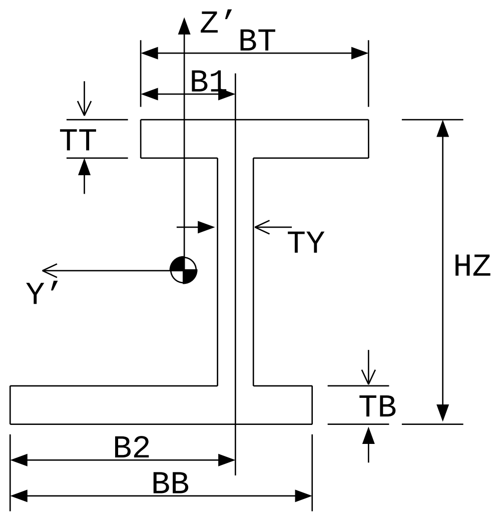


Figure 6-15 Unsymmetrical I beam

GEONO	Geometry type number, i.e. reference number used for element data definition of geometry properties (Cross sectional properties) of beams.
HZ	Height of beam
TY	Thickness of beam web
BT	Width of top flange
B1	Width of half top-flange in positive local y-direction
TT	Thickness of top flange
BB	Width of bottom flange

GUSYI

B2	Width of half bottom-flange in positive local y-direction
TB	Thickness of bottom flange
SFY,SFZ	Factors modifying the shear areas calculated by the preprocessor program such that the modified shear areas are respectively SHARY(MOD) = SHRY(PROG) · SFY SHARZ(MOD) = SHARZ(PROG) · SFZ (The shear areas on GBEAMG are SHARY(MOD) and SHARZ(MOD)).
NLOBYT	Number of integration points in top flange (optional)
NLOBYB	Number of integration points in bottom flange (optional)
NLOBZ	Number of integration points in beam web (optional)

6.4 Material Data

First Level

Axial Damper Between Two Nodal Points

MAXDMP

MAXDMP	MATNO	DAMP		

MATNO Material number, i.e. reference number referenced to by the element specification.

DAMP Axial damping constant.

The axial damping constant corresponds to the force to be applied in order to get a unit velocity in the direction of the basic element.

Axial Spring Between Two Nodal Points

MAXSPR

MAXSPR	MATNO	SCON		

MATNO Material number, i.e. reference number referenced to by the element specification.

SCON Axial spring constant.

The axial spring constant corresponds to the force to be applied in order to get a unit displacement in the direction of the basic element.

Material for Non-linear Contact Element

MCNT

MCNT	MATNO	MATYP	EMOD	STIFAC
	FRICOF			

MATNO Material number. Reference number referenced to by the element specification.

MATYP
= 1 Perfect sliding
= 2 Perfect sticking
= 3 Linear friction

EMOD Typical Young’s modulus of surrounding elements

STIFAC Factor that EMOD should be multiplied with to obtain contact stiffness.
Default: STIFAC = 10^5

FRICOF Linear friction coefficient when MATYP= 3.

Damping Element to Ground

MGDAMP

MGDAMP	MATNO	NDOF	C(1, 1)	C(2, 1)
	. . .	. . .	C(NDOF, 1)	C(2, 2)
	C(3, 2)	. . .	. . .	C(NDOF, 2)
	C(3, 3)	. . .	. . .	C(NDOF, NDOF)

MATNO Material number, i.e. reference number referenced to by the element specification.

NDOF Number of degrees of freedom of the node.

C(i,j) Elements of the damping matrix (only elements on and below the main diagonal are stored, i.e. symmetric damping matrix assumed). The elements are referred to a local coordinate system if defined (by TRANSNO on GELREF1), otherwise to the global coordinate system of the superelement.

The damper to ground matrix is the viscous damping matrix.

General 2-noded Damping Element

MGLDAMP

MGLDAMP	MATNO		NDOF1	NDOF2
	D(1, 1)	D(2, 1)	. . .	D(NDOF1, 1)
	D(NDOF1+1, 1)	. . .	D(TDOF, 1)	D(2, 2)
	D(3, 2)	. . .	D(TDOF, 2)	D(3, 3)
	. . .	D(TDOF, TDOF)		

MATNO Material number, i.e. reference number referenced to by the element specification.

NDOF1 Number of degrees of freedom in local node 1.

NDOF2 Number of degrees of freedom in local node 2.

D(i,j) Elements of the damping matrix (only elements on and below the main diagonal are stored, i.e. symmetric damping matrix assumed). The elements are referred to a local coordinate system if defined (by TRANSNO on GELREF1), otherwise to the global coordinate system of the superelement.
(TDOF = NDOF1 + NDOF2)

The (i,j)'th element of the damping matrix corresponds to the force to be given in the i'th d.o.f. to get a unit velocity in the j'th d.o.f.

A GELMNT1 record with element type = 13 and a GELREF1 record with reference to this (MGLDAMP) record is necessary in order to fulfill the definition of the 2-noded damping element.

General 2-noded Mass Element

MGLMASS

MGLMASS	MATNO		NDOF1	NDOF2
	M(1, 1)	M(2, 1)	. . .	M(NDOF1, 1)
	M(NDOF1+1, 1)	. . .	M(TDOF, 1)	M(2, 2)
	M(3, 2)	. . .	M(TDOF, 2)	M(3, 3)
	. . .	M(TDOF, TDOF)		

MATNO Material number, i.e. reference number referenced to by the element specification.

NDOF1 Number of degrees of freedom in local node 1.

NDOF2 Number of degrees of freedom in local node 2.

M(i,j) Elements of the mass matrix (only elements on and below the main diagonal are stored, i.e. symmetric mass matrix assumed). The elements are referred to a local coordinate system if defined (by TRANSNO on GELREF1), otherwise to the global coordinate system of the superelement.
(TDOF = NDOF1 + NDOF2)

The (i,j)'th element of the mass matrix corresponds to the force to be given in the i'th d.o.f. to get a unit acceleration in the j'th d.o.f.

A GELMNT1 record with element type = 12 and a GELREF1 record with reference to this (MGLMASS) record is necessary in order to fulfill the definition of the 2-noded mass element.

1-Noded Mass element

MGMASS

MGMASS	MATNO	NDOF	M(1, 1)	M(2, 1)
	. . .	. . .	M(NDOF, 1)	M(2, 2)
	M(3, 2)	. . .	. . .	M(NDOF, 2)
	M(3, 3)	. . .	. . .	M(NDOF, NDOF)

MATNO Material number, i.e. reference number referenced to by the element specification.

NDOF Number of degrees of freedom in the node.

M(i,j) Elements of the mass matrix (only elements on and below the main diagonal are stored, i.e. symmetric mass matrix assumed). The elements are referred to a local coordinate system if defined (by TRANSNO on GELREF1), otherwise to the global coordinate system of the superelement.

Element to Ground

MGSPRNG

MGSPRNG	MATNO	NDOF	K(1, 1)	K(2, 1)
	. . .	. . .	K(NDOF, 1)	K(2, 2)
	K(3, 2)	. . .	. . .	K(NDOF, 2)
	K(3, 3)	. . .	. . .	K(NDOF, NDOF)

MATNO Material number, i.e. reference number referenced to by the element specification.

NDOF Number of degrees of freedom of the node.

K(i,j) Elements of the stiffness matrix (only elements on and below the main diagonal are stored, i.e. symmetric stiffness matrix assumed). The elements are referred to a local coordinate system if defined (by TRANSNO on GELREF1), otherwise to the global coordinate system of the superelement.

The (i,j)’th element of the stiffness matrix corresponds to the force to be given in the i’th d.o.f. to get a unit displacement in the j’th d.o.f.

Isotropy, Linear Acoustic Field Problem

MISOAL

MISOAL	MATNO	C	CP	CV
	RHO	PRESS	TEMP	R

MATNO Material number, i.e. reference number referenced to by the element specification.

C Speed of sound in gas.

CP Specific heat of gas at constant pressure.

CV Specific heat of gas at constant volume.

RHO Specific density of gas.

PRESS Gas pressure.

TEMP Gas temperature.

R Universal gas constant.

Isotropy, Linear Electro-magnetic Field Problem

MISOEML

MISOEML	MATNO	PERM		

MATNO Material number, i.e. reference number referenced to by the element specification.

PERM Permittivity

Isotropy, Linear Heat Conduction Analysis

MISOHL

MISOHL	MATNO	RHO	CHEAT	COND

MATNO Material number, i.e. reference number referenced to by the element specification.

RHO Density.

CHEAT Specific heat.

COND Coefficient of heat conductivity.

Isotropy, Non-linear Heat Conduction Analysis **MISOHNL**

MISOHNL	MATNO	RHO	RTEMPNO	CHEAT
	CHTEMPNO	COND	COTEMPNO	

MATNO Material number, i.e. reference number referenced to by the element specification.

RHO1 Density

RTEMPNO Reference number to a temperature dependent scaling factor for RHO

CHEAT Specific heat

CHTEMPNO Reference number to a temperature dependent scaling factor for CHEAT

COND Coefficient of heat conductivity

COTEMPNO Reference number to a temperature dependent scaling factor for COND. If there is no temperature dependence, the corresponding reference number will be zero.

Non-linear Isotropic Material, Material Types 1-4 **MISOPL**

MISOPL	MATNO	MATYP	POISS	RHO
	DAMP	ALPH	B1	
	NP	SIG1	EPS1	SIG2
	EPS2	. . .	SIG(NP)	EPS(NP)

MATNO Material number

MATYP Material type
- =1 Elasto-plastic material
- =2 Non-linear hyperelastic material
- =3 Overly technique
- =4 Isotropic and kinematic hardening
  - B1 Parameter for combining of isotropic and kinematic hardening
    - = 0.0 Isotropic
    - = 1.0 Kinematic
    - Any value between 0.0 and 1.0 is legal

POISS Poisson's ratio

RHO Density

DAMP Specific damping

ALPH Thermal expansion coefficient

B1 Only used for MATYP=4, see above and next page.

NP Number of points to represent the uniaxial stress-strain curve for increased loading. Note NP<30

```
SIG1    Stress at the first point representing the stress-
strain curve.
EPS1    Corresponding strain at the first point representing
the stress-strain curve
        (YOUNG=SIG1/EPS1).
SIG2    Stress at the second point representing the stress-
strain curve.
EPS2    Corresponding strain at the second point representing
the stress-strain curve.
     :
SIG(NP) Stress at the last point representing the stress-
```

MISOPL

strain curve.
EPS(NP) Corresponding strain at the last point representing the stress-strain curve (See Figure 6-16).

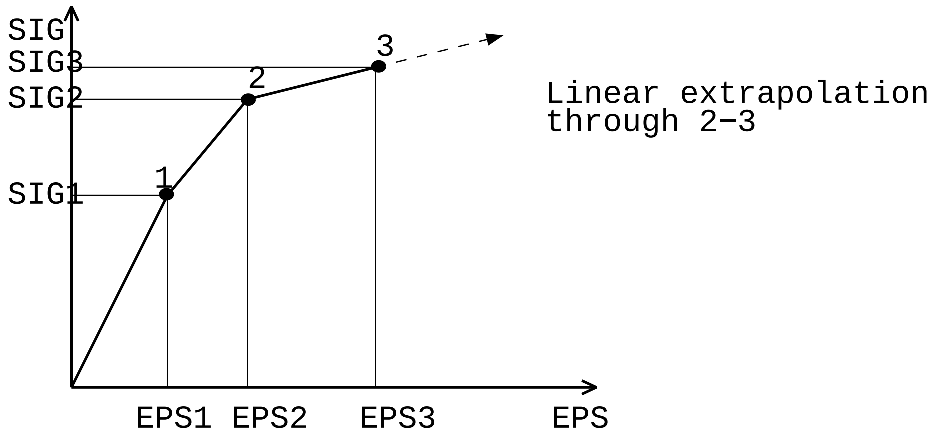


Figure 6-16 Uniaxial stress-strain curve for increased loading

The material parameter B1 may be found from a one-dimensional loading-unloading curve with yielding:

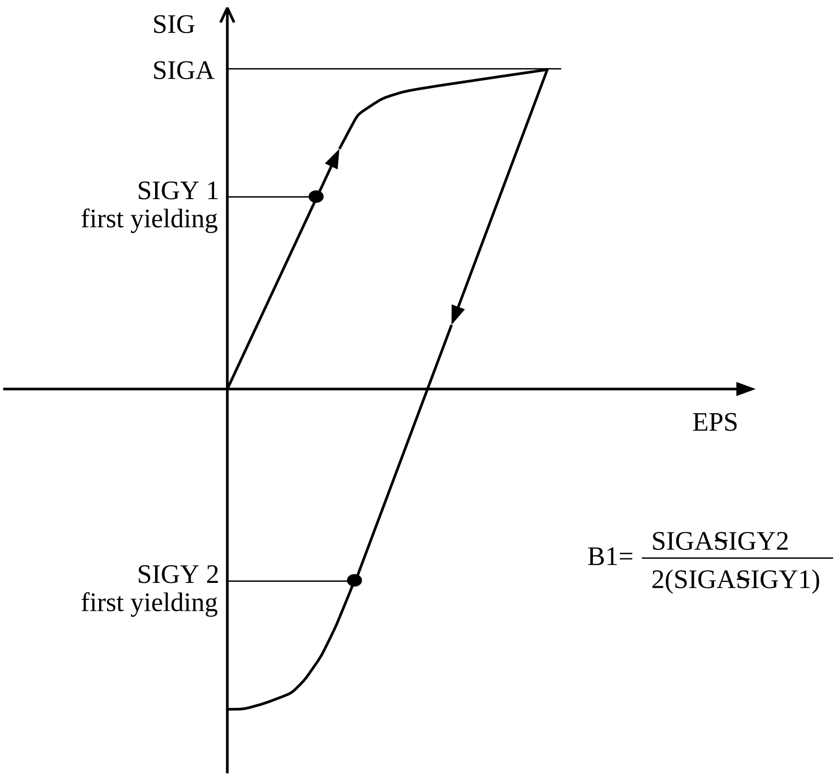


Figure 6-17 Stress-strain curve for a one-dimensional loading-unloading with yielding

Non-linear Isotropic Material for Grout, Material Type 5

MISOPL

MISOPL	MATNO	MATYP	POISS	RHO
	DAMP	ALPH		
	NP	SIG1	EPS1	FCM
				EU
	ET			

MATNO Material number

MATYP Material type
= 5 Special theory for grout

POISS Poisson's ratio (recommended value 0.15 - 0.2)

NP Number of points to represent the uniaxial stress-strain curve for increased loading (=1)

SIG1 Stress at the first point representing the stress-strain curve.

EPS1 Corresponding strain at the first point representing the stress-strain curve. The relation YOUNG=SIG1/EPS1 is only used to compute Young's modulus

FCM Compression stress (concrete) at which the grout becomes perfectly plastic

EU Compressive strain at crushing (uniaxial strain)

ET Tensile strain at cracking (uniaxial strain)

MISOPL

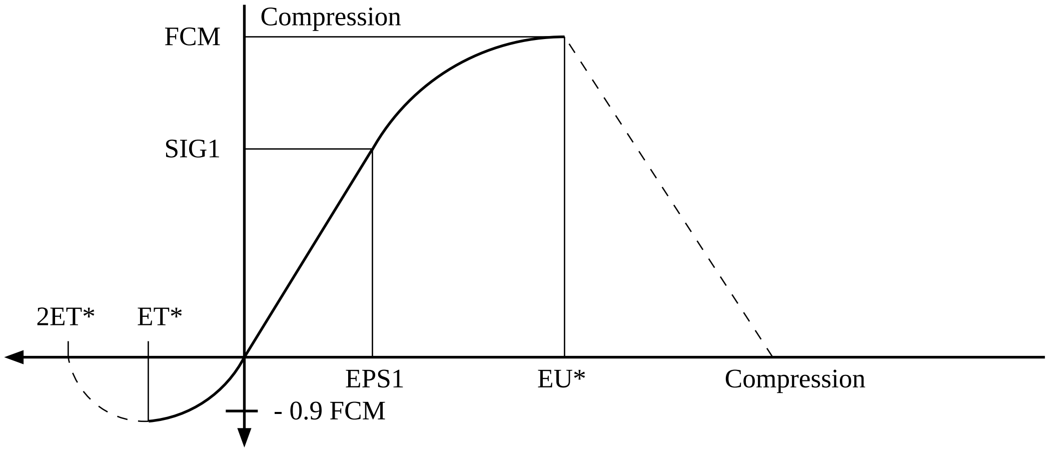


Figure 6-18 Uniaxial stress-strain curve for grout.

Non-linear Isotropic Material for Debonding Material, Material Type 6

MISOPL

MISOPL	MATNO	MATYP	POISS	RHO
	DAMP	ALPH		
	NP	SIG1	EPS1	SZMAX
	TAUMAX	EZREF	GREF	

MATNO	Material number
MATYP	Material type = 6 Special theory for debonding material
POISS	Poisson’s ratio (recommended value 0.15 - 0.20)
NP	Number of points to represent the uniaxial stress-strain curve for increased loading (=1)
SIG1	Stress at the first point representing the stress-strain curve.
EPS1	Corresponding strain at the first point representing the stress-strain curve (YOUNG=SIG1/EPS1. Recommended values: same as grout)
SZMAX	Maximum tensile separation stress capacity
TAUMAX	Maximum shear capacity
EZREF	Reference strain, i.e. strain where total debonding takes place
GREF	Friction stiffness for closed gaps, (typical 0.5 times the shear modulus)

MISOPL

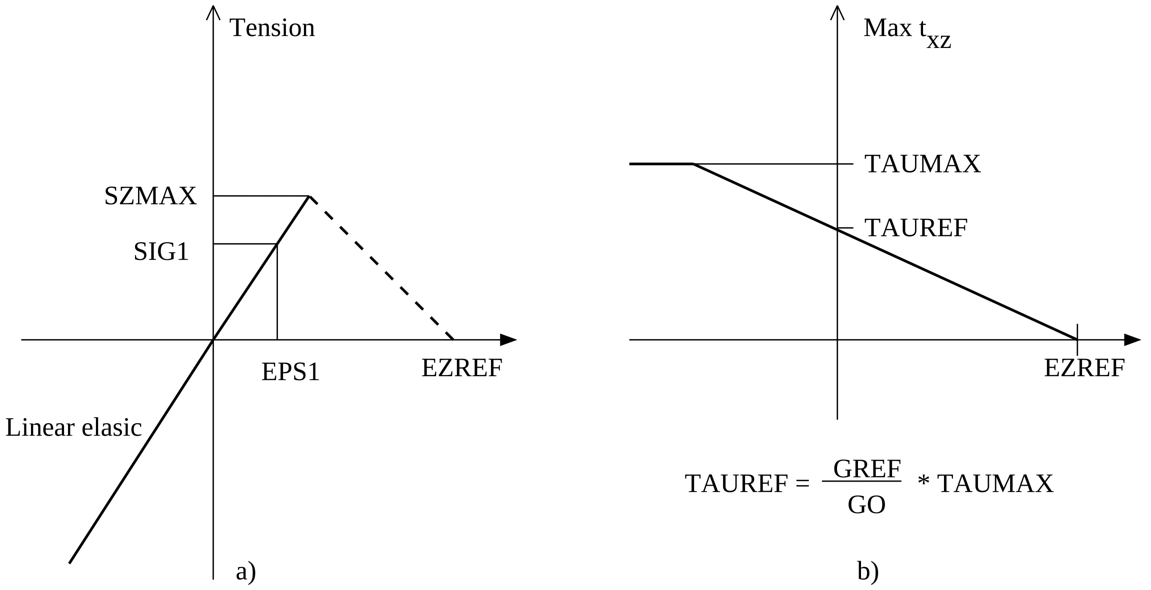


Figure 6-19 a) Uniaxial stress-strain normal to steel surface.
b) Maximum shear stress as function of normal strain.

Isotropy, Linear Elastic Structural Analysis

MISOSEL

MISOSEL	MATNO	YOUNG	POISS	RHO
	DAMP	ALPHA		

MATNO Material number, i.e. reference number referenced to by the element specification.

YOUNG Young’s modulus.

POISS Poisson’s ratio.

RHO Density.

DAMP Specific damping.

ALPHA Thermal expansion coefficient.

Temperature Dependent Isotropic, Linear Elastic Material

MISTEL

MISTEL	MATNO	YOUNG	YTEMPNO	POISS
	RHO	RTEMPNO	DAMP	DTEMPNO
	ALPHA	ATEMPNO		

MATNO Material number, i.e. reference number referenced to by the element specification.

YOUNG Young's modulus

POISS Poisson's ratio

RHO Density

DAMP Specific damping

ALPHA Thermal expansion coefficient

YTEMPNO Reference number to a temperature dependent scaling factor of YOUNG. See record type MTEMP.

RTEMPNO Reference number to a temperature dependent scaling factor for RHO.

DTEMPNO Reference number to a temperature dependent scaling factor for DAMP

ATEMPNO Reference number to a temperature dependnet scaling factor for ALPHA.

Temperature reference number is zero if no temperature dependence.

Anisotropy, Linear Elastic Structural Analysis, 2-D Membrane Elements and 2-D Thin Shell Elements

MORSMEL

MORSMEL	MATNO	Q1	Q2	Q3
	RHO	D11	D21	D22
	D31	D32	D33	PS1
	PS2	DAMP1	DAMP2	ALPHA1
	ALPHA2			

MATNO Material number. Reference number referenced to by the element specification.

Q1
Q2
Q3 Global components of a vector Q indicating axes of anisotropy. The first principal axis of anisotropy is referred to the projection of Q on the membrane plane.

RHO Density

D11-D33 Elements of the lower triangular part of the general anisotropic elasticity matrix. In case of orthotropy, only D11, D21, D22 and D33 are nonzero.

PS1,PS2 Only given for plane strain situation. The stress normal to the membrane plane (s_n) is calculated as follows: $s_n = PS1 \cdot s_1 + PS2 \cdot s_2$
(For an isotropic material PS1 and PS2 equal Poisson’s ratio)

DAMP1
DAMP2 Specific damping along respectively 1. and 2. principal axes of anisotropy.

ALPHA1
ALPHA2 Thermal expansion coefficients along respectively 1. and 2. principal axes of anisotropy.

Note: The vector Q must not be perpendicular to any of the elements

Anisotropy, Linear Elastic Structural Analysis, 3-D One- and Multilayered Thick Shell Elements

MORSSEL

MORSSEL	MATNO	Q1	Q2	Q3
	RHO	NLAY	THL_1	$OANG_1$
	$D11_1$	$D21_1$	$D22_1$	$D31_1$
	$D32_1$	$D33_1$	$D41_1$	$D42_1$
	$D43_1$	$D44_1$	$D51_1$	$D52_1$
	$D53_1$	$D54_1$	$D55_1$	$DAMP1_1$
	$DAMP2_1$	$ALPHA1_1$	$ALPHA2_1$	THL_2
	$OANG_2$	$D11_2$	. . .	. . .
	THL_{NLAY}	. . .	. . .	$ALPHA2_{NLAY}$

MATNO Material number. Reference number referenced to by the element specification.

Q1
Q2
Q3 Global components of a vector Q indicating axes of anisotropy. The first principal axis of anisotropy is referred to the projection of Q on the shell plane.

RHO Density

NLAY
- =1: One material type through the thickness
- ≥2: Number of layers of a multilayered (sandwich) material

THL_1 Thickness of first layer in percent of element thickness. If NLAY=1, THL1 is assumed equal to 100 (%)

$OANG_1$ Angle in degrees giving rotation of the axes of anisotropy in the shell plane for material layer no. 1.

$D11_1$-$D55_1$ Elements of the lower triangular part of the general anisotropic elasticity matrix for material layer no. 1.
In case of orthoptropy, only the diagonal terms and D21 are nonzero.
D is defined by the relation in local layer axes: $\sigma = \mathbf{D} \cdot \varepsilon$, where $\varepsilon = [\varepsilon_{xx}, \varepsilon_{yy}, \gamma_{xy}, \gamma_{yz}, \gamma_{zx}]^T$

MORSSEL

$DAMP1_1$ $DAMP2_1$ Specific damping along respectively 1. and 2. principal axes of anisotropy for material no. 1.

$ALPHA1_1$ $ALPHA2_1$ Thermal expansion coefficients along respectively 1. and 2. principal axes of anisotropy.

THL-ALPHA2 are repeated for all NLAY layers of the sandwich material.

THL must add up to 100(%).

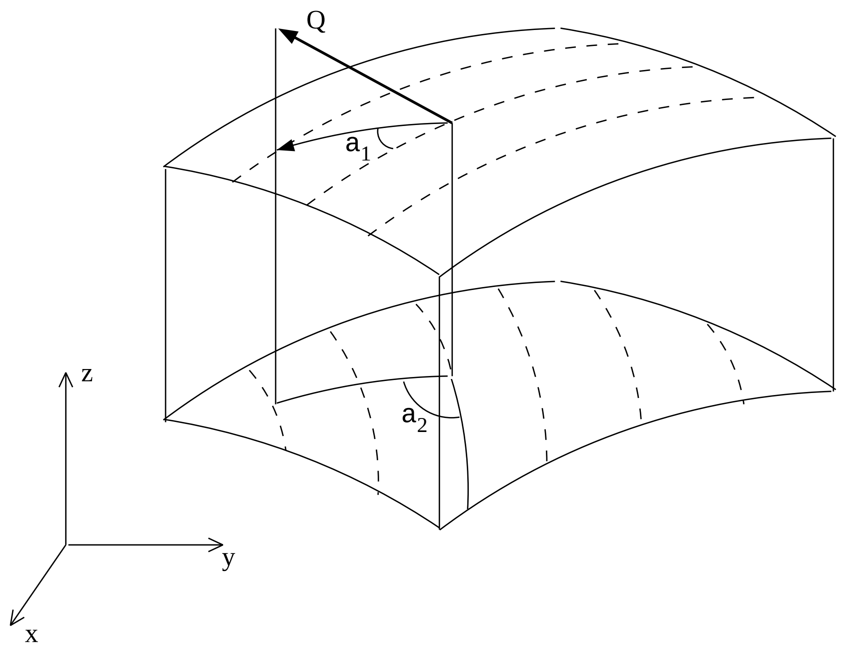


Figure 6-20 1. principal axis of anisotropy given by the global vector Q and a rotation angle a_1 ($OANG_1$) and a_2 ($OANG_2$) for a two-layered material.

For each integration point Q is projected on the shell surface and the same angle a is added. This implies that Q must not be perpendicular to the element surface in any of the integration points.

Anisotropy, Linear Elastic Structural Analysis, Solid Elements

MORSSOL

MORSSOL	MATNO	RHO	D11	D21
	D22	D31	D32	D33
	D41	D42	D43	D44
	D51	D52	D53	D54
	D55	D61	D62	D63
	D64	D65	D66	DAMP1
	DAMP2	DAMP3	ALPHA1	ALPHA2
	ALPHA3	TRANSNO		

MATNO Material number. Reference number referenced to by the element specification.

RHO Density

D11-D66 Elements of the lower triangular part of the general, anisotropic elasticity matrix. In case of orthotropy, only D21, D31, D32 and the diagonal terms are nonzero. **D** is defined by the relation $\sigma = \mathbf{D} \bullet \varepsilon$, where $\varepsilon = [\varepsilon_{xx}, \varepsilon_{yy}, \varepsilon_{zz}, \gamma_{xy}, \gamma_{yz}, \gamma_{zx}]^T$

DAMP1
DAMP2 Specific damping along respectively 1., 2. and 3. principal axes of anisotropy.
DAMP3

ALPHA1
ALPHA2 Thermal expansion coefficients along respectively 1., 2. and 3. principal axes of anisotropy.
ALPHA3

TRANSNO Reference number to the transformation to the anisotropy axes, defined on data type BNTRCOS. The transformation matrix is referred to the global coordinate system ($X_{anis} = T \cdot X_{glob}$) and is common to all elements of this material type. Additional local rotation is defined on record type MTRSOL for each element.

General 2-noded Spring/Shim Element

MSHGLSP

MSHGLSP	MATNO	MATKND	NDOF1	NDOF2
	K(1, 1)	K(2, 1)	. . .	K(NDOF1, 1)
	K(NDOF1+1, 1)	. . .	K(TDOF, 1)	K(2, 2)
	K(3, 2)	. . .	K(TDOF, 2)	K(3, 3)
	. . .	K(TDOF, TDOF)		

MATNO Material number, i.e. reference number referenced to by the element specification.

MATKND Material kind:
= 1 Shim-element
= 2 General spring

NDOF1 Number of degrees of freedom in local node 1.

NDOF2 Number of degrees of freedom in local node 2.

K(i,j) Elements of the stiffness matrix (only elements on and below the main diagonal are stored, i.e. symmetric stiffness matrix assumed). The elements are referred to a local coordinate system if defined (by TRANSNO on GELREF1), otherwise to the global coordinate system of the superelement.
(TDOF = NDOF1 + NDOF2)

The (i,j)'th element of the stiffness matrix corresponds to the force to be given in the i'th d.o.f. to get a unit displacement in the j'th d.o.f.

A GELMNT1 record with element type = 40 and a GELREF1 record with reference to this (MSHGLSP) record is necessary in order to fulfill the definition of the 2-noded spring or shim element.

Scaling Curve for Temperature Variation

MTEMP

MTEMP	TEMPNO	NPOINT	SCAL(1)	TEMP(1)
	. . .	. . .	SCAL(NPOINT)	TEMP(NPOINT)

TEMPNO Temperature reference number of this curve.

NPOINT Number of points in this curve.

SCAL(i)
TEMP(i) Scaling factor and corresponding temperature for point "i" on the curve.

Non-linear Material with Temperature Dependency **MTENONL**

MTENONL	MATNO	MATYP	POISS	PTEMPNO
	RHO	RTEMPNO	DAMP	DTEMPNO
	ALPHA	ATEMPNO	B1	void
	NPOINT	MTEMPNO	SIG1	EPS1
	MATNO	YOUNG	YTEMPNO	POISS
			SIG(NPOINT)	EPS(NPOINT)

MATNO Material number

MATYP Material type
- = 1 Elasto-plastic material
- = 2 Nonlinar hyperelastic material
- = 3 Overly technique
- = 4 Isotropic and kinematic hardening
  - B1 Parameter for combining of isotropic and kinematic hardening
    - = 0.0 Isotropic
    - = 1.0 Kinematic
    - Any value between 0.0 and 1.0 is legal
- = 5 Special theory for concrete

POISS Reference Poisson’s ratio

PTEMPNO Reference number for a temperature dependent scaling factor of POISS

RHO Reference density

RTEMPNO Reference number to a temperature dependent scaling factor of RHO

DAMP Reference specific damping

DTEMPNO Reference number to a temperature dependent scaling factor of DAMP

ALPHA Reference thermal expansion coefficient

ATEMPNO Reference number to a temperature dependent scaling factor of ALPHA

B1 Only employed for MATYP=4 (see above)

MTENONL

NPOINT Number of points to represent the uniaxial stress-strain curve for increased loading

MTEMPNO Reference number to a temperature dependent scaling factor to the uniaxial stress-strain curve

SIG1 Stress at the first point representing the stress-strain curve.
EPS1 Corresponding strain at the first point representing the stress-strain curve (=SIG1/YOUNG).
SIG2 Stress at the second point representing the stress-strain curve.
EPS2 Corresponding strain at the second point representing the stress-strain curve.
:
SIG(NPOINT) Stress at the last point representing the stress-strain curve.
EPS(NPOINT) Corresponding strain at the last point representing the stress-strain curve.

Comment: XTEMPNO (X= P, R, D, A or M) is given on record MTEMP. XTEMPNO = 0 means no temperature dependency of the actual parameter.

Local Transformation of the Axes of Anisotropy, 2-D Membrane Elements and 2-D Thin Shell Elements

MTRMEL

MTRMEL	ELNO	OANG		

ELNO Internal element number (generated by the program).

OANG Angle in degrees giving local rotation of the axes of anisotropy in the element plane (see Figure 6-21). OANG is referred to the projection of Q defined on the material record MORSMEL.

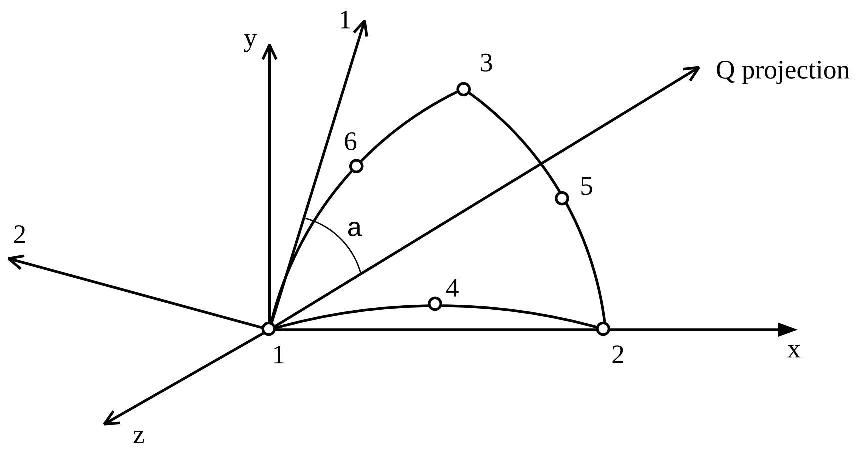


Figure 6-21 Axes of anisotropy (1, 2) given by Q (see material record MORSMEL) and a (OANG for a six-noded membrane in local coordinate system (x,y,z).

This record is only read if MORSMEL records are given. If MTRMEL is not found for the actual element, OANG is assumed equal to zero for this element.

Local Transformation of the Axes of Anisotropy, 3-D Multilayered Thick Shell Element

MTRSEL

MTRSEL	ELNO	QROT	NLAY	$OANG2_1$
	. . .	$OANG2_{NLAY}$		

ELNO Internal element number (generated by the program).

QROT Additional rotation in degrees of all material layers of this element.

NLAY Number of layers of sandwich material. If NLAY = 0, $OANG2_{1-NLAY}$ are assumed equal to zero.

$OANG2_1$ Additional rotation in degrees of material layer no. 1. Only read if NLAY ³ 1.

$OANG2_{1-NLAY}$ Are given for all NLAY layers of the sandwich material if NLAY is specified.

This record is only read if MORSSEL records are given. If MTRSEL is not found for the actual element, no local rotation is assumed for this element.

Local Transformation of the Axes of Anisotropy, Solid Elements

MTRSOL

MTRSOL	ELNO	TRANS2		

ELNO Internal element number (generated by the program)

TRANS2 Reference number to the transformation of the axes of anisotropy defined on data type BNTRCOS. This transformation is added to the transformation defined on material record MORSSOL ($X_{TRANS2} = T \cdot X_{TRANSNO}$)

This record is only read if MORSSOL records are given. If MTRSOL is not found for the actual element, no local transformation is assumed for this element.

7 HIGHER LEVEL DATA

7.1 Additional Subelement Data

Higher Level

Additional User defined Subelement Data

ADDATA

ADDATA	ADDNO	NPAR	PAR1	PAR2
	. . .	. . .	PAR(NPAR)	

ADDNO — Additional data type number, i.e. reference number referring to additional data specifications.

NPAR — Number of parameters specified by user.

PAR1
PAR2
:
PAR(NPAR) — Values for the different terms of the matrix input. The sequence is according to the convention of the analysis program. Relevant only if UNIT=0.

Whenever the analysis program requires data that are particular to a subelement of the superelement type in question (and which are not defined elsewhere) this record type may be employed to assign the data.

The data assigned above are data intended for a lower level subelement. In the record labeled GELMNT2 of the particular subelement an ADDNO must be included which corresponds with the ADDNO of the above record.

The definition of the various parameters is depending on the analysis program to be used and must be revised when switching to another analysis program.

Matrix control Data for Stiffness, Mass, Damping, Load and Resulting Displacement Matrix / Vector

AMATRIX

AMATRIX	NFIELD	MATNO		NNOD
	NSUB	NODGEN		
	MATRTYP	MATRREF	MATRFORM	IFREQ
	MCOMPL			
	. . .	. . .	. . .	. . .
	. . .	. . .	. . .	. . .
	MATRTYP	MATRREF	MATRFORM	IFREQ
	MCOMPL			

NFIELD Number of data fields on this record (including this field and embedded blank fields).

MATNO Reference number ('material number') for this AMATRIX record.

NNOD Number of 'normal' nodes on this element, not including possible generalised d.o.f.s (see description of NODGEN below) from e.g. component mode synthesis dynamic analysis.. NNOD must correspond to specification on GELMNT1 record.

NSUB No. of data fields in each subrecord (= 8 in present version of AMATRIX record).

NODGEN Number of 'nodes' with generalised dof.s. These extra 'nodes' are counted after the 'normal' nodes.

MATRTYP Matrix / vector type indicator:
= 1 Stiffness matrix
= 2 Damping matrix
= 3 Massmatrix
= 4 Load vector
= 5 Resulting Displacement vector
= 6 Resulting Velocity vector
= 7 Resulting Acceleration vector

MATRREF Matrix reference no. for the physical matrix. This no. is pointing to the reference MATRREF on the corresponding AMDSTIFF, AMDDAMP, AMDMASS, AMDLOAD, AMDDISP,

AMATRIX

AMDVELO, AMDACCL and / or AMDFREQ records. MATRREF is zero (0) if MATRFORM below is equal to -1.

MATRFORM
= -1 Element result vectors (displacement, velocity or acceleration) are stored in Result File Format as described in 'SIF, Results Interface File, File Description'.
= 0 Element vectors (load, displacement, velocity or acceleration) are stored.
= 1 Element matrix is symmetric and only upper triangle is stored. For submatrices on the diagonal, all terms are stored and the diagonal submatrices must be symmetric.
= 2 Element matrix is diagonal and only the diagonal nodal matrices are stored. All terms within the nodal submatrices are stored, also terms beeing zero.
= 3 Element matrix is non-symmetric and the full matrix is stored.
= 4 Element matrix is a null matrix, is uniquely defined and no elements need be stored. Hence: No storing of nodal matrices!
= 5 Element matrix is a unit matrix, is uniquely defined and no elements need be stored. Hence: No storing of nodal matrices!

IFREQ
Additional attribute reference number for the matrix of type MATRTYP (e.g. frequency no. for which a stiffness, mass or damping matrix is valid). This means that more than one matrix of same type may be stored for the same element. It is also possible that only one of the matrix types is e.g frequency dependent, while the other types are e.g. frequency independent (only one stiffness, mass and / or damping matrix stored). The correspondence between the frequency noumber and the frequency is stored on an AMDFREQ record.

MCOMPL
Indicator of matrix beeing real or complex.
= 0 Real values in matrix
= 1 Complex values in matrix

The matrices are stored as sparse block data, which means that nodal matrices and / or vectors with all terms beeing zero are not stored.

The flag for load / displacement / velocity / acceleration vectors beeing real or complex are on each nodal vector record AMDLOAD, AMDDISP and so on, since there may be a mixture of real and complex vectors.

A matrix element may only have one AMATRIX record.

Vector Data for Matrix Element Acceleration Vector **AMDACCL**

AMDACCL	NFIELD	MATRREF	MNODI	LLC
	COMPLX	IDOF	$RACCL_1$	$RACCL_2$
	. . .	. . .	$RACCL_{IDOF}$	$IACCL_1$
	$IACCL_2$	. . .	. . .	$IACCL_{IDOF}$

This record contains acceleration terms for a nodal subvector of an element (resulting) acceleration vector. It may be a "reduced" acceleration vector of a superelement or an element acceleration vector of a basic element. Each record contains the acceleration terms of one node for one loadcase.

NFIELD Number of data fields on this record (including this field).

MATRREF Reference number for this acceleration vector record.

MNODI Local matrix element node number.

LLC Local acceleration vector number (positive integer number).

COMPLX Phase shift definition:
= 0 no phase shift
= 1 phase shift

IDOF Number of degrees of freedom of MNODI.

$RACCL_1$
$RACCL_2$
:
$RACCL_{IDOF}$ Real component of the load vector.

$IACCL_1$
$IACCL_2$
:
$IACCL_{IDOF}$ Imaginary component of the load vector. Only present if COMPLX = 1.

The matrices / vectors are stored as sparse block data, which means that nodal matrices and / or vectors with all terms beeing zero are not stored.

Matrix Data for Matrix Element Damping Matrix

AMDDAMP

AMDDAMP	NFIELD	MATRREF	MNODI	MNODJ
	CODDOF	K_{11}	K_{21}	K_{31}
	K_{41}	. . .	$K_{IDOF,1}$	K_{12}
	K_{22}	. . .	$K_{IDOF,2}$	. . .
	$K_{1,JDOF}$	. . .	$K_{IDOF,JDOF}$	

This record contains damping terms for a nodal submatrix of an element damping matrix. It may be a reduced damping matrix of a superelement or an element damping matrix of a basic element. Each record contains the damping terms connecting one node with another, or with itself. For submatrices on the diagonal, all terms are always stored.
Each record of this type is indexed by the nodes which is connected by the damping terms of the submatrix.

NFIELD Number of data fields on this record (including this field).

MATRREF Reference number for this damping matrix record.

MNODI Local matrix element node number.

MNODJ Local matrix element node number.

CODDOF Coded form of submatrix dimension.
CODDOF= IDOF*1000 + JDOF
IDOF= Number of degrees of freedom of MNODI.
JDOF= Number of degrees of freedom of MNODJ.

If this is a complex damping matrix, the imaginary terms are stored after all the real terms.

The matrices are stored as sparse block data, which means that nodal matrices and / or vectors with all terms beeing zero are not stored.

Vector Data for Matrix Element Displacement Vector **AMDDISP**

AMDDISP	NFIELD	MATRREF	MNODI	LLC
	COMPLX	IDOF	$RDISP_1$	$RDISP_2$
	. . .	. . .	$RDISP_{IDOF}$	$IDISP_1$
	$IDISP_2$	. . .	. . .	$IDISP_{IDOF}$

This record contains displacement terms for a nodal subvector of an element (resulting) displacement vector. It may be a reduced displacement vector of a superelement or an element displacement vector of a basic element. Each record contains the displacement terms of one node for one loadcase.

NFIELD Number of data fields on this record (including this field).

MATRREF Reference number for this displacement vector record.

MNODI Local matrix element node number.

LLC Local displacement vector number (positive integer number).

COMPLX Phase shift definition:
= 0 no phase shift
= 1 phase shift

IDOF Number of degrees of freedom of MNODI.

$RDISP_1$ Real component of the displacement vector.
$RDISP_2$
:
$RDISP_{IDOF}$

$IDISP_1$ Imaginary component of the displacement vector. Only present if COMPLX = 1.
$IDISP_2$
:
$IDISP_{IDOF}$

The matrices / vectors are stored as sparse block data, which means that nodal matrices and / or vectors with all terms beeing zero are not stored.

Frequency Definition for AMATRIX Records

AMDFREQ

AMDFREQ	NFIELD	MATRREF	NFREQ	
	$IFREQ_1$	$FREQ_1$	. . .	. . .
	. . .	. . .	$IFREQ_{NFREQ}$	$FREQ_{NFREQ}$

This record contains the frequencies referred to by the IFREQ field on the AMATRIX record with the same MATRREF as this record.

NFIELD Number of data fields on this record (including this field).

MATRREF Reference number for this frequency definition record.

NFREQ Number of frequencies defined on this AMDFREQ record

$IFREQ_1$ The first frequency reference number.

$FREQ_1$ The frequency referred to by IFREQ1 on the AMATRIX record. The dimension of the frequency is Herz (1/second), or in other words oscillations per second.

.

.

$IFREQ_{NFREQ}$ The last frequency reference number.

$FREQ_{NFREQ}$ The frequency referred to by $IFREQ_{NFREQ}$ on the AMATRIX record.

All the IFREQ numbers referred to on AMATRIX records must be defined on the AMDFREQ record.

Vector Data for Matrix Element Load Vector

AMDLOAD

AMDLOAD	NFIELD	MATRREF	MNODI	LLC
	COMPLX	IDOF	$RLOAD_1$	$RLOAD_2$
	. . .	. . .	$RLOAD_{IDOF}$	$ILOAD_1$
	$ILOAD_2$	. . .	. . .	$ILOAD_{IDOF}$

This record contains load terms for a nodal subvector of an element load vector. It may be a reduced load vector of a superelement or an element load vector of a basic element.
Each record contains the load terms of one node for one loadcase.

NFIELD Number of data fields on this record (including this field).

MATRREF Reference number for this load vector record.

MNODI Local matrix element node number.

LLC Local load vector number (positive integer number).

COMPLX Phase shift definition:
= 0 no phase shift
= 1 phase shift

IDOF Number of degrees of freedom of MNODI.

$RLOAD_1$
$RLOAD_2$
:
$RLOAD_{IDOF}$ Real component of the load vector.

$ILOAD_1$
$ILOAD_2$
:
$ILOAD_{IDOF}$ Imaginary component of the load vector. Only present if COMPLX = 1.

The matrices / vectors are stored as sparse block data, which means that nodal matrices and / or vectors with all terms beeing zero are not stored.

Matrix Data for Matrix Element Mass Matrix

AMDMASS

AMDMASS	NFIELD	MATRREF	MNODI	MNODJ
	CODDOF	K_{11}	K_{21}	K_{31}
	K_{41}	. . .	$K_{IDOF,1}$	K_{12}
	K_{22}	. . .	$K_{IDOF,2}$	. . .
	$K_{1,JDOF}$	. . .	$K_{IDOF,JDOF}$	

This record contains mass terms for a nodal submatrix of an element mass matrix. It may be a reduced mass matrix of a superelement or an element mass matrix of a basic element. Each record contains the mass terms connecting one node with another, or with itself. For submatrices on the diagonal, all terms are always stored. Each record of this type is indexed by the nodes which is connected by the mass terms of the submatrix.

NFIELD Number of data fields on this record (including this field).

MATRREF Reference number for this mass matrix record.

MNODI Local matrix element node number.

MNODJ Local matrix element node number.

CODDOF Coded form of submatrix dimension.
CODDOF= IDOF*1000 + JDOF
IDOF= Number of degrees of freedom of MNODI.
JDOF= Number of degrees of freedom of MNODJ.

If this is a complex mass matrix, the imaginary terms are stored after all the real terms.

The matrices are stored as sparse block data, which means that nodal matrices and / or vectors with all terms beeing zero are not stored.

Matrix Data for Matrix Element Stiffness Matrix

AMDSTIFF

AMDSTIFF	NFIELD	MATRREF	MNODI	MNODJ
	CODDOF	K_{11}	K_{21}	K_{31}
	K_{41}	. . .	$K_{IDOF,1}$	K_{12}
	K_{22}	. . .	$K_{IDOF,2}$	. . .
	$K_{1,JDOF}$	. . .	$K_{IDOF,JDOF}$	

This record contains stiffness terms for a nodal submatrix of an element stiffness matrix. It may be a reduced stiffness matrix of a superelement or an element stiffness matrix of a basic element. Each record contains the stiffness terms connecting one node with another, or with itself. For submatrices on the diagonal, all terms are always stored.
Each record of this type is indexed by the nodes which is connected by the stiffness terms of the submatrix.

NFIELD Number of data fields on this record (including this field).

MATRREF Reference number for this stiffness matrix record.

MNODI Local matrix element node number.

MNODJ Local matrix element node number.

CODDOF Coded form of submatrix dimension.
CODDOF= IDOF*1000 + JDOF
IDOF= Number of degrees of freedom of MNODI.
JDOF= Number of degrees of freedom of MNODJ.

If this is a complex stiffness matrix, the imaginary terms are stored after all the real terms.

The matrices are stored as sparse block data, which means that nodal matrices and / or vectors with all terms beeing zero are not stored.

Vector Data for Matrix Element Velocity Vector

AMDVELO

AMDVELO	NFIELD	MATRREF	MNODI	LLC
	COMPLX	IDOF	$RVELO_1$	$RVELO_2$
	. . .	. . .	$RVELO_{IDOF}$	$IVELO_1$
	$IVELO_2$	. . .	. . .	$IVELO_{IDOF}$

This record contains velocity terms for a nodal subvector of an element (resulting) velocity vector. It may be a "reduced" velocity vector of a superelement or an element velocity vector of a basic element.
Each record contains the velocity terms of one node for one loadcase.

NFIELD Number of data fields on this record (including this field).

MATRREF Reference number for this velocity vector record.

MNODI Local matrix element node number.

LLC Local velocity vector number (positive integer number).

COMPLX Phase shift definition:
= 0 no phase shift
= 1 phase shift

IDOF Number of degrees of freedom of MNODI.

$RVELO_1$
$RVELO_2$
:
$RVELO_{IDOF}$
Real component of the load vector.

$IVELO_1$
$IVELO_2$
:
$IVELO_{IDOF}$
Imaginary component of the load vector. Only present if COMPLX = 1.

The matrices / vectors are stored as sparse block data, which means that nodal matrices and / or vectors with all terms beeing zero are not stored.

7.2 Boundary Conditions, Loads and Point Masses

Higher Level

Nodes with Linear Dependence

BLDEP

BLDEP	NODENO	CNOD	NDDOF	NDEP
	$DEPDOF_1$	$INDEPDOF_1$	$b_{DEP1,INDEP1}$	
	$DEPDOF_2$	$INDEPDOF_2$	$b_{DEP2,INDEP2}$	
	. . .	. . .	. . .	
	$DEPDOF_{NDEP}$	$INDEPDOF_{NDEP}$	$b_{DEPn,INDEPn}$	

NODENO Internal node number of the dependent node.

CNOD Internal node number of an independent node.

NDDOF Number of dependent degrees of freedom of node NODENO. When not specified, NDDOF is equal to NDEP.

NDEP Number of triplets with DEPDOF, INDEPDOF and $b_{i,j}$

DEPDOF[1] Dependent node's degree of freedom.

INDEPDOF[1] Independent node's degree of freedom.

$b_{i,j}$ The contribution of the j'th degree of freedom of the dependent node to the i'th dependent degrees of freedom of the dependent node.

Each line specifies one dependent degree of freedom which is dependent on the independent node's specified degree of freedom with the factor $b_{i,j}$. The degrees of freedom must also be specified on BNBCD-records as linear dependent (3) for the dependent node, and as retained (4) for the independent node.

A node may be dependent on many nodes. For each combination of NODENO and CNOD a new record, starting with the identifier BLDEP, is given.

The same combination of NODENO and CNOD may occur only once.

When node transformations have been specified for any of the nodes implied in the linear dependence, the degrees of freedom refers to the transformed local coordinate system.

1DEPDOF and
one degree of f
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BLDEP

Multipoint constraints (2nd and higher order dependence) may be specifed through more BLDEP records with the same linear dependent node and different independent nodes. The factors $b_{i,j}$ may be found as Lagrange multiplicators or coefficients (Lagrange interpolation polynomial). For 2nd order dependence this may as well be specified on one BQDP record.

Nodes with Boundary Conditions

BNBCD

BNBCD	NODENO	NDOF	FIX1	FIX2
	. . .	. . .	FIX(NDOF)	

NODENO Nodes with specified boundary condition.

NDOF Number of degrees of freedom.

FIX1
FIX2
: Specification of boundary condition codes of relevant degrees of freedom.
:
FIX(NDOF)

The codes of FIX1, FIX2, ..., FIX(NDDF) are explained below:

FIX1	= 0	free to stay
FIX2	= 1	fixed at zero displacement, temperature, etc.
:	= 2	prescribed displacement, temperature, velocity, acceleration, etc. different from zero
:	= 3	linearly dependent
FIX(NDOF)	= 4	retained degree of freedom, i.e. supernode.

The code FIX = 2 just indicates specified condition for the relevant degree of freedom. Whether it is displacement, first time derivative of the displacement etc. is definde on the BNDISPL record. Degrees of freedom with FIX = 2 which are not defined on the BNDISPL record will be fixed (have zero displacement, velocity and acceleration).

The node numbers (degrees of freedom) with FIX = 4 are called supernodes. The supernode numbering is according to the increasing order of their internal node number.

Nodes with Displacements, Velocities and Accelerations

BNDISPL

BNDISPL	LLC	DTYPE	COMPLX	
	NODENO	NDOF	RDISP1	RDISP2
	. . .	. . .	. . .	RDISP(NDOF)
	IDISP1	IDISP2	. . .	. . .
	. . .	IDISP(NDOF)		

LLC — Local load case number (positive integer number).

DTYPE — Type of boundary condition
- = 1 specified displacement, temperature, etc.
- = 2 specified velocity, first time derivative of the temperature, etc.
- = 3 specified acceleration, etc.

COMPLX — Phase shift definition.
- = 0 no phase shift
- = 1 phase shift

NODENO — Node number.

NDOF — Number of degrees of freedom at the node NODENO.

RDISP1 — The real part of the specified boundary condition with respect to the first degree of freedom.

RDISP2 — The real part of the specified boundary condition with respect to the second degree of freedom.
:
RDISP(NDOF) — The real part of the specified boundary condition with respect to the last degree of freedom.

IDISP1 — The imaginary part of the specified boundary condition with respect to the first degree of freedom.

IDISP2 — The imaginary part of the specified boundary condition with respect to the second degree of freedom.
:
IDISP(NDOF) — The imaginary part of the specified boundary condition with respect to the last degree of freedom.

DISP and IDISP refer to the transformed coordinate system if the node NODENO is transformed, else to the global coordinate system of the superelement.

BNDISPL

The imaginary numbers follow immediately after the real numbers, i.e. there are no blank fields between the last real part and the first imaginary part.

If phase shift is not specified, the fields or positions IDISP1, IDISP2, etc. are left out.

Nodes with Transformation

BNDOF

BNDOF	NODENO	TRANSD	TRANSR	

NODENO Program defined node number.

TRANSD Reference number to the transformed coordinate system of the displacements, given on BNTRCOS.

TRANSR Reference number to the transformed coordinate system of the rotations, given on BNTRCOS.

If no reference number is given, no transformation is relevant to the relevant type of degree of freedom, i.e. translations or rotations.

Nodes with Initial Conditions If Arbitrary Time Dependent Loading

BNINCO

BNINCO	INCONO	DTYPE		

	NODENO	NDOF	RDISP1	RDISP2

	RDISP3	RDISP4	RDISP5	RDISP6

INCONO Initial condition number.

DTYPE Type of condition.
= 1 Displacement
= 2 Velocities

NODENO Internal node number.

NDOF Number of degrees of freedom for node.

RDISP1
RDISP2
:
RDISP(NDOF) Value in the first degree of freedom.

Nodes with Loads

BNLOAD

BNLOAD	LLC	LOTYP	COMPLX	
	NODENO	NDOF	RLOAD1	RLOAD2
	. . .	. . .	. . .	RLOAD(NDOF)
	ILOAD1	ILOAD2	. . .	. . .
	. . .	ILOAD(NDOF)		

LLC — Local load case number (positive integer number).

LOTYP — Load type at node NODENO.

COMPLX — Phase shift definition.
= 0 no phase shift
= 1 phase shift

NODENO — Node number.

NDOF — Number of degrees of freedom at the node NODENO.

RLOAD1 — The real part of the load with respect to the first degree of freedom.

RLOAD2 — The real part of the load with respect to the second degree of freedom.
:
RLOAD(NDOF) — The real part of the load with respect to the last degree of freedom.

ILOAD1 — The imaginary part of the load with respect to the first degree of freedom.

ILOAD2 — The imaginary part of the load with respect to the second degree of freedom.
:
ILOAD(NDOF) — The imaginary part of the load with respect to the last degree of freedom.

The imaginary numbers follow immediately after the real numbers, i.e. there are no blank fields between the last real part and the first imaginary part.

If phase shift is not specified, i.e. COMPLX = 0, the fields or positions ILOAD1, ILOAD2, etc. are left out.

Nodes with Point Masses

BNMASS

BNMASS	NODENO	NDOF	MASS1	MASS2
	. . .	. . .	MASS(NDOF)	

NODENO Node number.

NDOF Number of degrees of freedom.

MASS1 Point mass with respect to the first degree of freedom.

MASS2 Point mass with respect to the second degree of freedom.

:

MASS(NDOF) Point mass with respect to the last degree of freedom (NDOF).

Transformation to Local Coordinate System, Direction Cosines

BNTRCOS

BNTRCOS	TRANS	C11	C21	C31
	C12	C22	C32	C13
	C23	C33		

TRANS Reference number to the transformed coordinate system.

C11
C21
C31
: Terms (9 direction cosines) of the transformation matrix (rotation).
C23
C33

The transformation matrix **c** describes the tranformation defined by

r' = c r

where **r'** refers to the local coordinate system and **r** to the global (superelement) coordinate system.

The GUNIVEC records are used for beam elements only, i.e. basic element types 2, 15 and 23. Other basic element types may refer to BNTRCOS records. No ambiguity thus exists if both a GUNIVEC and BNTRCOS record have same TRANSNO.

Nodes with Simple Quadratic Dependence

BQDP

BQDP	NODENO	DDOF		
	CNOD1	$CDOF_1$	$BETA_1$	$CDOF_2$
	$BETA_2$	. . .	. . .	CDOF(DDOF)
	BETA(DDOF)			
	CNOD2	. . .	. . .	. . .
	CNOD3	. . .	. . .	. . .

NODENO Program defined node number of the dependent node.

DDOF Dependent degrees of freedom of NODENO. (Must correspond with the number of degrees of freedom with the code FIX = 3 referenced in BNBCD for the very same node.)

CNOD1 Node number of the first independent node.

$CDOF_1$ The first relevant degree of freedom of CNOD1 which is coupled to the corresponding dependent degree of freedom of NODENO.

$BETA_1$ The corresponding contribution of the first relevant degree of freedom of CNOD1 to the quadratic dependence of the corresponding dependent degree of freedom of NODENO.

$CDOF_2$ The second relevant degree of freedom of CNOD1 which is coupled to the corresponding dependent degree of freedom of NODENO.

$BETA_2$ The corresponding contribution of the second relevant degree of freedom of CNOD1 to the quadratic dependence of the corresponding dependent degree of freedom of NODENO.

:

CDOF(DDOF) The last relevant degree of freedom of CNOD1 which is coupled to the corresponding dependent degree of freedom of NODENO.

BETA(DDOF) The corresponding contribution of the last relevant degree of freedom of CNOD1 to the quadratic dependence of the corresponding dependent degree of freedom of NODENO.

CNOD2 As above for the second independent node.

:

CNOD3 As above for the third and last independent node.

BQDP

By simple is meant that f.ex. the first dependent degree of freedom is always coupled to the first independent degree of freedom, the second dependent degree of freedom is always coupled to the second independent degree of freedom, etc.

Subelement Load Description

BSELL

BSELL	LC	SUBNO		
	LLC1	FACT1	LLC2	FACT2
	. . .	. . .	LLCN	FACTN

LC Global load case number (positive integer number).

SUBNO Subelement number of the superelement in question.

LLC1 First local load case included in the global load case LC.

FACT1 Scaling factor for the first local load case.

LLC2 Second local load case included in the global load case LC.

FACT2 Scaling factor for the second local load case.

:

LLCN Last local load case included in the global load case LC.

FACTN Scaling factor for the last local load case.

7.3 Nodal Data and Element Geometry Definition

Higher Level

Nodal Coordinates

GCOORD

GCOORD	NODENO	XCOORD	YCOORD	ZCOORD

NODENO   Node number (internal).

XCOORD
YCOORD   Cartesian X-, Y- and Z-coordinates of node NODENO.
ZCOORD

There will be one record with the identifier GCOORD for each node. The sequence of the records must correspond to the internal node numbering.

Element Data Definition

GELMNT1

GELMNT1	ELNOX	ELNO	ELTYP	ELTYAD
	NODIN1	NODIN2	. . .	. . .
	...	NODIN(N)		

ELNOX External element number (specified or controlled by user).

ELNO Internal element number (generated by program).

ELTYP Element type number. Refer to chapter 6 for description of legal type no. For element type no. 70 ("matrix element") all relevant element data are stored as stiffness, mass, damping matrices a.s.o. See the AMATRIX record for more information.

ELTYAD Additional information related to element type:
= IPLANE for membranes
= ISTRUCT for two noded beam elements
= IMATRX for "matrix elements"

IPLANE	Used to specify plane stress / plane strain conditions
0	Plane stress
1	Plane strain
ISTRUCT	Used to specify structural / nonstructural elements
0	Structural beam
1	Non structural beam
IMATRX	Reference no. to the corresponding AMATRIX record.
n	Referring to the the AMATRIX record with IMATRX = n

NODIN1
NODIN2
:
NODIN(N) Global internal node numbers of the elements in question. The sequence of the node numbers is in accordance with the local node numbering of the basic elements.

By global node number is meant the node numbering of the entire superelement of which the element ELNOX is a part. The internal node number refers to the node number generated by the program.

The program-defined element number ranges from 1 up to number of elements.

The sequence of the records will correspond to the program-defined element numbering, ELNO.

Subelement Description with Simple Correspondence between Degrees of Freedom of Subelement and Relevant Assembly

GELMNT2

GELMNT2	SUBNO	SLEVEL	STYPE	ADDNO
	T_{11}	T_{21}	T_{31}	T_{12}
	T_{22}	T_{32}	T_{13}	T_{23}
	T_{33}	T_{14}	T_{24}	T_{34}
	NNOD	NOD1	NOD2	. . .
	. . .	NOD(NNOD)		

SUBNO Subelement number within the relevant assembly which this superelement is part of.

SLEVEL Superelement level. Should be identical to SLEVEL on the IDENT record for this subelement.

STYPE Superelement type of the subelement in question.

ADDNO Additional data type number, i.e. reference number referring to additional data specifications.

T11
T21
T31 Elements of the general transformation matrix (see next page).
:
T34

NNOD Number of nodes of the subelement in question.

NOD1
NOD2 Node numbers of the subelement in question.
: Note: The sequence of the nodes defined on this record must be in ascending order of the
: internal node numbers of the supernodes on the level below. If this is not the case the
NOD(NNOD) coupling of the superelements will be wrong.

GELMNT2

The general transformation matrix:

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \left[\begin{array}{ccc|c} T_{11} & T_{12} & T_{13} & T_{14} \\ T_{21} & T_{22} & T_{23} & T_{24} \\ T_{31} & T_{32} & T_{33} & T_{34} \\ \hline 0 & 0 & 0 & 1 \end{array}\right] \cdot \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

where

$$\begin{bmatrix} x' \\ y' \\ z' \end{bmatrix} = \text{subelement coordinate system,} \qquad \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \text{assembly coordinate system}$$

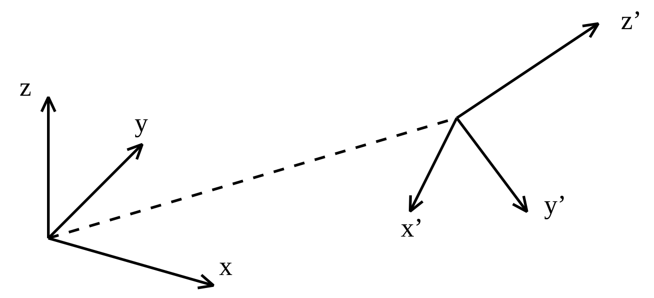


Figure 7-1 Subelement and assembly coordinate system

The 9 terms (cosines) of the first submatrix are due to a possible rotation and/or mirroring of the subelement in question

The three terms of the second submatrix are the coordinates of the origin of the global (assembly) coordinate system in the local coordinate system.

Reference to Element Data

GELREF1

GELREF1	ELNO	MATNO	ADDNO	INTNO
	MINTNO	STRANO	STRENO	–
	GEONO/OPT	FIXNO/OPT	ECCNO/OPT	TRANSNO/OPT
	GEONO(1)	. . .	GEONO(N)	FIXNO(1)
	. . .	FIXNO(1)	ECCNO(1)	. . .
	ECCNO(N)	TRANSNO(1)	. . .	TRANSNO(N)

Shortest version:

GELREF1	ELNO	MATNO	ADDNO	INTNO
	MINTNO	STRANO	STRENO	–
	GEONO/OPT	FIXNO/OPT	ECCNO/OPT	TRANSNO/OPT

Shortest version:

ELNO Internal element number (generated by the program).

MATNO Material number.
= 0 no material data attached to the element.

ADDNO Additional data type number, i.e. number referring to additional data specification.
= 0 no additional data attached to the element.

INTNO Integration station reference number for stiffness matrix, i.e. number referring to the specification of integration stations. An integration station is defined as:
- an assembly of integration points over a cross section of a 1-dimensional (beam or bar)
element,
- an assembly of integration points on a line through the thickness of a 2-dimensional element,

GELREF1

	- one single integration point for a 3-dimensional element. For further explanation see record GELINT. INTNO = 0: Default values of the analysis program are employed.
MINTNO	Integration station reference number for mass and damping matrices. Integration station, see INTNO. MINTNO = 0: Default values of the analysis program are employed.
STRANO	Initial strain number, i.e. number referring to the specification of initial strains given on data type ASTR.
STRENO	Initial stress number, i.e. number referring to the specification of initial stresses given on data type ASTR.
GEONO/OPT	Geometry reference number or option for geometry reference number specified later in this record sequence. > 0 The geometry reference number (the same for all nodes in the element). GEONO(1), ..., GEONO(N) will not be specified. = 0 No geometry data is given, i.e. neither here nor on GEONO(1), ..., GEONO(N). =-1 Reference numbers to geometry data are specified later in this record sequence for all nodes, i.e. all GEONO(1), ..., GEONO(N) will be given.
FIXNO/OPT	Fixation reference number or option for fixation reference numbers specified later in this record sequence. The meaning assigned to the values of FIXNO/OPT will be the same as for GEONO/OPT.
ECCNO/OPT	Eccentricity reference number or option for eccentricity reference numbers specified later in this record sequence. The meaning assigned to the values of ECCNO/OPT will be the same as for GEONO/OPT.
TRANSNO/OPT	Reference number for local coordinate system specification or option for specification of local nodal coordinate systems later in this record sequence. The meaning assigned to the values of TRANSNO/OPT will be the same as for GEONO/OPT.
GEONO(1)	Geometry reference number, i.e. number referring to thickness or cross sectional specification. Not employed for 3-dimensional elements. GEONO(1) is the reference number for the 1st local node of the element, GEONO(i) will be the reference number for the i’th local node.
GEONO(N)	Geometry reference number for the last local node of the element.
FIXNO(1)	Number referring to the specification of degree of fixation (Data type BELFIX). FIXNO(1) is the reference number for the 1st local node of the element, FIXNO(i) will be the reference number for the i’th local node.
FIXNO(N)	Degree of fixation reference number for the last local node of the element.

GELREF1

ECCNO(1)	Eccentricity number for the first local node of the element, i.e. number referring to the specification of eccentricities.
ECCNO(N)	As ECCNO(1) only for the last local node.
TRNSNO(1)	Number referring to the specification of the local element coordinate system for the 1st local node of the element. Refers to BNTRCOS or GUNIVEC record depending on element type.
TRANSNO(N)	As TRANSNO(1) only for the last local node.

N is the number of local nodes of the element.
Note: Parameters appear in succeeding order from third line.

Correspondence between External and Internal Node Numbering, and Number of Degrees of Freedom of Each Node

GNODE

GNODE	NODEX	NODENO	NDOF	ODOF

NODEX External node number (specified or controlled by user).

NODENO Internal node number defined by the program (may be generated by internal node numbering optimalizer). The internal node numbers range from 1 up to number of nodes.

NDOF Number of degrees of freedom of nodal point NODENO.

ODOF Order of degrees of freedom. NDOF digits.
Example NDOF = 3, ODOF = 135 means 3 degrees of freedom in x, z and Ry direction respectively in the superelement's coordinate system, unless a local nodal coordinate system is specified (see the BNDOF and BNTRCOS record).

There will be one record with the identifier GNODE for each node. The sequence of the records will correspond to the internal node number, NODENO.

7.4Super-Element Hierarchy Information in Highest Level T-File

Higher Level

Superelement Hierarchy Description

HIERARCH

HIERARCH	NFIELD	IHREF	ISELTY	INDSEL
	ISLEVL	ITREF	IHPREF	NSUB
	$IHSREF_1$	. . .	$IHSREF_{NSUB}$	

This record identifies a superelement in the hierarchy. All the HIERARCH records are written in the highest level (top-level) T-file.

The set of HIERARCH - records stored will define the superelement hierarchy, see figure 1-1. Note that the reference IHREF is unique for all "nodes" in the superelement tree, i.e. unique for every HIERARCH - record. If superelements are repeated, each repetition will have a unique hierarchy reference IHREF, although the superelement type number is identical.

NFIELD No. of data fields on this record (including this field).

IHREF Hierarchy reference number. Number 1 is reserved for the top level superelement. In SESAM, PRESEL (super-element pre-processor) is writing the HIERARCH records and defining a unique number (IHREF) for each appearance of the differenet superelements

ISELTY Superelement type number.

INDSEL Superelement index number. Superelement index in case of repeated superelements. If superelement is not repeated, INDSEL=1 must be used.

ISLEVL Super-element level.

ITREF Reference to record HSUPTRAN, defining super-element transformation between actual super-element and parent super-element.

IHPREF Reference to HIERARCH record of parent super-element.

NSUB No. of sub-elements in this super-element.

$IHSREF_i$ Reference to HIERARCH record for sub-element number ’i’.

HIERARCH

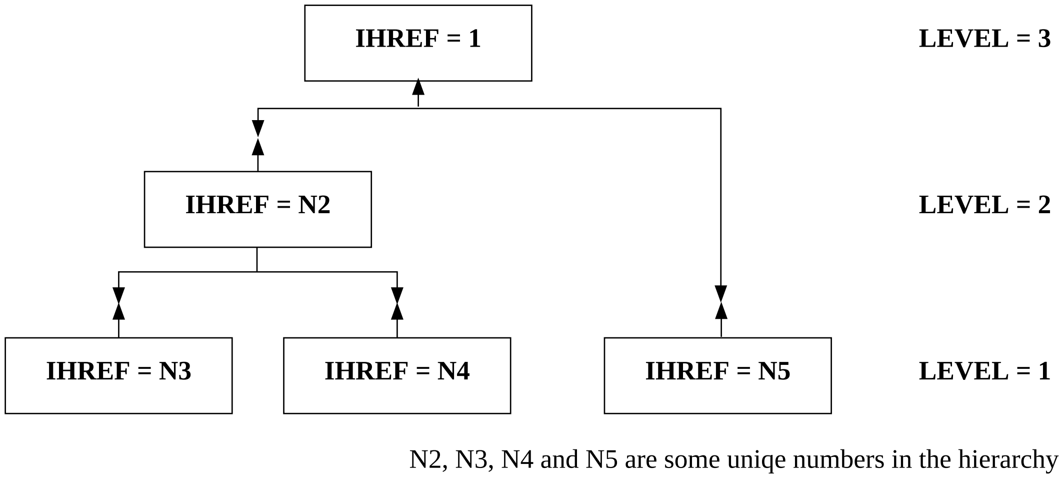


Figure 7-2 Superelement hierarchy with 3 levels.

Example 7.1 Superelement hierarchy with 3 levels. Contents of the HIERARCH records.

IHREF	ISLEVL	IHPREF	NSUB	$IHSREF_1$	$IHSREF_2$
1	3	0	2	N2	N5
N2	2	1	2	N3	N4
N3	1	N2	0		
N4	1	N2	0		
N5	1	1	0		

Number of HIERARCH-records needed to represent this example = 5. The above values would be used in the 5 HIERARCH records. Note that N2, N3, N4 & N5 may take any values as long as they are unique.

Superelement Statistical Information **HSUPSTAT**

HSUPSTAT	NFIELD	ISELTY	NIDOF	NRDOF
	NBAND	NELT	LINDEP	RELOADC
	COMPLC			

This record lists statistical information about superelements. All the HSUPSTAT records are written in the highest level (top-level) T-file. The HSUPSTAT record is referenced from the HIERARCH record through the superelement type number (ISELTY).

NFIELD No. of data fields on this record (including this field).

ISELTY Superelement type number.

NIDOF Estimated number of internal degrees of freedoms.

NRDOF Estimated number of retained degrees of freedoms.

NBAND Estimated bandwidth of the internal degrees freedoms. The estimated bandwidth shall be equal to -1 if no bandwidth information exists.

NELT Estimated number of elements. The estimated number of elements is only required for first level superelements.

LINDEP If LINDEP > 0, this superelement has linear dependent nodes.

RELOADC Number of real loadcases.

COMPLC Number of complex loadcases.

Superelement Transformations

HSUPTRAN

HSUPTRAN	NFIELD	ITREF	T_{11}	T_{21}
	T_{31}	T_{41}	T_{12}	. . .
	T_{42}	. . .	T_{14}	T_{24}
	T_{34}	T_{44}		

This record is defining the super-element transformation between actual super-element and parent super-element. All the HSUPTRAN records are written in the highest level (top-level) T-file. The HSUPTRAN record is referenced from the HIERARCH record through the superelement transformation reference number, ITREF.

NFIELD No. of data fields on this record (including this field).

ITREF Reference to the HSUPTRAN record (from the HIERARCH record).

T_{ij} Term with index 'i','j' of the transformation matrix between actual super-element and parent superelement, defined by: $\mathbf{X'}_{actual} = \mathbf{T} \cdot \mathbf{X}_{parent}$

Superelement transformation:

$$\begin{bmatrix} X' \\ Y' \\ Z' \\ 1 \end{bmatrix} = \begin{bmatrix} T_{11} & T_{12} & T_{13} & T_{14} \\ T_{21} & T_{22} & T_{23} & T_{24} \\ T_{31} & T_{32} & T_{33} & T_{34} \\ 0 & 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$

$$\begin{bmatrix} X' \\ Y' \\ Z' \end{bmatrix} =$$ Coordinate system of actual superelement.

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} =$$ Coordinate system of parent superelement.

$$\begin{bmatrix} T_{14} \\ T_{24} \\ T_{34} \end{bmatrix} = \begin{bmatrix} DX \\ DY \\ DZ \end{bmatrix} =$$ Displacement terms of superelement transformation

7.5 Material Data

Higher Level

Record Type **Page**

Element Type (Number)

Axial Damper between Two Nodal Points **MAXDMP**

MAXDMP	MATNO	DAMP		

MATNO Material number, i.e. reference number referred to by the element specification.

DAMP Axial damping constant.

The axial damping constant corresponds to the force to be applied in order to get a unit velocity in the direction of the basic element.

Axial Spring between Two Nodal Points

MAXSPR

MAXSPR	MATNO	SCON		

MATNO Material number, i.e. reference number referred to by the element specification.

SCON Axial spring constant.

The axial spring constant corresponds to the force to be applied in order to get a unit displacement in the direction of the basic element.

Damping Element to Ground

MGDAMP

MGDAMP	MATNO	NDOF	C(1, 1)	C(2, 1)
	. . .	. . .	C(NDOF, 1)	C(2, 2)
	C(3, 2)	. . .	. . .	C(NDOF, 2)
	C(3, 3)	. . .	. . .	C(NDOF, NDOF)

MATNO Material number, i.e. reference number referred to by the element specification.

NDOF Number of degrees of freedom of the node.

C(i,j) Elements of the damping matrix (only elements on and below the main diagonal are stored, i.e. symmetric damping matrix assumed). The elements are referred to a local system if defined (by TRANSNO on GELREF1), otherwise to the global coordinate system of the superelement.

The damper to ground matrix is the viscous damping matrix.

Spring Element to Ground

MGSPRNG

MGSPRNG	MATNO	NDOF	K(1, 1)	K(2, 1)
	. . .	. . .	K(NDOF, 1)	K(2, 2)
	K(3, 2)	. . .	. . .	K(NDOF, 2)
	K(3, 3)	. . .	. . .	K(NDOF, NDOF)

MATNO Material number, i.e. reference number referred to by the element specification.

NDOF Number of degrees of freedom of the node.

K(i,j) Elements of the stiffness matrix (only elements on and below the main diagonal are stored, i.e. symmetric stiffness matrix assumed). The elements are referred to a local system if defined (by TRANSNO on GELREF1), otherwise to the global coordinate system of the superelement.

The (i,j)'th element of the stiffness matrix corresponds to the force to be given in the i'th d.o.f. to get a unit displacement in the j'th d.o.f.

8 RULES FOR EXTENSION OF THE INTERFACE

The interface may easily be extended to include new application areas, or simply to include data which have been left out. Some rules must, however, be followed in order to avoid confusion and misunderstandings. The rules can be summarized as:

a) Data on one record must belong to only one group, i.e. one of the eight groups defined in Section 3.

b) No identifier already employed must be used to identify data of different meaning.

c) The first character of each identifier must have the appropriate letter already defined in Section 3.

d) The maximum number of characters of each identifier is eight.

e) Alphanumeric characters (ASKII) may be employed to describe an identifier.

f) Otherwise identical identifiers for first and higher levels may be separated with a numeric character at the end of the identifier, i.e. 1 for first level and 2 for higher levels.

g) Identifiers should preferably be chosen which can easily be related to the type of data which are stored.

h) Each file record is fixed consisting of 72 characters, i.e. an eight character identifier field and four data fields compatible with the FORTRAN 4E16.8 format.

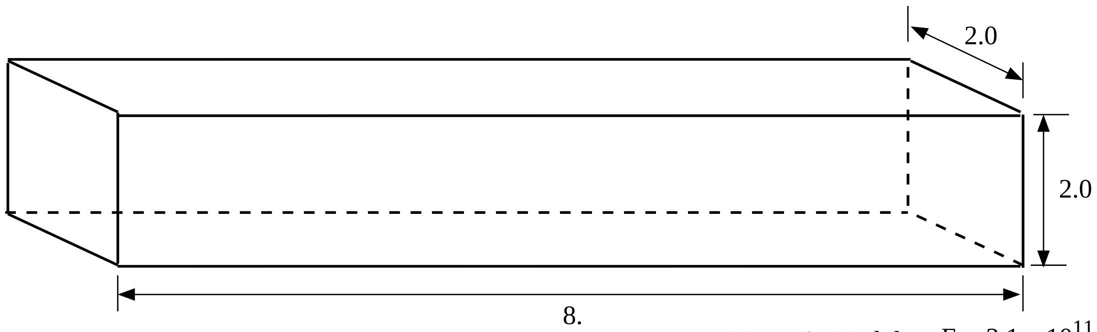
i) Text strings may follow TEXT identifiers. Text data have a separate format (A72). See description of the TEXT record.

A EXAMPLES

Two test examples have been included to demonstrate the application of the interface file. The first example is a one-level static analysis of a cantilever beam, and the second is a static analysis of a steel jacket by use of the super-element technique. The examples are collected from Ref. /10/, testexample 11DA and 3A and are briefly described below. The appropriate interface files follow Figure A-7.

EXAMPLE 1. ONE-LEVEL STATIC ANALYSIS OF CANTILEVER BEAM MODELLED WITH TWO 20-NODED SOLID ELEMENTS.

The geometry of the beam is given in Figure A-1



Young's Modulus $E = 2.1 \times 10^{11}$
Poisson's Ratio $\nu = 0.0$
Density $\rho = 7850$

Figure A-1 Cantilever beam - Geometry and material properties

The finite element model consists of 32 nodes and two 20-noded solid elements as illustrated in Figure A-2 .

This beam is used in static analyses including with four different loadcases at the end of the cantilever beam (example 11DA in Ref. /10/).

The interface file used in this analyses, X11DAT1.FEM, is given below. It contains necessary information about geometry, material and boundary conditions. Given in addition is the load in the 4 loadcases. The load is surface loads (BEUSLO records) at the end in loadcase 1,2 and 3 and gravitational load in the global X-direction in loadcase 4 (BGRAV record).

After modelling the beam in PREFEM, the internal node numbering has been redone to optimize the bandwidth with the program BPOPT. The internal node numbers in the interface file X11DAT1.FEM is after bandwidth optimization.

The rest of the information needed to carry out these analyses is given as direct command input to SESTRA (see ref. /11/).

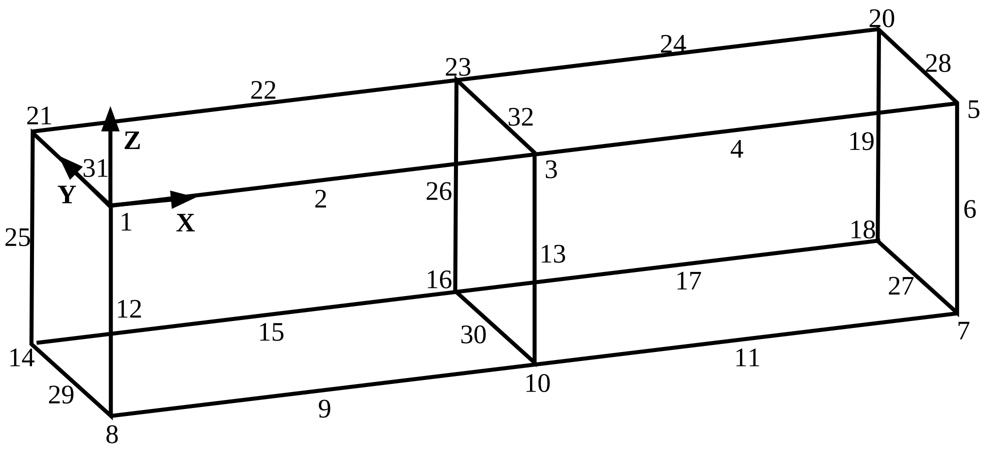


Figure A-2 Node numbering of cantilever beam

EXAMPLE 2 STATICAL ANALYSIS OF A JACKET MODELLED BY REPEATED SUPERELEMENTS.

The geometry and loads on the jacket is shown in Figure A-3.

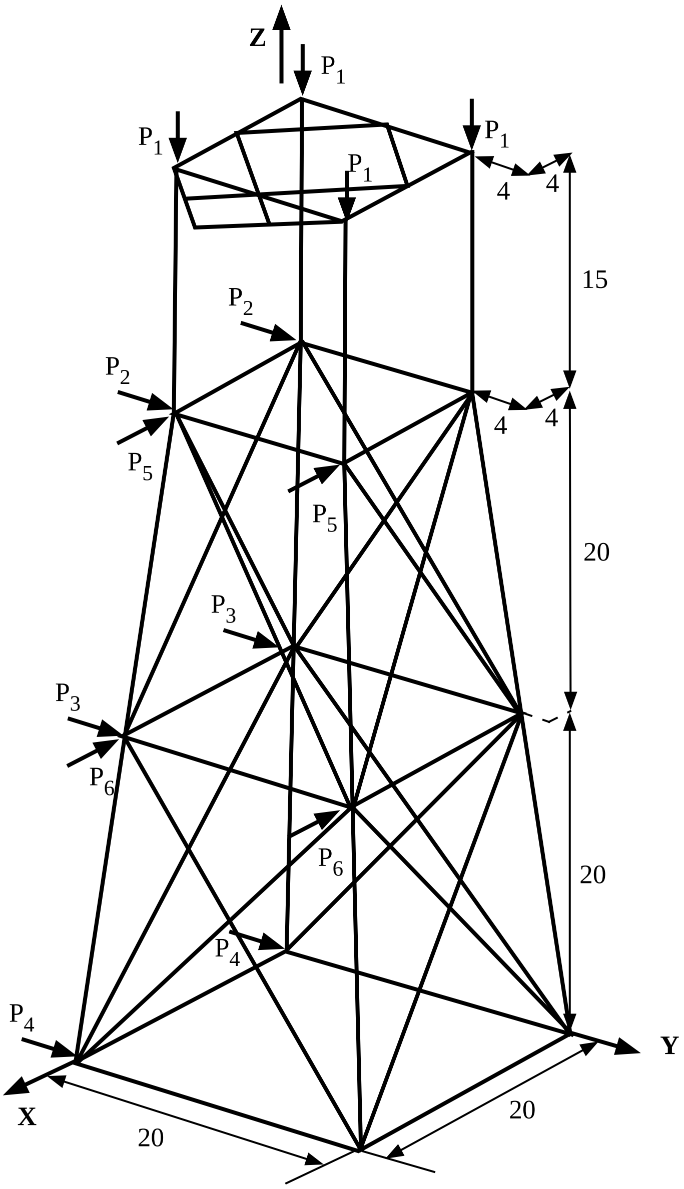
The jacket is assemled of two-noded beams only. The model is based on two first level superelements (types 11 and 12) illustrated in Figure A-4. The corresponding interface files created by use of PREFRAME are named X3AT11.FEM and X3AT12.FEM.

The first level superelement type 11 is repeated four times by use of PRESEL, giving the second level superelement type 21 as shown in Figure A-5. Similarily, two first level elements type 12 (one mirrored) are assembled in superelement type 22 on second level.

Further, the two second level superelements are assembled in the third level superelement type 31, shown in Figure A-6.

In this example also a fourth level superelement type 41 is used, see superelement hierarchy in Figure A-7. This is because this example is based on test example 3 in Ref. /10/, where also piles are included in the model, and this requires the coordinate system to be turned, see comment in Figure A-7.

Note that load case number 5 (LC5 in Figure A-3) in the test example is generated by the wave loading program WAJAC, and is therefore not included in the first level interface files given below. Two load interface files X3AL11.FEM and X3AL12.FEM are made by WAJAC, but they are not included here.

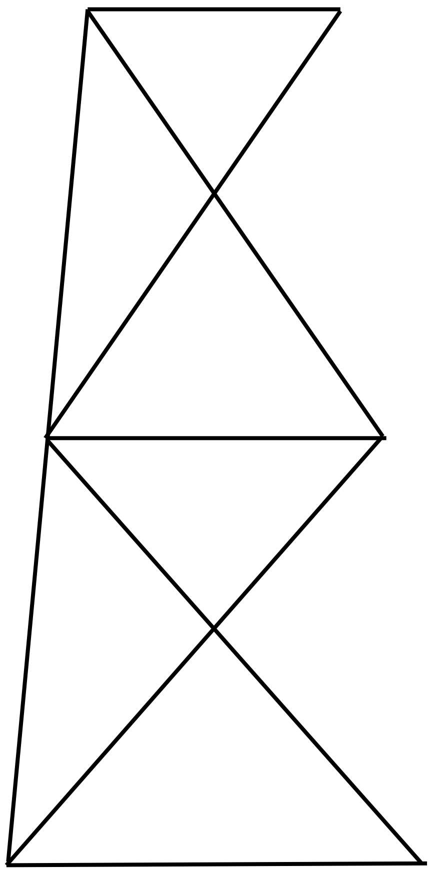


P_1: 4 x 10^6
P_2: 7 x 10^6
P_3: 5 x 10^6
P_4: 3 x 10^6
P_5: 7 x 10^6
P_6: 5 x 10^6

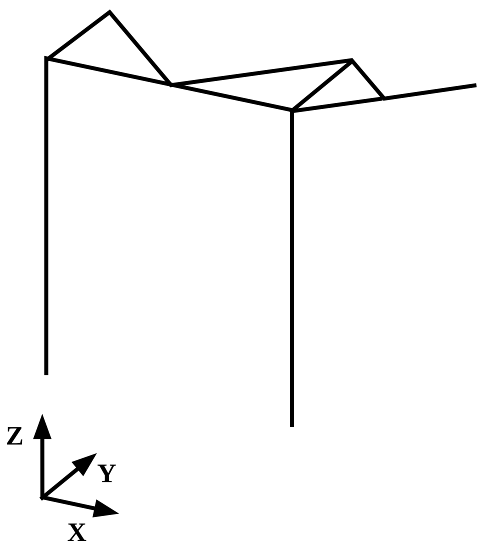
LC1: gravity
LC1: P_1
LC1: $P_2+P_3+P_4$
LC1: P_5+P_6
LC1: wave loading from WAJACE

Young's Modulus $E = 2.1 \times 10^{11}$
Poisson's Ratio $\nu = 0.0$
Density $\rho = 7850$

Figure A-3 Jacket - Geometry and loads

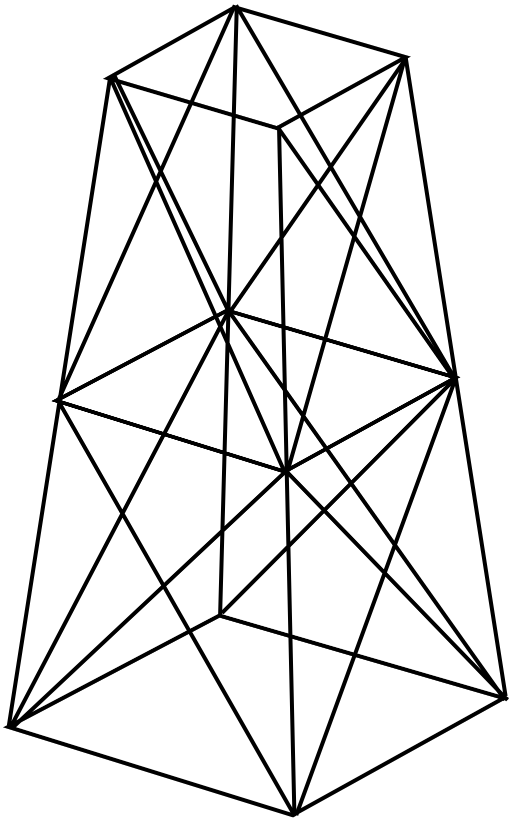


Type 11

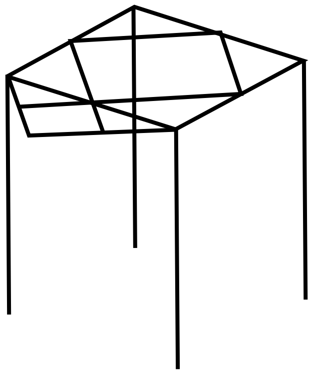


Type 12

Figure A-4 First level Superelements

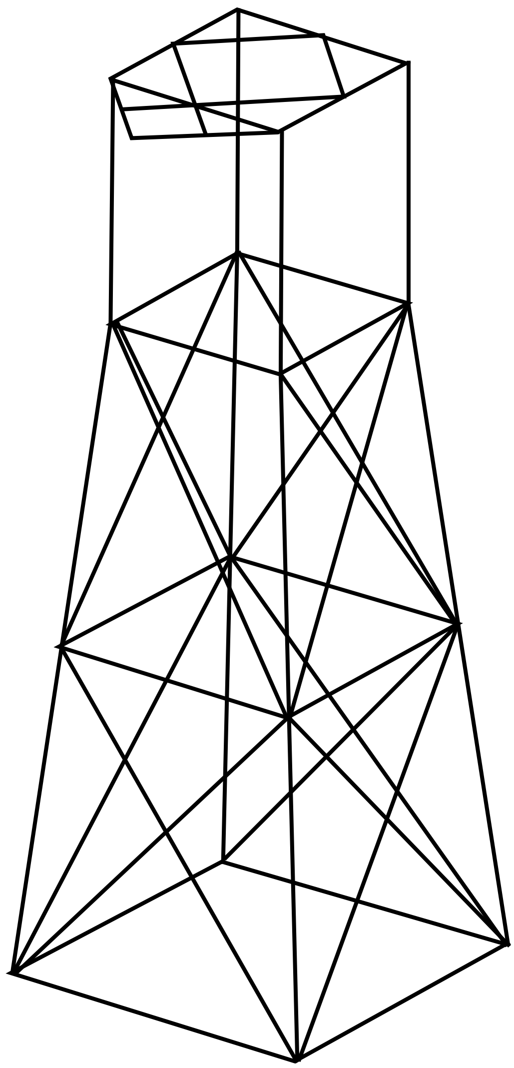


Type 21



Type 22

Figure A-5 Second level superelements



Type 31

Figure A-6 Third level superelements

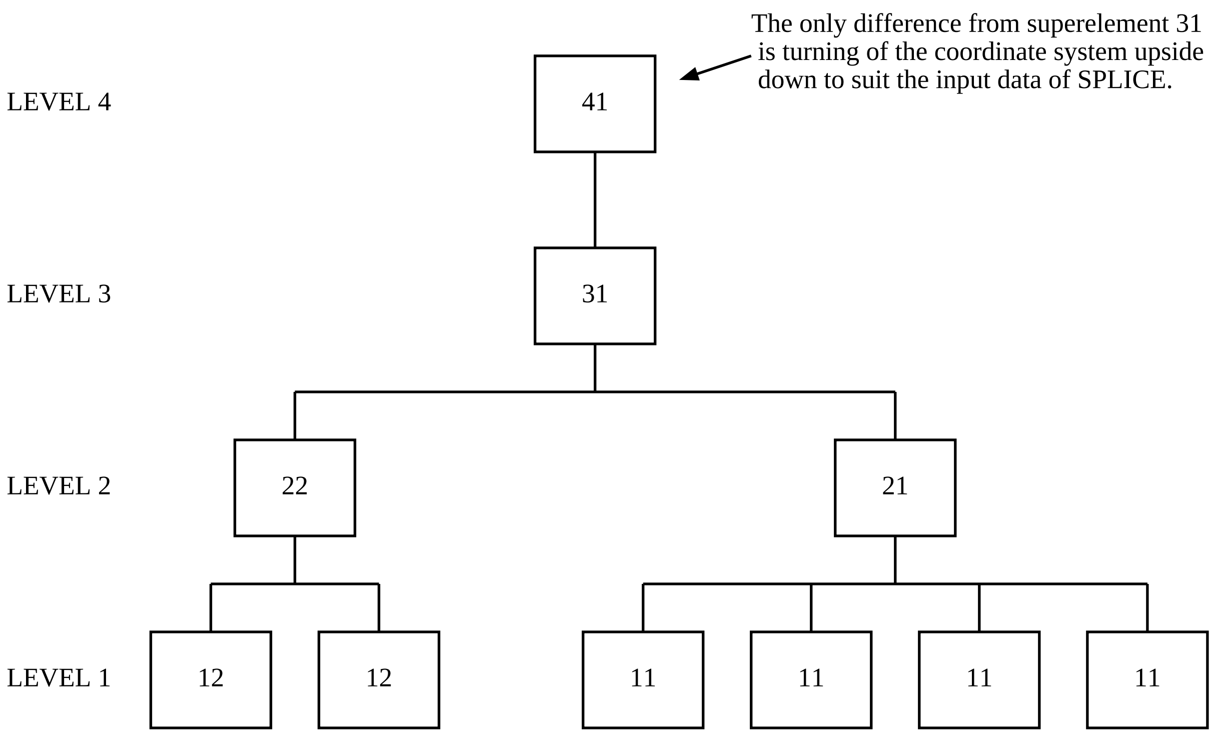


Figure A-7 Superelement hierarchy

File: X11DAT1.FEM

```
IDENT     0.10000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
DATE      0.10000000E+01  0.00000000E+00  0.40000000E+01  0.72000000E+02
        DATE:     22-NOV-1996         TIME:         10:15:49
        PROGRAM:  SESAM PREFEM        VERSION:      6.2-01  8-OCT-1996
        COMPUTER: VAXSTATION 4000-VMS INSTALLATION: DNVS BALDER
        USER:     HFK                 ACCOUNT:      VSS12051
DATE      1.00000000E+00  0.00000000E+00  4.00000000E+00  7.20000000E+01
        DATE:     22-NOV-1996         TIME:         10:16:25
        PROGRAM:  SESAM BPOPT         VERSION:      5.6-01 11-NOV-1996
        COMPUTER: VAXSTATION 4000-VMS INSTALLATION: DNVS BALDER
        USER:     HFK                 ACCOUNT:      VSS12051
GNODE     0.10000000E+01  0.10000000E+01  0.30000000E+01  0.12300000E+03
GNODE     0.14000000E+02  0.20000000E+01  0.30000000E+01  0.12300000E+03
GNODE     0.15000000E+02  0.30000000E+01  0.30000000E+01  0.12300000E+03
GNODE     0.22000000E+02  0.40000000E+01  0.30000000E+01  0.12300000E+03
GNODE     0.21000000E+02  0.50000000E+01  0.30000000E+01  0.12300000E+03
GNODE     0.25000000E+02  0.60000000E+01  0.30000000E+01  0.12300000E+03
GNODE     0.29000000E+02  0.70000000E+01  0.30000000E+01  0.12300000E+03
GNODE     0.31000000E+02  0.80000000E+01  0.30000000E+01  0.12300000E+03
GNODE     0.80000000E+01  0.90000000E+01  0.30000000E+01  0.12300000E+03
GNODE     0.90000000E+01  0.10000000E+02  0.30000000E+01  0.12300000E+03
GNODE     0.20000000E+01  0.11000000E+02  0.30000000E+01  0.12300000E+03
GNODE     0.12000000E+02  0.12000000E+02  0.30000000E+01  0.12300000E+03
GNODE     0.16000000E+02  0.13000000E+02  0.30000000E+01  0.12300000E+03
GNODE     0.26000000E+02  0.14000000E+02  0.30000000E+01  0.12300000E+03
GNODE     0.23000000E+02  0.15000000E+02  0.30000000E+01  0.12300000E+03
GNODE     0.30000000E+02  0.16000000E+02  0.30000000E+01  0.12300000E+03
GNODE     0.32000000E+02  0.17000000E+02  0.30000000E+01  0.12300000E+03
GNODE     0.10000000E+02  0.18000000E+02  0.30000000E+01  0.12300000E+03
GNODE     0.13000000E+02  0.19000000E+02  0.30000000E+01  0.12300000E+03
GNODE     0.30000000E+01  0.20000000E+02  0.30000000E+01  0.12300000E+03
GNODE     0.17000000E+02  0.21000000E+02  0.30000000E+01  0.12300000E+03
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GNODE     0.19000000E+02  0.23000000E+02  0.30000000E+01  0.12300000E+03
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GNODE     0.60000000E+01  0.30000000E+02  0.30000000E+01  0.12300000E+03
GNODE     0.50000000E+01  0.31000000E+02  0.30000000E+01  0.12300000E+03
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GCOORD    0.30000000E+01  0.20000000E+01  0.20000000E+01 -0.20000000E+01
GCOORD    0.40000000E+01  0.20000000E+01  0.20000000E+01  0.00000000E+00
GCOORD    0.50000000E+01  0.00000000E+00  0.20000000E+01  0.00000000E+00
GCOORD    0.60000000E+01  0.00000000E+00  0.20000000E+01 -0.10000000E+01
GCOORD    0.70000000E+01  0.00000000E+00  0.10000000E+01 -0.20000000E+01
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GCOORD    0.90000000E+01  0.00000000E+00  0.00000000E+00 -0.20000000E+01
GCOORD    0.10000000E+02  0.20000000E+01  0.00000000E+00 -0.20000000E+01
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GCOORD    0.26000000E+02  0.80000000E+01  0.10000000E+01 -0.20000000E+01
GCOORD    0.27000000E+02  0.80000000E+01  0.10000000E+01  0.00000000E+00
```

```
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GCOORD     0.30000000E+02  0.80000000E+01  0.00000000E+00 -0.10000000E+01
GCOORD     0.31000000E+02  0.80000000E+01  0.00000000E+00  0.00000000E+00
GCOORD     0.32000000E+02  0.60000000E+01  0.00000000E+00  0.00000000E+00
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           0.10000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
BNBCD      0.90000000E+01  0.30000000E+01  0.10000000E+01  0.10000000E+01
           0.10000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
BNBCD      0.12000000E+02  0.30000000E+01  0.10000000E+01  0.10000000E+01
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BNBCD      0.20000000E+01  0.30000000E+01  0.10000000E+01  0.10000000E+01
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BNBCD      0.50000000E+01  0.30000000E+01  0.10000000E+01  0.10000000E+01
           0.10000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
BNBCD      0.60000000E+01  0.30000000E+01  0.10000000E+01  0.10000000E+01
           0.10000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
BNBCD      0.70000000E+01  0.30000000E+01  0.10000000E+01  0.10000000E+01
           0.10000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
BNBCD      0.80000000E+01  0.30000000E+01  0.10000000E+01  0.10000000E+01
           0.10000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
GELMNT1    0.10000000E+01  0.10000000E+01  0.20000000E+02  0.00000000E+00
           0.20000000E+01  0.30000000E+01  0.13000000E+02  0.14000000E+02
           0.15000000E+02  0.40000000E+01  0.50000000E+01  0.60000000E+01
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           0.90000000E+01  0.10000000E+02  0.18000000E+02  0.19000000E+02
           0.20000000E+02  0.11000000E+02  0.10000000E+01  0.12000000E+02
GELMNT1    0.20000000E+01  0.20000000E+01  0.20000000E+02  0.00000000E+00
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           0.24000000E+02  0.25000000E+02  0.15000000E+02  0.14000000E+02
           0.16000000E+02  0.26000000E+02  0.27000000E+02  0.17000000E+02
           0.18000000E+02  0.28000000E+02  0.29000000E+02  0.30000000E+02
           0.31000000E+02  0.32000000E+02  0.20000000E+02  0.19000000E+02
TDMATER    0.40000000E+01  0.10000000E+01  0.10200000E+03  0.00000000E+00
        M1
MORSSOL    0.10000000E+01  0.78500000E+04  0.21000000E+12  0.00000000E+00
           0.21000000E+12  0.00000000E+00  0.00000000E+00  0.21000000E+12
           0.00000000E+00  0.00000000E+00  0.00000000E+00  0.10500000E+12
           0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
           0.10500000E+12  0.00000000E+00  0.00000000E+00  0.00000000E+00
           0.00000000E+00  0.00000000E+00  0.10500000E+12  0.00000000E+00
           0.00000000E+00  0.00000000E+00  0.99999997E-04  0.00000000E+00
           0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
GELREF1    0.10000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
           0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
           0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
GELREF1    0.20000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
           0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
           0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
BGRAV      0.40000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
           0.98100004E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
BEUSLO     0.10000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
           0.20000000E+01  0.80000000E+01  0.00000000E+00  0.10000000E+05
          -0.25000000E+05 -0.25000000E+05 -0.25000000E+05 -0.25000000E+05
          -0.25000000E+05 -0.25000000E+05 -0.25000000E+05 -0.25000000E+05
BEUSLO     0.20000000E+01  0.20000000E+01  0.00000000E+00  0.00000000E+00
           0.20000000E+01  0.24000000E+02  0.00000000E+00  0.10000000E+05
           0.00000000E+00 -0.25000000E+05  0.00000000E+00  0.00000000E+00
          -0.25000000E+05  0.00000000E+00  0.00000000E+00 -0.25000000E+05
           0.00000000E+00  0.00000000E+00 -0.25000000E+05  0.00000000E+00
           0.00000000E+00 -0.25000000E+05  0.00000000E+00  0.00000000E+00
          -0.25000000E+05  0.00000000E+00  0.00000000E+00 -0.25000000E+05
           0.00000000E+00  0.00000000E+00 -0.25000000E+05  0.00000000E+00
BEUSLO     0.30000000E+01  0.20000000E+01  0.00000000E+00  0.00000000E+00
           0.20000000E+01  0.24000000E+02  0.00000000E+00  0.10000000E+05
           0.00000000E+00  0.00000000E+00 -0.25000000E+05  0.00000000E+00
           0.00000000E+00 -0.25000000E+05  0.00000000E+00  0.00000000E+00
          -0.25000000E+05  0.00000000E+00  0.00000000E+00 -0.25000000E+05
           0.00000000E+00  0.00000000E+00 -0.25000000E+05  0.00000000E+00
           0.00000000E+00 -0.25000000E+05  0.00000000E+00  0.00000000E+00
          -0.25000000E+05  0.00000000E+00  0.00000000E+00 -0.25000000E+05
BEISTE     0.50000000E+01  0.10000000E+01  0.00000000E+00  0.10000000E+01
           0.20000000E+01  0.20000000E+02  0.00000000E+00  0.50000000E+01
BEISTE     0.50000000E+01  0.10000000E+01  0.00000000E+00  0.10000000E+01
           0.10000000E+01  0.20000000E+02  0.00000000E+00  0.50000000E+01
IEND       0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
```

File: X3AT11.FEM

```
IDENT      0.10000000E+01  0.11000000E+02  0.00000000E+00  0.00000000E+00
DATE       0.10000000E+01  0.00000000E+00  0.40000000E+01  0.72000000E+02
        DATE:     06-NOV-89           TIME:         15:14:33
        PROGRAM:  SESAM PREFRAME      VERSION:      5.3-02  6-OCT-89
        COMPUTER: VAX FAMILY VMS V5.1-INSTALLATION: VSS JORD
        USER:     HFK                 ACCOUNT:      VSS12051
GNODE      0.10300000E+03  0.10000000E+01  0.60000000E+01  0.12345600E+06
GNODE      0.10100000E+03  0.20000000E+01  0.60000000E+01  0.12345600E+06
GNODE      0.20100000E+03  0.30000000E+01  0.60000000E+01  0.12345600E+06
GNODE      0.30100000E+03  0.40000000E+01  0.60000000E+01  0.12345600E+06
GNODE      0.30300000E+03  0.50000000E+01  0.60000000E+01  0.12345600E+06
GNODE      0.50100000E+03  0.60000000E+01  0.60000000E+01  0.12345600E+06
GNODE      0.40100000E+03  0.70000000E+01  0.60000000E+01  0.12345600E+06
GNODE      0.50300000E+03  0.80000000E+01  0.60000000E+01  0.12345600E+06
GCOORD     0.10000000E+01  0.20000000E+02  0.00000000E+00  0.00000000E+00
GCOORD     0.20000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
GCOORD     0.30000000E+01  0.10000001E+02  0.11111112E+01  0.11111112E+02
GCOORD     0.40000000E+01  0.20000000E+01  0.20000000E+01  0.20000000E+02
GCOORD     0.50000000E+01  0.18000000E+02  0.20000000E+01  0.20000000E+02
GCOORD     0.60000000E+01  0.40000000E+01  0.40000000E+01  0.40000000E+02
GCOORD     0.70000000E+01  0.10000000E+02  0.31428573E+01  0.31428572E+02
GCOORD     0.80000000E+01  0.16000000E+02  0.40000000E+01  0.40000000E+02
BNBCD      0.10000000E+01  0.60000000E+01  0.40000000E+01  0.40000000E+01
           0.40000000E+01  0.40000000E+01  0.40000000E+01  0.40000000E+01
BNBCD      0.20000000E+01  0.60000000E+01  0.40000000E+01  0.40000000E+01
           0.40000000E+01  0.40000000E+01  0.40000000E+01  0.40000000E+01
BNBCD      0.40000000E+01  0.60000000E+01  0.40000000E+01  0.40000000E+01
           0.40000000E+01  0.40000000E+01  0.40000000E+01  0.40000000E+01
BNBCD      0.50000000E+01  0.60000000E+01  0.40000000E+01  0.40000000E+01
           0.40000000E+01  0.40000000E+01  0.40000000E+01  0.40000000E+01
BNBCD      0.60000000E+01  0.60000000E+01  0.40000000E+01  0.40000000E+01
           0.40000000E+01  0.40000000E+01  0.40000000E+01  0.40000000E+01
BNBCD      0.80000000E+01  0.60000000E+01  0.40000000E+01  0.40000000E+01
           0.40000000E+01  0.40000000E+01  0.40000000E+01  0.40000000E+01
GELMNT1    0.10100000E+03  0.10000000E+01  0.15000000E+02  0.00000000E+00
           0.20000000E+01  0.40000000E+01  0.00000000E+00  0.00000000E+00
GELMNT1    0.10200000E+03  0.20000000E+01  0.15000000E+02  0.00000000E+00
           0.40000000E+01  0.60000000E+01  0.00000000E+00  0.00000000E+00
GELMNT1    0.10400000E+03  0.30000000E+01  0.15000000E+02  0.00000000E+00
           0.20000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
GELMNT1    0.10500000E+03  0.40000000E+01  0.15000000E+02  0.00000000E+00
           0.20000000E+01  0.30000000E+01  0.00000000E+00  0.00000000E+00
GELMNT1    0.10600000E+03  0.50000000E+01  0.15000000E+02  0.00000000E+00
           0.30000000E+01  0.50000000E+01  0.00000000E+00  0.00000000E+00
GELMNT1    0.10700000E+03  0.60000000E+01  0.15000000E+02  0.00000000E+00
           0.10000000E+01  0.30000000E+01  0.00000000E+00  0.00000000E+00
GELMNT1    0.10800000E+03  0.70000000E+01  0.15000000E+02  0.00000000E+00
           0.30000000E+01  0.40000000E+01  0.00000000E+00  0.00000000E+00
GELMNT1    0.10900000E+03  0.80000000E+01  0.15000000E+02  0.00000000E+00
           0.40000000E+01  0.50000000E+01  0.00000000E+00  0.00000000E+00
GELMNT1    0.11000000E+03  0.90000000E+01  0.15000000E+02  0.00000000E+00
           0.40000000E+01  0.70000000E+01  0.00000000E+00  0.00000000E+00
GELMNT1    0.11100000E+03  0.10000000E+02  0.15000000E+02  0.00000000E+00
           0.70000000E+01  0.80000000E+01  0.00000000E+00  0.00000000E+00
GELMNT1    0.11200000E+03  0.11000000E+02  0.15000000E+02  0.00000000E+00
           0.50000000E+01  0.70000000E+01  0.00000000E+00  0.00000000E+00
GELMNT1    0.11300000E+03  0.12000000E+02  0.15000000E+02  0.00000000E+00
           0.70000000E+01  0.60000000E+01  0.00000000E+00  0.00000000E+00
GELMNT1    0.11400000E+03  0.13000000E+02  0.15000000E+02  0.00000000E+00
           0.60000000E+01  0.80000000E+01  0.00000000E+00  0.00000000E+00
GPIPE      0.10000000E+01  0.11000000E+01  0.12000000E+01  0.50000001E-01
           0.10000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
GBEAMG     0.10000000E+01  0.00000000E+00  0.18064159E+00  0.59837516E-01
           0.29918758E-01  0.29918758E-01  0.00000000E+00  0.99729188E-01
           0.49864594E-01  0.49864594E-01  0.90434521E-01  0.90434521E-01
           0.00000000E+00  0.00000000E+00  0.33083338E-01  0.33083338E-01
GPIPE      0.20000000E+01  0.57000005E+00  0.60000002E+00  0.15000000E-01
           0.10000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
GBEAMG     0.20000000E+01  0.00000000E+00  0.27567478E-01  0.23601169E-02
           0.11800585E-02  0.11800585E-02  0.00000000E+00  0.78670559E-02
           0.39335280E-02  0.39335280E-02  0.13789769E-01  0.13789769E-01
           0.00000000E+00  0.00000000E+00  0.25672477E-02  0.25672477E-02
MISOSEL    0.10000000E+01  0.21000000E+12  0.30000001E+00  0.78500000E+04
```

```
          0.00000000E+00  0.12000000E-04  0.00000000E+00  0.00000000E+00
GUNIVEC   0.10000000E+01 -0.70014006E+00 -0.70014006E+00  0.14002801E+00
GUNIVEC   0.20000000E+01 -0.70014006E+00 -0.70014006E+00  0.14002801E+00
GUNIVEC   0.30000000E+01  0.00000000E+00  0.00000000E+00  0.10000000E+01
GUNIVEC   0.40000000E+01 -0.73671561E+00 -0.81857279E-01  0.67122984E+00
GUNIVEC   0.50000000E+01 -0.73671561E+00 -0.81857294E-01  0.67122972E+00
GUNIVEC   0.60000000E+01  0.73671567E+00 -0.81857316E-01  0.67122972E+00
GUNIVEC   0.70000000E+01  0.73671556E+00 -0.81857264E-01  0.67122984E+00
GUNIVEC   0.80000000E+01  0.00000000E+00  0.00000000E+00  0.10000000E+01
GUNIVEC   0.90000000E+01 -0.80829036E+00 -0.11547007E+00  0.57735026E+00
GUNIVEC   0.10000000E+02 -0.80829030E+00 -0.11547001E+00  0.57735026E+00
GUNIVEC   0.11000000E+02  0.80829036E+00 -0.11547007E+00  0.57735026E+00
GUNIVEC   0.12000000E+02  0.80829030E+00 -0.11547001E+00  0.57735026E+00
GUNIVEC   0.13000000E+02  0.00000000E+00  0.00000000E+00  0.10000000E+01
GELREF1   0.10000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
          0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.10000000E+01  0.00000000E+00  0.00000000E+00  0.10000000E+01
GELREF1   0.20000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
          0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.10000000E+01  0.00000000E+00  0.00000000E+00  0.20000000E+01
GELREF1   0.30000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
          0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.20000000E+01  0.00000000E+00  0.00000000E+00  0.30000000E+01
GELREF1   0.40000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
          0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.20000000E+01  0.00000000E+00  0.00000000E+00  0.40000000E+01
GELREF1   0.50000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
          0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.20000000E+01  0.00000000E+00  0.00000000E+00  0.50000000E+01
GELREF1   0.60000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
          0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.20000000E+01  0.00000000E+00  0.00000000E+00  0.60000000E+01
GELREF1   0.70000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
          0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.20000000E+01  0.00000000E+00  0.00000000E+00  0.70000000E+01
GELREF1   0.80000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
          0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.20000000E+01  0.00000000E+00  0.00000000E+00  0.80000000E+01
GELREF1   0.90000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
          0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.20000000E+01  0.00000000E+00  0.00000000E+00  0.90000000E+01
GELREF1   0.10000000E+02  0.10000000E+01  0.00000000E+00  0.00000000E+00
          0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.20000000E+01  0.00000000E+00  0.00000000E+00  0.10000000E+02
GELREF1   0.11000000E+02  0.10000000E+01  0.00000000E+00  0.00000000E+00
          0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.20000000E+01  0.00000000E+00  0.00000000E+00  0.11000000E+02
GELREF1   0.12000000E+02  0.10000000E+01  0.00000000E+00  0.00000000E+00
          0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.20000000E+01  0.00000000E+00  0.00000000E+00  0.12000000E+02
GELREF1   0.13000000E+02  0.10000000E+01  0.00000000E+00  0.00000000E+00
          0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.20000000E+01  0.00000000E+00  0.00000000E+00  0.13000000E+02
BGRAV     0.10000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.00000000E+00  0.00000000E+00 -0.98100004E+01  0.00000000E+00
BNLOAD    0.30000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.10000000E+01  0.60000000E+01  0.00000000E+00  0.30000000E+07
          0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
BNLOAD    0.30000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.20000000E+01  0.60000000E+01  0.00000000E+00  0.30000000E+07
          0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
BNLOAD    0.30000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.40000000E+01  0.60000000E+01  0.00000000E+00  0.50000000E+07
          0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
BNLOAD    0.30000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.50000000E+01  0.60000000E+01  0.00000000E+00  0.50000000E+07
          0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
BNLOAD    0.30000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.80000000E+01  0.60000000E+01  0.00000000E+00  0.70000000E+07
          0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
BNLOAD    0.30000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.60000000E+01  0.60000000E+01  0.00000000E+00  0.70000000E+07
          0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
BNLOAD    0.40000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.40000000E+01  0.60000000E+01  0.00000000E+00  0.50000000E+07
          0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
```

```
BNLOAD    0.40000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.50000000E+01  0.60000000E+01  0.00000000E+00  0.50000000E+07
          0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
BNLOAD    0.40000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.80000000E+01  0.60000000E+01  0.00000000E+00  0.70000000E+07
          0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
BNLOAD    0.40000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.60000000E+01  0.60000000E+01  0.00000000E+00  0.70000000E+07
          0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
IEND      0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
```

File: X3AT12.FEM

```
IDENT     0.10000000E+01  0.12000000E+02  0.00000000E+00  0.00000000E+00
DATE      0.10000000E+01  0.00000000E+00  0.40000000E+01  0.72000000E+02
        DATE:      06-NOV-89           TIME:        15:16:01
        PROGRAM:   SESAM PREFRAME      VERSION:     5.3-02  6-OCT-89
        COMPUTER:  VAX FAMILY VMS V5.1-INSTALLATION: VSS JORD
        USER:      HFK                 ACCOUNT:     VSS12051
GNODE     0.50100000E+03  0.10000000E+01  0.60000000E+01  0.12345600E+06
GNODE     0.70100000E+03  0.20000000E+01  0.60000000E+01  0.12345600E+06
GNODE     0.70800000E+03  0.30000000E+01  0.60000000E+01  0.12345600E+06
GNODE     0.70200000E+03  0.40000000E+01  0.60000000E+01  0.12345600E+06
GNODE     0.50300000E+03  0.50000000E+01  0.60000000E+01  0.12345600E+06
GNODE     0.70400000E+03  0.60000000E+01  0.60000000E+01  0.12345600E+06
GNODE     0.70300000E+03  0.70000000E+01  0.60000000E+01  0.12345600E+06
GNODE     0.70600000E+03  0.80000000E+01  0.60000000E+01  0.12345600E+06
GNODE     0.71000000E+03  0.90000000E+01  0.60000000E+01  0.12345600E+06
GCOORD    0.10000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
GCOORD    0.20000000E+01  0.00000000E+00  0.00000000E+00  0.15000000E+02
GCOORD    0.30000000E+01  0.00000000E+00  0.60000000E+01  0.15000000E+02
GCOORD    0.40000000E+01  0.60000000E+01  0.00000000E+00  0.15000000E+02
GCOORD    0.50000000E+01  0.12000000E+02  0.00000000E+00  0.00000000E+00
GCOORD    0.60000000E+01  0.12000000E+02  0.60000000E+01  0.15000000E+02
GCOORD    0.70000000E+01  0.12000000E+02  0.00000000E+00  0.15000000E+02
GCOORD    0.80000000E+01  0.15000000E+02  0.30000000E+01  0.15000000E+02
GCOORD    0.90000000E+01  0.18000000E+02  0.60000000E+01  0.15000000E+02
BNBCD     0.10000000E+01  0.60000000E+01  0.40000000E+01  0.40000000E+01
          0.40000000E+01  0.40000000E+01  0.40000000E+01  0.40000000E+01
BNBCD     0.30000000E+01  0.60000000E+01  0.40000000E+01  0.40000000E+01
          0.40000000E+01  0.40000000E+01  0.40000000E+01  0.40000000E+01
BNBCD     0.50000000E+01  0.60000000E+01  0.40000000E+01  0.40000000E+01
          0.40000000E+01  0.40000000E+01  0.40000000E+01  0.40000000E+01
BNBCD     0.60000000E+01  0.60000000E+01  0.40000000E+01  0.40000000E+01
          0.40000000E+01  0.40000000E+01  0.40000000E+01  0.40000000E+01
BNBCD     0.90000000E+01  0.60000000E+01  0.40000000E+01  0.40000000E+01
          0.40000000E+01  0.40000000E+01  0.40000000E+01  0.40000000E+01
GELMNT1   0.50100000E+03  0.10000000E+01  0.15000000E+02  0.00000000E+00
          0.10000000E+01  0.20000000E+01  0.00000000E+00  0.00000000E+00
GELMNT1   0.50200000E+03  0.20000000E+01  0.15000000E+02  0.00000000E+00
          0.50000000E+01  0.70000000E+01  0.00000000E+00  0.00000000E+00
GELMNT1   0.50500000E+03  0.30000000E+01  0.15000000E+02  0.00000000E+00
          0.20000000E+01  0.40000000E+01  0.00000000E+00  0.00000000E+00
GELMNT1   0.50600000E+03  0.40000000E+01  0.15000000E+02  0.00000000E+00
          0.40000000E+01  0.70000000E+01  0.00000000E+00  0.00000000E+00
GELMNT1   0.50700000E+03  0.50000000E+01  0.15000000E+02  0.00000000E+00
          0.70000000E+01  0.60000000E+01  0.00000000E+00  0.00000000E+00
GELMNT1   0.51200000E+03  0.60000000E+01  0.15000000E+02  0.00000000E+00
          0.30000000E+01  0.20000000E+01  0.00000000E+00  0.00000000E+00
GELMNT1   0.51300000E+03  0.70000000E+01  0.15000000E+02  0.00000000E+00
          0.40000000E+01  0.60000000E+01  0.00000000E+00  0.00000000E+00
GELMNT1   0.51600000E+03  0.80000000E+01  0.15000000E+02  0.00000000E+00
          0.30000000E+01  0.40000000E+01  0.00000000E+00  0.00000000E+00
GELMNT1   0.51700000E+03  0.90000000E+01  0.15000000E+02  0.00000000E+00
          0.70000000E+01  0.80000000E+01  0.00000000E+00  0.00000000E+00
GELMNT1   0.51800000E+03  0.10000000E+02  0.15000000E+02  0.00000000E+00
          0.60000000E+01  0.80000000E+01  0.00000000E+00  0.00000000E+00
GELMNT1   0.51900000E+03  0.11000000E+02  0.15000000E+02  0.00000000E+00
          0.80000000E+01  0.90000000E+01  0.00000000E+00  0.00000000E+00
GPIPE     0.10000000E+01  0.94999999E+00  0.10000000E+01  0.25000000E-01
          0.10000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
GBEAMG    0.10000000E+01  0.00000000E+00  0.76576322E-01  0.18210815E-01
          0.91054076E-02  0.91054076E-02  0.00000000E+00  0.36421631E-01
          0.18210815E-01  0.18210815E-01  0.38304947E-01  0.38304947E-01
          0.00000000E+00  0.00000000E+00  0.11885419E-01  0.11885419E-01
```

```
GPIPE     0.20000000E+01  0.57000005E+00  0.60000002E+00  0.15000000E-01
          0.10000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
GBEAMG    0.20000000E+01  0.00000000E+00  0.27567478E-01  0.23601169E-02
          0.11800585E-02  0.11800585E-02  0.00000000E+00  0.78670559E-02
          0.39335280E-02  0.39335280E-02  0.13789769E-01  0.13789769E-01
          0.00000000E+00  0.00000000E+00  0.25672477E-02  0.25672477E-02
MISOSEL   0.10000000E+01  0.21000000E+12  0.30000001E+00  0.78500000E+04
          0.00000000E+00  0.12000000E-04  0.00000000E+00  0.00000000E+00
GUNIVEC   0.10000000E+01  0.00000000E+00  0.10000000E+01  0.00000000E+00
GUNIVEC   0.20000000E+01  0.00000000E+00  0.10000000E+01  0.00000000E+00
GUNIVEC   0.30000000E+01  0.00000000E+00  0.00000000E+00  0.10000000E+01
GUNIVEC   0.40000000E+01  0.00000000E+00  0.00000000E+00  0.10000000E+01
GUNIVEC   0.50000000E+01  0.00000000E+00  0.00000000E+00  0.10000000E+01
GUNIVEC   0.60000000E+01  0.00000000E+00  0.00000000E+00  0.10000000E+01
GUNIVEC   0.70000000E+01  0.00000000E+00  0.00000000E+00  0.10000000E+01
GUNIVEC   0.80000000E+01  0.00000000E+00  0.00000000E+00  0.10000000E+01
GUNIVEC   0.90000000E+01  0.00000000E+00  0.00000000E+00  0.10000000E+01
GUNIVEC   0.10000000E+02  0.00000000E+00  0.00000000E+00  0.10000000E+01
GUNIVEC   0.11000000E+02  0.00000000E+00  0.00000000E+00  0.10000000E+01
GELREF1   0.10000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
          0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.10000000E+01  0.00000000E+00  0.00000000E+00  0.10000000E+01
GELREF1   0.20000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
          0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.10000000E+01  0.00000000E+00  0.00000000E+00  0.20000000E+01
GELREF1   0.30000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
          0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.20000000E+01  0.00000000E+00  0.00000000E+00  0.30000000E+01
GELREF1   0.40000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
          0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.20000000E+01  0.00000000E+00  0.00000000E+00  0.40000000E+01
GELREF1   0.50000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
          0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.20000000E+01  0.00000000E+00  0.00000000E+00  0.50000000E+01
GELREF1   0.60000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
          0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.20000000E+01  0.00000000E+00  0.00000000E+00  0.60000000E+01
GELREF1   0.70000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
          0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.20000000E+01  0.00000000E+00  0.00000000E+00  0.70000000E+01
GELREF1   0.80000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
          0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.20000000E+01  0.00000000E+00  0.00000000E+00  0.80000000E+01
GELREF1   0.90000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
          0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.20000000E+01  0.00000000E+00  0.00000000E+00  0.90000000E+01
GELREF1   0.10000000E+02  0.10000000E+01  0.00000000E+00  0.00000000E+00
          0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.20000000E+01  0.00000000E+00  0.00000000E+00  0.10000000E+02
GELREF1   0.11000000E+02  0.10000000E+01  0.00000000E+00  0.00000000E+00
          0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.20000000E+01  0.00000000E+00  0.00000000E+00  0.11000000E+02
BGRAV     0.10000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.00000000E+00  0.00000000E+00 -0.98100004E+01  0.00000000E+00
BNLOAD    0.20000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.70000000E+01  0.60000000E+01  0.00000000E+00  0.00000000E+00
         -0.40000000E+07  0.00000000E+00  0.00000000E+00  0.00000000E+00
BNLOAD    0.20000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.20000000E+01  0.60000000E+01  0.00000000E+00  0.00000000E+00
         -0.40000000E+07  0.00000000E+00  0.00000000E+00  0.00000000E+00
BNLOAD    0.30000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.20000000E+01  0.60000000E+01  0.00000000E+00  0.00000000E+00
          0.99999997E-20  0.00000000E+00  0.00000000E+00  0.00000000E+00
BNLOAD    0.40000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.20000000E+01  0.60000000E+01  0.00000000E+00  0.00000000E+00
          0.99999997E-20  0.00000000E+00  0.00000000E+00  0.00000000E+00
IEND      0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
```

File: X3AT21.FEM

```
IDENT     0.20000000E+01  0.21000000E+02  0.00000000E+00  0.00000000E+00
DATE      0.10000000E+01  0.00000000E+00  0.40000000E+01  0.72000000E+02
        DATE:     06-NOV-89          TIME:         15:18:03
        PROGRAM:  SESAM PRESEL       VERSION:      5.3-01 14-APR-89
        COMPUTER: VAX FAMILY VMS V5.1-INSTALLATION: VSS JORD
```

```
        USER:     HFK                 ACCOUNT:      VSS12051
GNODE     0.10000000E+01  0.10000000E+01  0.60000000E+01  0.12345600E+06
GNODE     0.20000000E+01  0.20000000E+01  0.60000000E+01  0.12345600E+06
GNODE     0.30000000E+01  0.30000000E+01  0.60000000E+01  0.12345600E+06
GNODE     0.40000000E+01  0.40000000E+01  0.60000000E+01  0.12345600E+06
GNODE     0.50000000E+01  0.50000000E+01  0.60000000E+01  0.12345600E+06
GNODE     0.60000000E+01  0.60000000E+01  0.60000000E+01  0.12345600E+06
GNODE     0.70000000E+01  0.70000000E+01  0.60000000E+01  0.12345600E+06
GNODE     0.80000000E+01  0.80000000E+01  0.60000000E+01  0.12345600E+06
GNODE     0.90000000E+01  0.90000000E+01  0.60000000E+01  0.12345600E+06
GNODE     0.10000000E+02  0.10000000E+02  0.60000000E+01  0.12345600E+06
GNODE     0.11000000E+02  0.11000000E+02  0.60000000E+01  0.12345600E+06
GNODE     0.12000000E+02  0.12000000E+02  0.60000000E+01  0.12345600E+06
GCOORD    0.10000000E+01  0.20000000E+02  0.00000000E+00  0.00000000E+00
GCOORD    0.20000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
GCOORD    0.30000000E+01  0.20000000E+01  0.20000000E+01  0.20000000E+02
GCOORD    0.40000000E+01  0.18000000E+02  0.20000000E+01  0.20000000E+02
GCOORD    0.50000000E+01  0.40000000E+01  0.40000000E+01  0.40000000E+02
GCOORD    0.60000000E+01  0.16000000E+02  0.40000000E+01  0.40000000E+02
GCOORD    0.70000000E+01  0.20000000E+02  0.20000000E+02  0.00000000E+00
GCOORD    0.80000000E+01  0.18000000E+02  0.18000000E+02  0.20000000E+02
GCOORD    0.90000000E+01  0.16000000E+02  0.16000000E+02  0.40000000E+02
GCOORD    0.10000000E+02  0.00000000E+00  0.19999998E+02  0.00000000E+00
GCOORD    0.11000000E+02  0.20000000E+01  0.17999998E+02  0.20000000E+02
GCOORD    0.12000000E+02  0.40000000E+01  0.15999999E+02  0.40000000E+02
BNBCD     0.10000000E+01  0.60000000E+01  0.40000000E+01  0.40000000E+01
          0.40000000E+01  0.40000000E+01  0.40000000E+01  0.40000000E+01
BNBCD     0.20000000E+01  0.60000000E+01  0.40000000E+01  0.40000000E+01
          0.40000000E+01  0.40000000E+01  0.40000000E+01  0.40000000E+01
BNBCD     0.50000000E+01  0.60000000E+01  0.40000000E+01  0.40000000E+01
          0.40000000E+01  0.40000000E+01  0.40000000E+01  0.40000000E+01
BNBCD     0.60000000E+01  0.60000000E+01  0.40000000E+01  0.40000000E+01
          0.40000000E+01  0.40000000E+01  0.40000000E+01  0.40000000E+01
BNBCD     0.70000000E+01  0.60000000E+01  0.40000000E+01  0.40000000E+01
          0.40000000E+01  0.40000000E+01  0.40000000E+01  0.40000000E+01
BNBCD     0.90000000E+01  0.60000000E+01  0.40000000E+01  0.40000000E+01
          0.40000000E+01  0.40000000E+01  0.40000000E+01  0.40000000E+01
BNBCD     0.10000000E+02  0.60000000E+01  0.40000000E+01  0.40000000E+01
          0.40000000E+01  0.40000000E+01  0.40000000E+01  0.40000000E+01
BNBCD     0.12000000E+02  0.60000000E+01  0.40000000E+01  0.40000000E+01
          0.40000000E+01  0.40000000E+01  0.40000000E+01  0.40000000E+01
GELMNT2   0.10000000E+01  0.10000000E+01  0.11000000E+02  0.00000000E+00
          0.10000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.10000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.10000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.60000000E+01  0.10000000E+01  0.20000000E+01  0.30000000E+01
          0.40000000E+01  0.50000000E+01  0.60000000E+01  0.00000000E+00
GELMNT2   0.20000000E+01  0.10000000E+01  0.11000000E+02  0.00000000E+00
         -0.43711388E-07 -0.10000000E+01  0.00000000E+00  0.10000000E+01
         -0.43711388E-07  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.10000000E+01  0.87422779E-06  0.20000000E+02  0.00000000E+00
          0.60000000E+01  0.70000000E+01  0.10000000E+01  0.40000000E+01
          0.80000000E+01  0.60000000E+01  0.90000000E+01  0.00000000E+00
GELMNT2   0.30000000E+01  0.10000000E+01  0.11000000E+02  0.00000000E+00
         -0.10000000E+01  0.87422777E-07  0.00000000E+00 -0.87422777E-07
         -0.10000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.10000000E+01  0.20000002E+02  0.19999998E+02  0.00000000E+00
          0.60000000E+01  0.10000000E+02  0.70000000E+01  0.80000000E+01
          0.11000000E+02  0.90000000E+01  0.12000000E+02  0.00000000E+00
GELMNT2   0.40000000E+01  0.10000000E+01  0.11000000E+02  0.00000000E+00
         -0.43711388E-07  0.10000000E+01  0.00000000E+00 -0.10000000E+01
         -0.43711388E-07  0.00000000E+00  0.00000000E+00  0.00000000E+00
          0.10000000E+01  0.20000000E+02  0.87422779E-06  0.00000000E+00
          0.60000000E+01  0.20000000E+01  0.10000000E+02  0.11000000E+02
          0.30000000E+01  0.12000000E+02  0.50000000E+01  0.00000000E+00
BSELL     0.10000000E+01  0.40000000E+01  0.00000000E+00  0.00000000E+00
          0.10000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
BSELL     0.10000000E+01  0.30000000E+01  0.00000000E+00  0.00000000E+00
          0.10000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
BSELL     0.10000000E+01  0.20000000E+01  0.00000000E+00  0.00000000E+00
          0.10000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
BSELL     0.10000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
          0.10000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
BSELL     0.30000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
          0.30000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
BSELL     0.40000000E+01  0.20000000E+01  0.00000000E+00  0.00000000E+00
```

```
            0.40000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
  BSELL     0.50000000E+01  0.40000000E+01  0.00000000E+00  0.00000000E+00
            0.80000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
  BSELL     0.50000000E+01  0.30000000E+01  0.00000000E+00  0.00000000E+00
            0.70000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
  BSELL     0.50000000E+01  0.20000000E+01  0.00000000E+00  0.00000000E+00
            0.60000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
  BSELL     0.50000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
            0.50000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
  IEND      0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
```

File: X3AT22.FEM

```
  IDENT     0.20000000E+01  0.22000000E+02  0.00000000E+00  0.00000000E+00
  DATE      0.10000000E+01  0.00000000E+00  0.40000000E+01  0.72000000E+02
        DATE:     06-NOV-89           TIME:         15:18:12
        PROGRAM:  SESAM PRESEL        VERSION:      5.3-01 14-APR-89
        COMPUTER: VAX FAMILY VMS V5.1-INSTALLATION: VSS JORD
        USER:     HFK                 ACCOUNT:      VSS12051
  GNODE     0.10000000E+01  0.10000000E+01  0.60000000E+01  0.12345600E+06
  GNODE     0.20000000E+01  0.20000000E+01  0.60000000E+01  0.12345600E+06
  GNODE     0.30000000E+01  0.30000000E+01  0.60000000E+01  0.12345600E+06
  GNODE     0.40000000E+01  0.40000000E+01  0.60000000E+01  0.12345600E+06
  GNODE     0.50000000E+01  0.50000000E+01  0.60000000E+01  0.12345600E+06
  GNODE     0.60000000E+01  0.60000000E+01  0.60000000E+01  0.12345600E+06
  GNODE     0.70000000E+01  0.70000000E+01  0.60000000E+01  0.12345600E+06
  GCOORD    0.10000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
  GCOORD    0.20000000E+01  0.00000000E+00  0.60000000E+01  0.15000000E+02
  GCOORD    0.30000000E+01  0.12000000E+02  0.00000000E+00  0.00000000E+00
  GCOORD    0.40000000E+01  0.12000000E+02  0.60000000E+01  0.15000000E+02
  GCOORD    0.50000000E+01  0.18000000E+02  0.60000000E+01  0.15000000E+02
  GCOORD    0.60000000E+01  0.00000000E+00  0.12000000E+02  0.00000000E+00
  GCOORD    0.70000000E+01  0.12000000E+02  0.12000000E+02  0.00000000E+00
  BNBCD     0.10000000E+01  0.60000000E+01  0.40000000E+01  0.40000000E+01
            0.40000000E+01  0.40000000E+01  0.40000000E+01  0.40000000E+01
  BNBCD     0.30000000E+01  0.60000000E+01  0.40000000E+01  0.40000000E+01
            0.40000000E+01  0.40000000E+01  0.40000000E+01  0.40000000E+01
  BNBCD     0.60000000E+01  0.60000000E+01  0.40000000E+01  0.40000000E+01
            0.40000000E+01  0.40000000E+01  0.40000000E+01  0.40000000E+01
  BNBCD     0.70000000E+01  0.60000000E+01  0.40000000E+01  0.40000000E+01
            0.40000000E+01  0.40000000E+01  0.40000000E+01  0.40000000E+01
  GELMNT2   0.10000000E+01  0.10000000E+01  0.12000000E+02  0.00000000E+00
            0.10000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
            0.10000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
            0.10000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
            0.50000000E+01  0.10000000E+01  0.20000000E+01  0.30000000E+01
            0.40000000E+01  0.50000000E+01  0.00000000E+00  0.00000000E+00
  GELMNT2   0.20000000E+01  0.10000000E+01  0.12000000E+02  0.00000000E+00
            0.10000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
           -0.10000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
            0.10000000E+01  0.00000000E+00  0.12000000E+02  0.00000000E+00
            0.50000000E+01  0.60000000E+01  0.20000000E+01  0.70000000E+01
            0.40000000E+01  0.50000000E+01  0.00000000E+00  0.00000000E+00
  BSELL     0.10000000E+01  0.20000000E+01  0.00000000E+00  0.00000000E+00
            0.10000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
  BSELL     0.10000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
            0.10000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
  BSELL     0.20000000E+01  0.20000000E+01  0.00000000E+00  0.00000000E+00
            0.20000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
  BSELL     0.20000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
            0.20000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
  BSELL     0.50000000E+01  0.20000000E+01  0.00000000E+00  0.00000000E+00
            0.60000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
  BSELL     0.50000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
            0.50000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
  IEND      0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
```

File: X3AT31.FEM

```
  IDENT     0.30000000E+01  0.31000000E+02  0.00000000E+00  0.00000000E+00
  DATE      0.10000000E+01  0.00000000E+00  0.40000000E+01  0.72000000E+02
        DATE:     06-NOV-89           TIME:         15:18:01
        PROGRAM:  SESAM PRESEL        VERSION:      5.3-01 14-APR-89
        COMPUTER: VAX FAMILY VMS V5.1-INSTALLATION: VSS JORD
```

```
           USER:     HFK                 ACCOUNT:      VSS12051
GNODE       0.10000000E+01  0.10000000E+01  0.60000000E+01  0.12345600E+06
GNODE       0.20000000E+01  0.20000000E+01  0.60000000E+01  0.12345600E+06
GNODE       0.30000000E+01  0.30000000E+01  0.60000000E+01  0.12345600E+06
GNODE       0.40000000E+01  0.40000000E+01  0.60000000E+01  0.12345600E+06
GNODE       0.50000000E+01  0.50000000E+01  0.60000000E+01  0.12345600E+06
GNODE       0.60000000E+01  0.60000000E+01  0.60000000E+01  0.12345600E+06
GNODE       0.70000000E+01  0.70000000E+01  0.60000000E+01  0.12345600E+06
GNODE       0.80000000E+01  0.80000000E+01  0.60000000E+01  0.12345600E+06
GCOORD      0.10000000E+01  0.20000000E+02  0.00000000E+00  0.00000000E+00
GCOORD      0.20000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
GCOORD      0.30000000E+01  0.40000000E+01  0.40000000E+01  0.40000000E+02
GCOORD      0.40000000E+01  0.16000000E+02  0.40000000E+01  0.40000000E+02
GCOORD      0.50000000E+01  0.20000000E+02  0.20000000E+02  0.00000000E+00
GCOORD      0.60000000E+01  0.16000000E+02  0.16000000E+02  0.40000000E+02
GCOORD      0.70000000E+01  0.00000000E+00  0.19999998E+02  0.00000000E+00
GCOORD      0.80000000E+01  0.40000000E+01  0.15999999E+02  0.40000000E+02
BNBCD       0.10000000E+01  0.60000000E+01  0.40000000E+01  0.40000000E+01
            0.40000000E+01  0.40000000E+01  0.40000000E+01  0.40000000E+01
BNBCD       0.20000000E+01  0.60000000E+01  0.40000000E+01  0.40000000E+01
            0.40000000E+01  0.40000000E+01  0.40000000E+01  0.40000000E+01
BNBCD       0.50000000E+01  0.60000000E+01  0.40000000E+01  0.40000000E+01
            0.40000000E+01  0.40000000E+01  0.40000000E+01  0.40000000E+01
BNBCD       0.70000000E+01  0.60000000E+01  0.40000000E+01  0.40000000E+01
            0.40000000E+01  0.40000000E+01  0.40000000E+01  0.40000000E+01
GELMNT2     0.10000000E+01  0.20000000E+01  0.21000000E+02  0.00000000E+00
            0.10000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
            0.10000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
            0.10000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
            0.80000000E+01  0.10000000E+01  0.20000000E+01  0.30000000E+01
            0.40000000E+01  0.50000000E+01  0.60000000E+01  0.70000000E+01
            0.80000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
GELMNT2     0.20000000E+01  0.20000000E+01  0.22000000E+02  0.00000000E+00
            0.10000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
            0.10000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
            0.10000000E+01 -0.40000000E+01 -0.40000000E+01 -0.40000000E+02
            0.40000000E+01  0.30000000E+01  0.40000000E+01  0.80000000E+01
            0.60000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
BSELL       0.10000000E+01  0.20000000E+01  0.00000000E+00  0.00000000E+00
            0.10000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
BSELL       0.10000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
            0.10000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
BSELL       0.20000000E+01  0.20000000E+01  0.00000000E+00  0.00000000E+00
            0.20000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
BSELL       0.30000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
            0.30000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
BSELL       0.40000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
            0.40000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
BSELL       0.50000000E+01  0.20000000E+01  0.00000000E+00  0.00000000E+00
            0.50000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
BSELL       0.50000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
            0.50000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
IEND        0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
```

File: X3AT41.FEM

```
IDENT       0.40000000E+01  0.41000000E+02  0.00000000E+00  0.00000000E+00
DATE        0.10000000E+01  0.00000000E+00  0.40000000E+01  0.72000000E+02
        DATE:     06-NOV-89            TIME:         15:17:59
        PROGRAM:  SESAM PRESEL         VERSION:      5.3-01 14-APR-89
        COMPUTER: VAX FAMILY VMS V5.1-INSTALLATION: VSS JORD
        USER:     HFK                  ACCOUNT:      VSS12051
GNODE       0.10000000E+01  0.10000000E+01  0.60000000E+01  0.12345600E+06
GNODE       0.20000000E+01  0.20000000E+01  0.60000000E+01  0.12345600E+06
GNODE       0.30000000E+01  0.30000000E+01  0.60000000E+01  0.12345600E+06
GNODE       0.40000000E+01  0.40000000E+01  0.60000000E+01  0.12345600E+06
GCOORD      0.10000000E+01  0.87422779E-06  0.20000000E+02  0.17484556E-05
GCOORD      0.20000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
GCOORD      0.30000000E+01  0.20000000E+02  0.20000000E+02  0.17484556E-05
GCOORD      0.40000000E+01  0.19999998E+02 -0.87422768E-06  0.00000000E+00
GELMNT2     0.10000000E+01  0.30000000E+01  0.31000000E+02  0.00000000E+00
            0.43711388E-07  0.10000000E+01  0.38213709E-14  0.10000000E+01
           -0.43711388E-07  0.87422777E-07  0.87422777E-07  0.00000000E+00
           -0.10000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
            0.40000000E+01  0.10000000E+01  0.20000000E+01  0.30000000E+01
```

```
               0.40000000E+01  0.00000000E+00  0.00000000E+00  0.00000000E+00
BSELL          0.10000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
               0.10000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
BSELL          0.20000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
               0.20000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
BSELL          0.30000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
               0.30000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
BSELL          0.40000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
               0.40000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
BSELL          0.50000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
               0.50000000E+01  0.10000000E+01  0.00000000E+00  0.00000000E+00
IEND           0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
```

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