Contents

List of Tables

Chapter 1

Notation

This chapter introduces the notation and terminology used in the manual.

1.1 Data type, variable

The C programming language contains several data types but only three of them are used in the SIFEL code. The data types are long, double, char. Typical example is the following one

```
long i;
```

long is the data type, i is a variable of the type long.

1.2 Class, attribute, member function, object

The C++ enables to define additional data types. The SIFEL code uses the data type class. Example of the class is the following

```
class matrix
{
    long m, n;
    double *a;
    read(FILE *in);
};
matrix mat;
```

matrix is the data type of class, m, n, a are the attributes (data members, class attributes) of the class matrix, the class matrix contains the member function (method) read(...), mat is an object (instance) of the class matrix.

Another example

```
class probdesc
{
    probtype tp;
```

```
};
probdesc Mp;
Mp.tp = linear_statics;
```

probtype is an enumeration data type, tp is the attribute (data member, class attribute) of the class probdesc, tp is of the type probtype, linear_statics is an enumerator (identifier) from the enumeration probtype.

Chapter 2

Definitions–Problem Description

2.1 Setting of general function

2.1.1 General description

There are many variables which are described by a function or table. For such description, the class gfunct is implemented. The type of the function is stored in the attribute tfunc and the appropriate keyword is funct_type. The values of the attribute tfunc are summarized in Table 2.1.

attribute	enumerator	description
tfunc = 0	stat	constant value
tfunc = 1	pars	parser
tfunc = 2	tab	the relationship is described by a table

Table 2.1: Attribute tfunc

If the constant value is selected, the value is stored in the attribute f with the keyword const_val.

If the table is selected, the type of interpolation in the table is read and stored to the attribute itype of the class tablefunct. The keyword for the type of interpolation is approx_type. The values of the attribute itype are summarized in Table 2.2.

attribute	enumerator	description
itype = 1	piecewiselin	piecewise linear interpolation
itype = 2	piecewiseconst	piecewise constant interpolation
itype = 3	lagrange	Lagrange interpolation

Table 2.2: Attribute itype

The number of rows in the table is read and stored in the attribute asize with the keyword ntab_items. After that, asize couples of table entries are read.

2.1.2 Examples

2.1.2.1 Definition of constant function

Example without keywords

```
0       # the type of general function - the constant value
234.5   # the constant value
```

Example with keywords

```
funct_type stat   # the type of general function - the constant value
const_val 234.5   # the constant value
```

2.1.2.2 Definition of relationship described by table

Example without keywords

```
2               # the type of general function - the table
1               # piecewise linear interpolation
3               # the number of rows in the table
0.0 234.5       # first row
10.0 456.32     # second row
200.0 213.56    # third row
```

Example with keywords

```
funct_type tab              # the type of general function - the table
approx_type piecewiselin    # piecewise linear interpolation
ntab_items 3                # the number of rows in the table
0.0 234.5                   # first row
10.0 456.32                 # second row
200.0 213.56                # third row
```

2.2 Setting of storage of matrices

2.2.1 General description

Several types of matrix storage are available. The type of storage is located in the attribute ts of the class gmatrix.

attribute	enumerator	description
ts = 0	without_matrix	matrix is not stored
ts = 1	dense_matrix	all matrix entries are stored row-wise
ts = 2	skyline_matrix	skyline format
ts = 3	double_skyline	double skyline format
ts = 10	compressed_rows	compressed rows
ts = 11	symm_comp_rows	symmetric compressed rows
ts = 40	element_matrices	matrix is not stored, all element matrices are stored consequently
ts = 140	spdirect_stor_scr	storage for the sparse direct solver based on symmetric compressed rows
ts = 141	spdirect_stor_cr	storage for the sparse direct solver based on compressed rows

Table 2.3: Attribute ts

2.2.2 Examples

2.2.2.1 Matrix stored in the skyline storage scheme

```
2   # the matrix is stored in the skyline storage scheme
```

2.3 Setting of solver of linear algebraic equations

2.3.1 General description

Type of solver of linear algebraic equations is read and stored in the class slesolv to the attribute tlinsol. The values of the attribute tlinsol are summarized in Table 2.4. The keyword for the type of solver is typelinsol. If a direct method is selected, no additional infor-

attribute	enumerator	description
tlinsol = 1	gauss_elim	Gaussian elimination
tlinsol = 2	ldl	$\boldsymbol{LDL}^T$ factorization
tlinsol = 3	lu	$\boldsymbol{LU}$ factorization
tlinsol = 4	ll	$\boldsymbol{LL}^T$ factorization
tlinsol = 20	cg	conjugate gradient method
tlinsol = 30	bicg	bi-conjugate gradient method
tlinsol = 140	spdirldl	sparse direct solver based on the $\boldsymbol{LDL}^T$ factorization
tlinsol = 141	spdirlu	sparse direct solver based on the $\boldsymbol{LU}$ factorization

Table 2.4: Attribute tlinsol

mation is needed. If an iterative method is selected, the number of iterations ni (keyword number_of_iterations) and the required norm of residual err (keyword error_of_computation) are required.

The class slesolv contains an object prec of the class precond which is used for reading and storage of data about preconditioners. If an iterative method is selected, the type of preconditioner pt is read. The values of the attribute pt are summarized in Table 2.5. SSOR preconditioner requires parameter ω stored in the attribute ssoromega and the

attribute	enumerator	description
pt = 0	noprecond	no preconditioner
pt = 1	diagprec	diagonal (Jacobi) preconditioner
pt = 5	ssorprec	SSOR preconditioner
pt = 10	incomdec	preconditioner based on incomplete factorization
pt = 101	boss	BOSS preconditioner

Table 2.5: Attribute pt

incompleted factorization requires the threshold for off-diagonal matrix entries rejection which is stored in incompltresh.

2.3.2 Examples

2.3.2.1 $\boldsymbol{LDL}^T$ factorization

Example without keywords

```
2   # LDL factorization
```

Example with keywords

```
typelinsol ldl   # LDL factorization
```

2.3.2.2 LU^T factorization

Example without keywords

```
3   # LU factorization
```

Example with keywords

```
typelinsol lu   # LU factorization
```

2.3.2.3 Conjugate gradient method without preconditioner

Example without keywords

```
20      # the conjugate gradient method
400     # the maximum number of iterations
1.0e-6  # required norm of residual
0       # no preconditioner is required
```

Example with keywords

```
typelinsol cg                  # the conjugate gradient method
number_of_iterations 400       # the maximum number of iterations
error_of_computation 1.0e-6    # required norm of residual
0                              # no preconditioner is required
```

2.3.2.4 Conjugate gradient method with preconditioner based on incomplete factorization

Example without keywords

```
20      # the conjugate gradient method
400     # the maximum number of iterations
1.0e-6  # required norm of residual
10      # preconditioner based on incomplete factorization
1.0e-2  # threshold for off-diagonal entries rejection
```

2.4 Setting of solver of non-linear algebraic equations

2.4.1 General description

Type of solver of non-linear algebraic equations is read and stored in the class nonlinman to the attribute tnlinsol. The keyword for the type of solver of non-linear algebraic equations is type_of_nonlin_solver. The values of the attribute tnlinsol are summarized in Table 2.6.

attribute	enumerator	description
tnlinsol = 1	arcl	arc-length method
tnlinsol = 2	newton	the Newton-Raphson method

Table 2.6: Attribute tnlinsol

After the type of solver of non-linear algebraic equations, the type of the stiffness matrix is read and stored into the attribute stmat described by the keyword stiffmat_type. The attribute stmat has the values summarized in Table 2.7.

attribute	enumerator	description
stmat = 1	initial_stiff	the initial stiffness matrix
stmat = 2	tangent_stiff	the tangent stiffness matrix

Table 2.7: Attribute stmat

2.4.1.1 Arc-length method

If the arc-length method is selected, the following parameters have to be defined:

keyword	abbreviation	description
lambda_determination	dlam	type of λ determination
al_num_steps	nial	the number of increment
al_num_iter	niilal	the number of iterations within increment
al_error	erral	required norm of residual
al_init_length	dlal	the initial length of the arc
al_min_length	dlminal	the minimum lenght of arc
al_max_length	dlmaxal	the maximum lenght of arc
al_psi	psial	the parameter ψ
al_displ_contr_type	displnorm	the type of displacement norm

Determination of λ described by the attribute has the following possibilities

attribute	enumerator	description
detlambda=0	nodetermination	the determination is not defined
detlambda=1	minvalue	the minimum value is used
detlambda=2	maxvalue	the maximum value is used
detlambda=3	minangle	the minimum angle is used
detlambda=4	linearizedmeth	linearized arc-length method is used
detlambda=5	fullmethod	the full method is used

Displacement norm described by the attribute displnorm and by the keyword al_displ_contr_type has the following possibilities

attribute	enumerator	description
displnorm=1	alldofs	all degrees of freedom are used
displnorm=2	seldofs	selected degrees of freedom are used
displnorm=3	seldofscoord	
displnorm=6	selecnodes	DOFs defined in selected nodes are used
displnorm=8	nodesdistincr	norm of distance increment of selected nodes

If the selected degrees of freedom are selected, the number of selected DOFs has to be stored in the attribute nsdofal described by the keyword num_sel_dofs. Then, a list of selected node numbers and DOFs follows.

If the selected nodes are used, the number of nodes is stored in the attribute num_sel_nodes. Then, a list of the selected node numbers follows.

2.4.1.2 Newton-Raphson method

If the Newton-Raphson method is selected, the following parameters have to be defined:

keyword	enumerator	description
nr_num_steps	ninr	the number of increments
nr_num_iter	niilnr	the number of iterations within increments
nr_error	errnr	required norm of residual
nr_init_incr	incrnr	the intial increment
nr_minincr	minincrnr	the minimum increment
nr_maxincr	maxincrnr	the maximum increment

2.4.2 Examples

2.4.2.1 Arc-length method, all DOFs are used

Example without keywords

```
1         # the arc-length method is used
1         # the initial stiffness matrix is used
1         # determination of lambda (the minimum values is used)
300       # the number of increments
30        # the number of iterations within increment
1.0e-04   # the required norm of residual
1.0e-01   # the initial lenght of arc
1.0e-08   # the minimum length of arc
1.0e+03   # the maximum length of arc
0         # the parameter psi
1         # the type of displacement norm (all DOFs in this case)
```

Example with keywords

```
type_of_nonlin_solver arcl          # the arc-length method is used
stiffmat_type initial_stiff         # the initial stiffness matrix is used
lambda_determination minvalue       # the minimum value is used
al_num_steps 300                    # the number of increments
al_num_iter 30                      # the number of iterations within increment
al_error 1.0e-04                    # the required norm of residual
al_init_length 1.0e-01              # the initial lenght of arc
al_min_length 1.0e-08               # the minimum length of arc
al_max_length 1.0e+03               # the maximum length of arc
al_psi 0                            # the parameter psi
al_displ_contr_type alldofs         # the type of displacement norm
                                    # (all DOFs in this case)
```

2.4.2.2 Arc-length method, selected DOFs are used

Example without keywords

```
1           # the arc-length method is used
2           # the tangent stiffness matrix is used
1           # determination of lambda (the minimum values is used)
300         # the number of increments
30          # the number of iterations within increment
1.0e-04     # the required norm of residual
1.0e-01     # the initial lenght of arc
1.0e-08     # the minimum length of arc
1.0e+03     # the maximum length of arc
0           # the parameter psi
2           # the type of displacement norm (selected DOFs in this case)
4           # the number of selected DOFs
12 1        # first DOF in the 12th node
23 1        # first DOF in the 23rd node
45 2        # second DOF in the 45th node
78 3        # third DOF in the 78th node
```

Example with keywords

```
type_of_nonlin_solver arcl              # the arc-length method is used
stiffmat_type initial_stiff             # the initial stiffness matrix is used
lambda_determination minvalue           # the minimum value is used
al_num_steps 300                        # the number of increments
al_num_iter 30                          # the number of iterations within increment
al_error 1.0e-04                        # the required norm of residual
al_init_length 1.0e-01                  # the initial lenght of arc
al_min_length 1.0e-08                   # the minimum length of arc
al_max_length 1.0e+03                   # the maximum length of arc
al_psi 0                                # the parameter psi
al_displ_contr_type seldofs             # selected DOFs
num_sel_dofs 4                          # the number of selected DOFs
12 1                                    # first DOF in the 12th node
23 1                                    # first DOF in the 23rd node
45 2                                    # second DOF in the 45th node
78 3                                    # third DOF in the 78th node
```

2.4.2.3 Newton-Rahpson method

Example without keywords

```
2         # the Newton-Raphson method is used
1         # the initial stiffness matrix is used
500       # the number of increments
40        # the number of iterations within increment
1.0e-04   # the required norm of residual
1.0e-01   # the initial increment
1.0e-08   # the minimum increment
1.0e+03   # the maximum increment
```

Example with keywords

```
tnlinsol newton             # the Newton-Raphson method is used
stiffmat_type initial_stiff # the initial stiffness matrix is used
nr_num_steps 500            # the number of increments
nr_num_iter 40              # the number of iterations within increment
nr_error 1.0e-04            # the required norm of residual
nr_init_incr 1.0e-01        # the initial increment
nr_minincr 1.0e-08          # the minimum increment
nr_maxincr 1.0e+03          # the maximum increment
```

2.5 Setting of time controller

2.5.1 General description

Type of time controller is read and stored in the class timecontr to the attribute tct. The values of the attribute tct are summarized in Table 2.8. The keyword for the type of time controller is time_contr_type.

attribute	enumerator	description
tct = 0	fixed	the time step is constant
tct = 1	adaptive	the time step is changed
tct = 2	adaptivemin	the time step is only reduced
tct = 3	adaptivemax	the time step is only increased

Table 2.8: Attribute tct

Starting time is stored in the attribute start_time with the keyword start_time. End time is stored in the attribute end_time with the keyword end_time. The important times are time instants when the solver certainly computes the response without respect to the time steps. The number of important times is stored in the attribute nit and the keyword is num_imp_times.

The time step is governed by an instance timefun of the class gfunct. Setting of the instances of the class gfunct are described in Section 2.1.

If the type of time controller is adaptive, the minimum time step stored in the attribute dtmin with the keyword dtmin and the maximum time step stored in the attribute dtmax with the keyword dtmax are required. If the type of time controller is adaptivemin, the minimum time step stored in the attribute dtmin with the keyword dtmin is required. If the type of time controller is adaptivemax, the maximum time step stored in the attribute dtmax with the keyword dtmax is required.

2.5.2 Examples

2.5.2.1 Time controller with constant time step

Example without keywords

```
0       # the type of time controller - fixed
0.0     # the starting time
123.0   # the end time
0       # the number of important times
0       # the type of general function governing the time step
        # the constant value
2.5     # the time step
```

Example with keywords

```
time_contr_type fixed    # the type of time controller - fixed
0.0                      # the starting time
123.0                    # the end time
0                        # the number of important times
funct_type stat          # the type of general function - the constant value
const_val 2.5            # the time step
```

2.5.2.2 Time controller with variable time step

Example without keywords

```
0              # the type of time controller - fixed
0.0            # the starting time
123.0          # the end time
0              # the number of important times
2              # the type of general function governing the time step
               # the table
1              # piecewise linear interpolation
3              # the number of rows in the table
0.0 2.5        # first row
10.0 5.0       # second row
200.0 20.0     # third row
```

Example with keywords

```
time_contr_type fixed      # the type of time controller - fixed
0.0                        # the starting time
123.0                      # the end time
0                          # the number of important times
funct_type tab             # the type of general function - the table
approx_type piecewiselin   # piecewise linear interpolation
ntab_items 3               # the number of rows in the table
3                          # the number of rows in the table
0.0 2.5                    # first row
10.0 5.0                   # second row
200.0 20.0                 # third row
```

2.5.2.3 Time controller with adaptive time step

Example without keywords

```
1       # the type of time controller - adaptive
0.0     # the starting time
123.0   # the end time
0       # the number of important times
0       # the type of general function governing the time step
        # the constant value
2.5     # the time step
1.0e-4  # the minimum time step
1.0e2   # the maximum time step
```

Example with keywords

```
time_contr_type adaptive  # the type of time controller - adaptive
0.0                       # the starting time
123.0                     # the end time
0                         # the number of important times
funct_type stat           # the type of general function - the constant value
const_val 2.5             # the time step
dtmin 1.0e-4              # the minimum time step
dtmax 1.0e2               # the maximum time step
```

2.6 Setting of node renumbering

2.6.1 General description

Type of node renumbering is read and stored in the class gtopology to the attribute nodren. The values of the attribute nodren are summarized in Table 2.9. The keyword for the type of node renumbering is noderenumber.

attribute	enumerator	description
nodren = 0	no_renumbering	no renumbering
nodren = 1	cuthill_mckee	Cuthill-McKey renumbering
nodren = 2	rev_cuthill_mckee	reverse Cuthill-McKey renumbering
nodren = 3	sloan	Sloan renumbering

Table 2.9: Attribute nodren

2.6.2 Examples

2.6.2.1 No node renumbering

Example without keywords

```
0   # nodes are not renumbered
```

Example with keywords

```
noderenumber no_renumbering   # nodes are not renumbered
```

2.7 Setting of strain computation

2.7.1 General description

There are three attributes devoted to the strain computation. The attribute straincomp with the keyword straincomp indicates whether the strains are computed and stored. The attribute strainpos with the keyword strainposdefines the position where the strains are computed. The attribute strainaver with the keyword strainaver defines whether the strains are averaged. The strains are averaged only in the case that they are required in nodes where contributions from all adjacent finite elements are added. Values of all attributes are summarized in Tables 2.10, 2.11 and 2.12.

attribute	description
straincomp = 0	strains are not computed and stored
straincomp = 1	strains are computed and stored

Table 2.10: Attribute straincomp

attribute	description
strainpos = 1	strains are computed and stored in integration points
strainpos = 2	strains are computed in integration points and stored in nodes
strainpos = 3	strains are computed and stored in nodes

Table 2.11: Attribute strainpos

attribute	description
strainaver = 0	strains are not averaged
strainaver = 1	strains are averaged in nodes

Table 2.12: Attribute strainaver

2.7.2 Examples

2.7.2.1 Strains are not required

Example without keywords

```
0   # strains are not computed and stored
```

Example with keywords

```
straincomp 0   # strains are not computed and stored
```

2.7.2.2 Strains are computed in nodes, average values are required

Example without keywords

```
1  # strains are computed and stored
3  # strains are computed in nodes
1  # the final strains are average values of strains from adjacent elements
```

2.8 Setting of stress computation

2.8.1 General description

There are three attributes devoted to the stress computation. The attribute stresscomp with the keyword stresscomp indicates whether the stresses are computed and stored. The attribute stresspos with the keyword stresspos defines the position where the stresses are required. Stresses can be computed only in integration points because of definition of material models. The attribute stressaver with the keyword stressaver defines whether the stresses are averaged. The stresses are averaged only in the case that they are required in nodes where contributions from all adjacent finite elements are added. Values of all attributes are summarized in Tables 2.13, 2.14 and 2.15.

attribute	description
stresscomp = 0	stresses are not computed and stored
stresscomp = 1	stresses are computed and stored

Table 2.13: Attribute stresscomp

attribute	description
stresspos = 1	stresses are computed and stored in integration points
stresspos = 2	stresses are computed in integration points and stored in nodes

Table 2.14: Attribute stresspos

attribute	description
stressaver = 0	stresses are not averaged
stressaver = 1	stresses are averaged in nodes

Table 2.15: Attribute stressaver

2.8.2 Examples

2.8.2.1 Stresses are not required

Example without keywords

```
0   # stresses are not computed and stored
```

2.8.2.2 Stresses are stored in nodes, average values are required

Example without keywords

```
1  # stresses are computed and stored
2  # stresses are computed in nodes
1  # the final stresses are average values of stresses from adjacent elements
```

2.9 Setting of computation of internal variables

2.9.1 General description

There are three attributes devoted to the computation of internal variables. The attribute othercomp with the keyword othercomp indicates whether the internal variables are computed and stored. The attribute otherpos with the keyword otherpos defines the position where the internal variables are required. The internal variables can be computed only in integration points where the material models are defined. The attribute othernaver with the keyword otheraver defines whether the internal variables are averaged. The internal variables are averaged only in the case that they are required in nodes where contributions from all adjacent finite elements are added. Values of all attributes are summarized in Tables 2.16, 2.17 and 2.18.

attribute	description
othercomp = 0	internal variables are not computed and stored
othercomp = 1	internal variables are computed and stored

Table 2.16: Attribute othercomp

attribute	description
otherpos = 1	internal variables are computed and stored in integration points
otherpos = 2	internal variables computed in integration points and stored in nodes

Table 2.17: Attribute otherpos

attribute	description
otheraver = 0	internal variables are not averaged
otheraver = 1	internal variables are averaged in nodes

Table 2.18: Attribute otheraver

2.9.2 Examples

2.9.2.1 Internal variables are not required

Example without keywords

```
0   # internal variables are not computed and stored
```

2.9.2.2 Internal variables are stored in nodes, average values are required

Example without keywords

```
1  # internal variables are computed and stored
2  # internal variables are computed in nodes
1  # the final internal variables are average values of
   # internal variables from adjacent elements
```

2.10 Setting of gradient computation

2.10.1 General description

There are three attributes devoted to the gradient computation. The attribute gradcomp with the keyword gradcomp indicates whether the gradients are computed and stored. The attribute gradpos with the keyword gradpos defines the position where the gradients are required. The attribute gradaver with the keyword gradaver defines whether the gradients are averaged. The gradients are averaged only in the case that they are required in nodes where contributions from all adjacent finite elements are added. Values of all attributes are summarized in Tables 2.19, 2.20 and 2.21.

attribute	description
gradcomp = 0	gradients are not computed and stored
gradcomp = 1	gradients are computed and stored

Table 2.19: Attribute gradcomp

attribute	description
gradpos = 1	gradients are computed and stored in integration points
gradpos = 2	gradients are computed in integration points and stored in nodes
gradpos = 3	gradients are computed and stored in nodes

Table 2.20: Attribute gradpos

attribute	description
gradaver = 0	gradients are not averaged
gradaver = 1	gradients are averaged in nodes

Table 2.21: Attribute gradaver

2.10.2 Examples

2.10.2.1 Gradients are not required

Example without keywords

```
0   # gradients are not computed and stored
```

2.10.2.2 Gradients are stored in nodes, average values are required

Example without keywords

```
1  # gradients are computed and stored
2  # gradients computed in nodes
1  # the final gradients are average values of gradients from adjacent elements
```

2.11 Setting of fluxes computation

2.11.1 General description

There are three attributes devoted to the flux computation. The attribute fluxcomp with the keyword fluxcomp indicates whether the fluxes are computed and stored. The attribute fluxpos with the keyword fluxpos defines the position where the fluxes are required. Fluxes can be computed only in integration points because of definition of material models. The attribute fluxaver with the keyword fluxaver defines whether the fluxes are averaged. The fluxes are averaged only in the case that they are required in nodes where contributions from all adjacent finite elements are added. Values of all attributes are summarized in Tables 2.22, 2.23 and 2.24.

attribute	description
fluxcomp = 0	fluxes are not computed and stored
fluxcomp = 1	fluxes are computed and stored

Table 2.22: Attribute fluxcomp

attribute	description
fluxpos = 1	fluxes are computed and stored in integration points
fluxpos = 2	fluxes are computed in integration points and stored in nodes

Table 2.23: Attribute fluxpos

attribute	description
fluxaver = 0	fluxes are not averaged
fluxaver = 1	fluxes are averaged in nodes

Table 2.24: Attribute fluxaver

2.11.2 Examples

2.11.2.1 Fluxes are not required

Example without keywords

```
0   # fluxes are not computed and stored
```

2.11.2.2 Fluxes are stored in nodes, average values are required

Example without keywords

```
1  # fluxes are computed and stored
2  # fluxes are computed in nodes
1  # the final fluxes are average values of fluxes from adjacent elements
```

Chapter 3

Mesh–Nodes, Constraints, Elements

3.1 SIFEL mesh format

For the purposes of the finite element method, the domains solved are described by entities and their "properties" (markers). The entities are vertices, edges, surfaces, regions, patches and shells. The entities are denoted by integer numbers summarized in Table 3.1.

Finite element meshes obtained from mesh generators are summarized in Table 3.2.

3.1.1 Nodes, edges, surface on elements

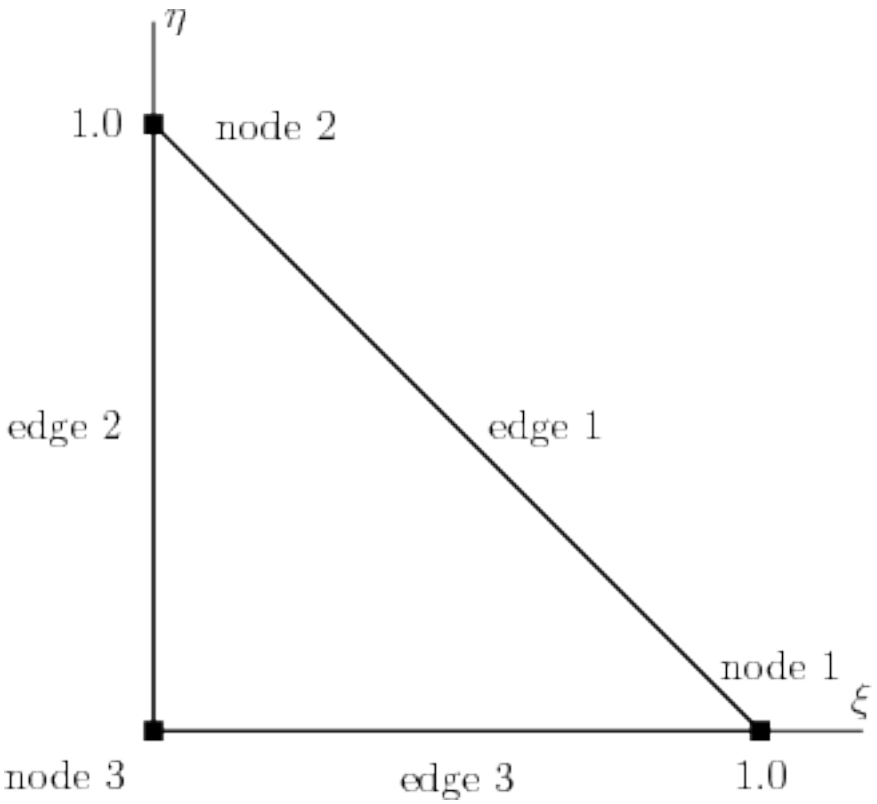
3.1.1.1 Triangular element

entity	entity number
vertex	1
edge	2
surface	3
region	4
patch	5
shell	6

Table 3.1: Type of entity used for domain description

element type	the number of nodes	the number of edges	the number of surfaces	element description
one-dimensional elements				
1	2	1	0	line with linear shape functions
2	3	1	0	line with quadratic shape functions (there is midside node)
two-dimensional elements				
3	3	3	1	triangular element with linear shape functions
4	6	3	1	triangular element with quadratic shape functions (there are mid-edge nodes)
5	4	4	1	quadrilateral element with linear shape functions
6	8	4	1	quadrilateral element with quadratic shape functions (there are mid-edge nodes)
three-dimensional elements				
7	4	6	4	tetrahedral element with linear shape functions
8	10	6	4	tetrahedral element with quadratic shape functions (there are mid-edge nodes)
9	5	8	5	pyramid element with linear shape functions
10	13	8	5	pyramid element with quadratic shape functions (there are mid-edge nodes)
11	6	9	5	triangular prism element with linear shape functions
12	15	9	5	triangular prism element with quadratic shape functions (there are mid-edge nodes)
13	8	12	6	hexahedral elements with linear shape functions
14	20	12	6	hexahedral elements with quadratic shape functions (there are mid-edge nodes)

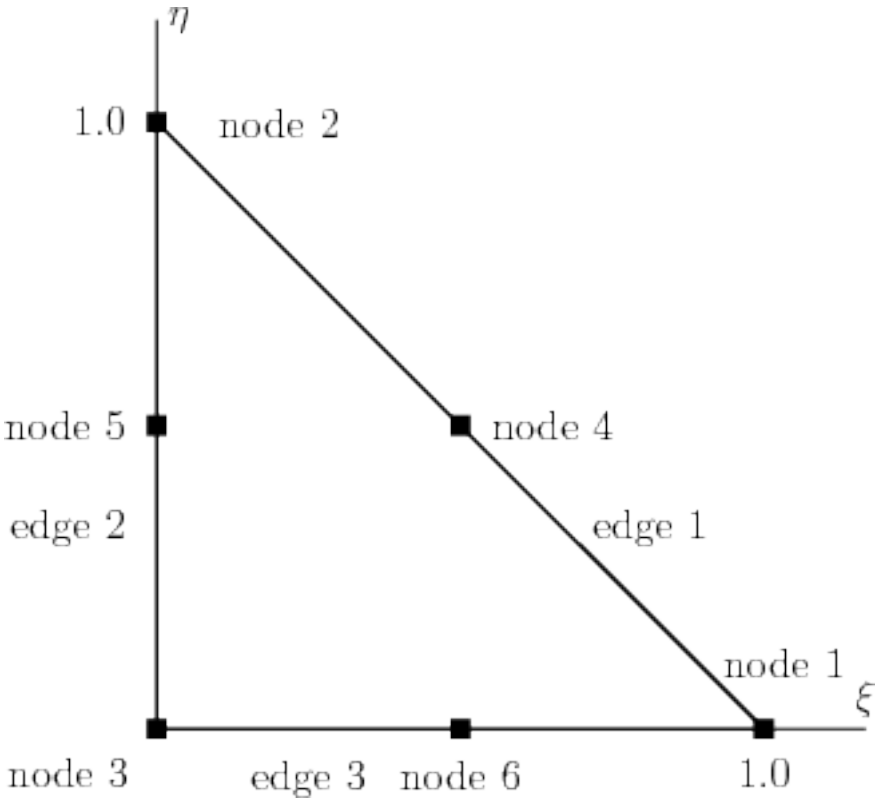
Table 3.2: Element types used in mesh generators



edge number	node numbers
1	1, 2
2	2, 3
3	3, 1

Table 3.3: Ordering of edges for triangular element with 3 nodes.

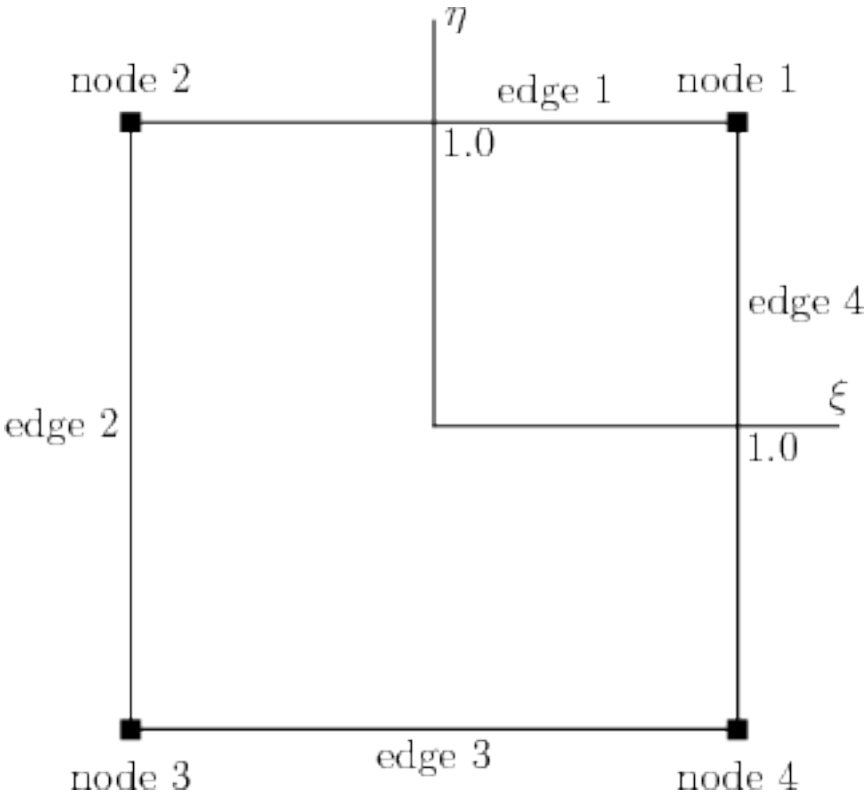
3.1.1.2 Triangular element with mid-side nodes



edge number	node numbers
1	1, 2, 4
2	2, 3, 5
3	3, 1, 6

Table 3.4: Ordering of edges for triangular element with 6 nodes.

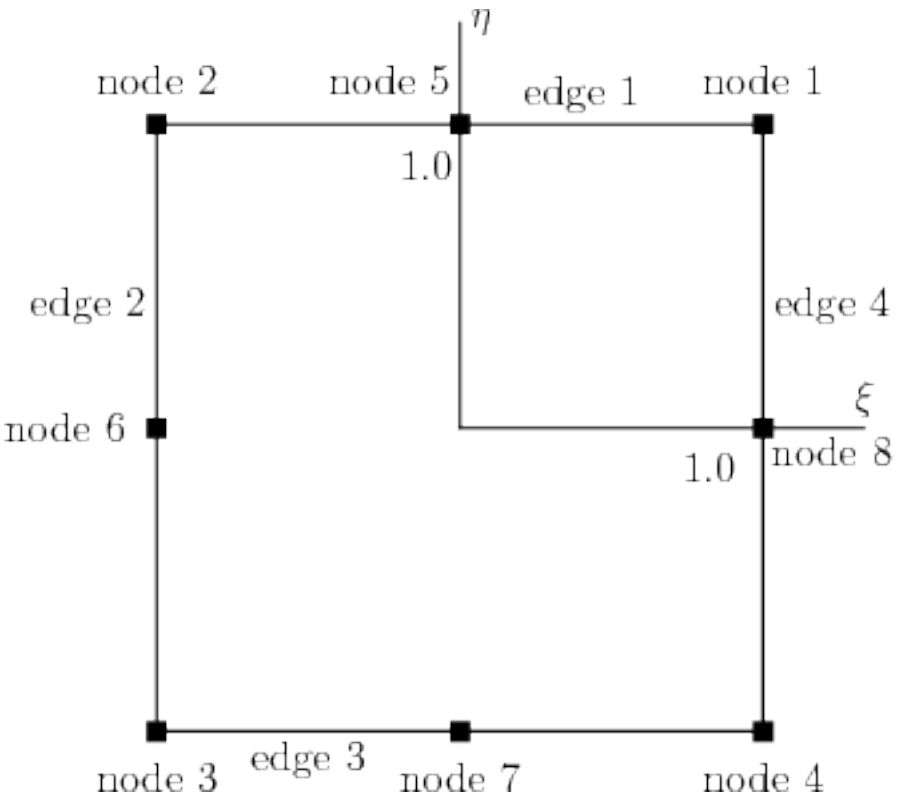
3.1.1.3 Quadrilateral elements



edge number	node numbers
1	1, 2
2	2, 3
3	3, 4
4	4, 1

Table 3.5: Ordering of edges for quadrilateral element with 4 nodes.

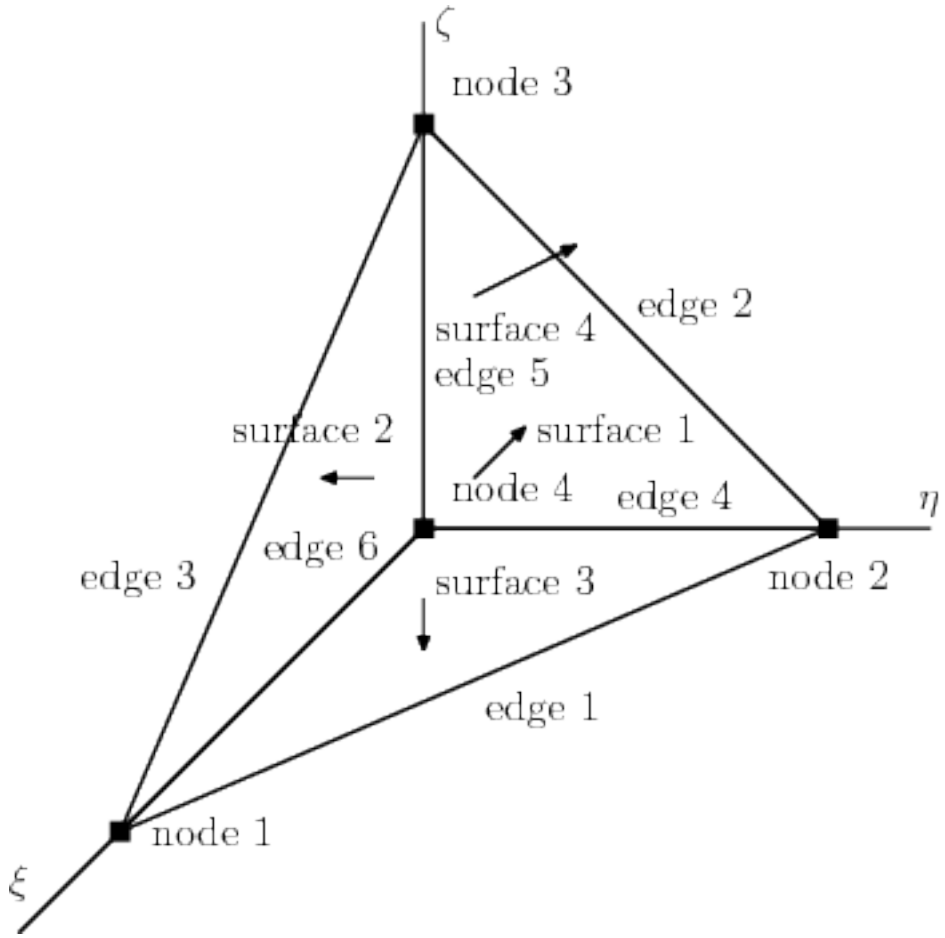
3.1.1.4 Quadrilateral elements with mid-side nodes



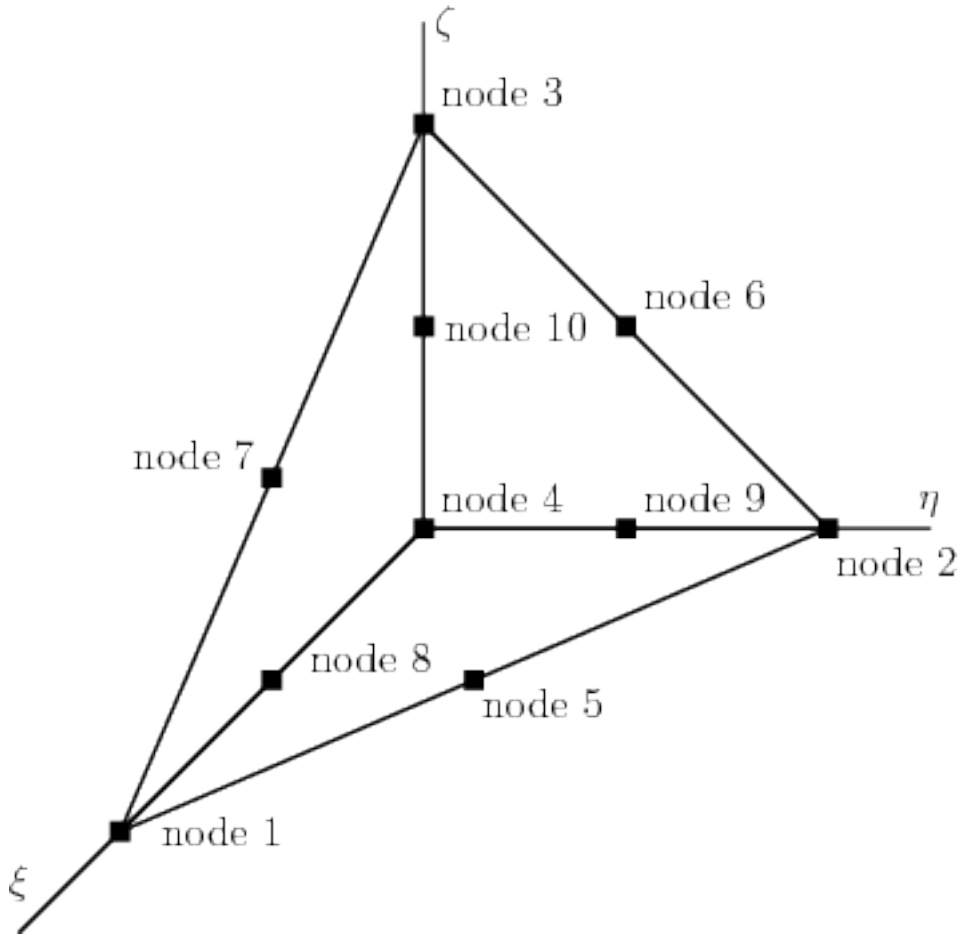
edge number	node numbers
1	1, 2, 5
2	2, 3, 6
3	3, 4, 7
4	4, 1, 8

Table 3.6: Ordering of edges for quadrilateral element with 8 nodes.

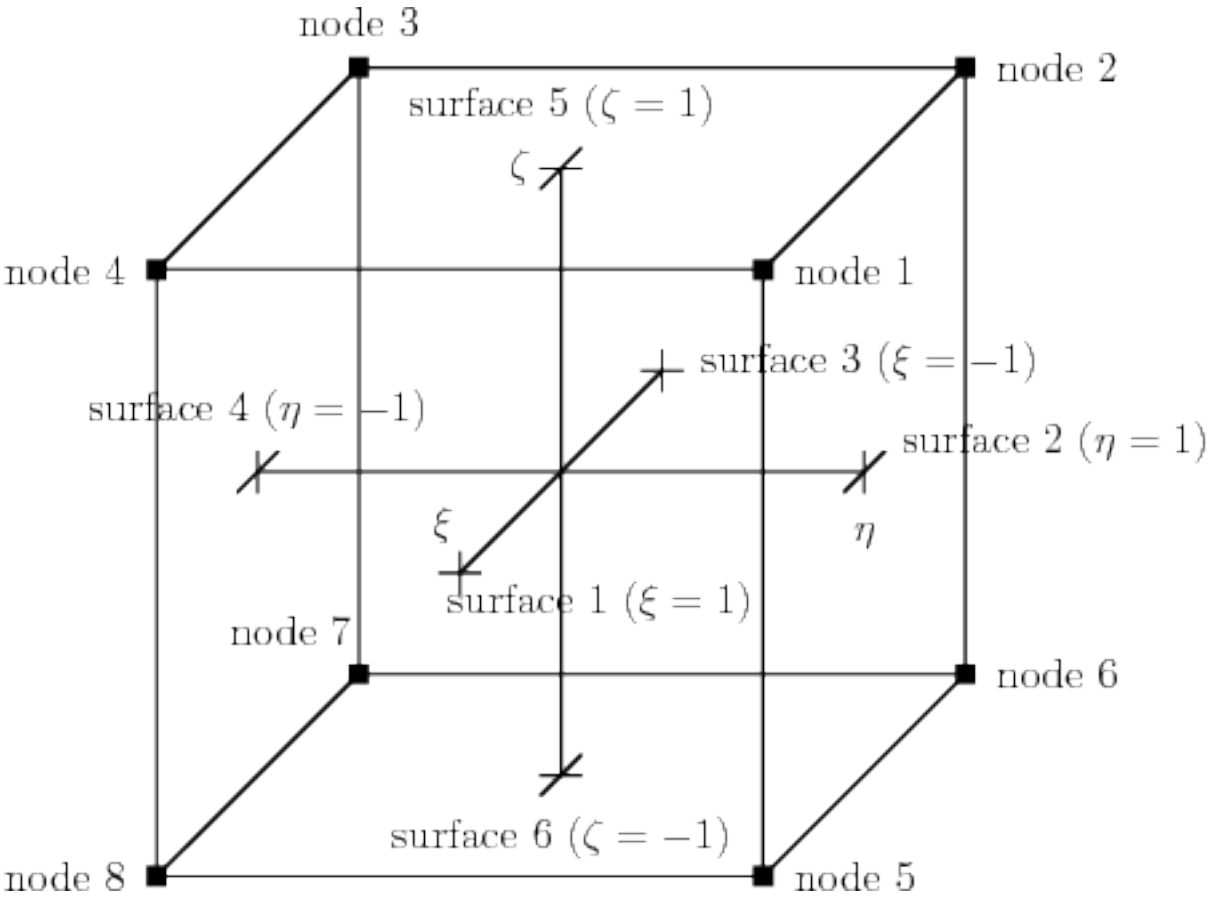
3.1.1.5 Tetrahedral elements



3.1.1.6 Tetrahedral elements with mid-side nodes



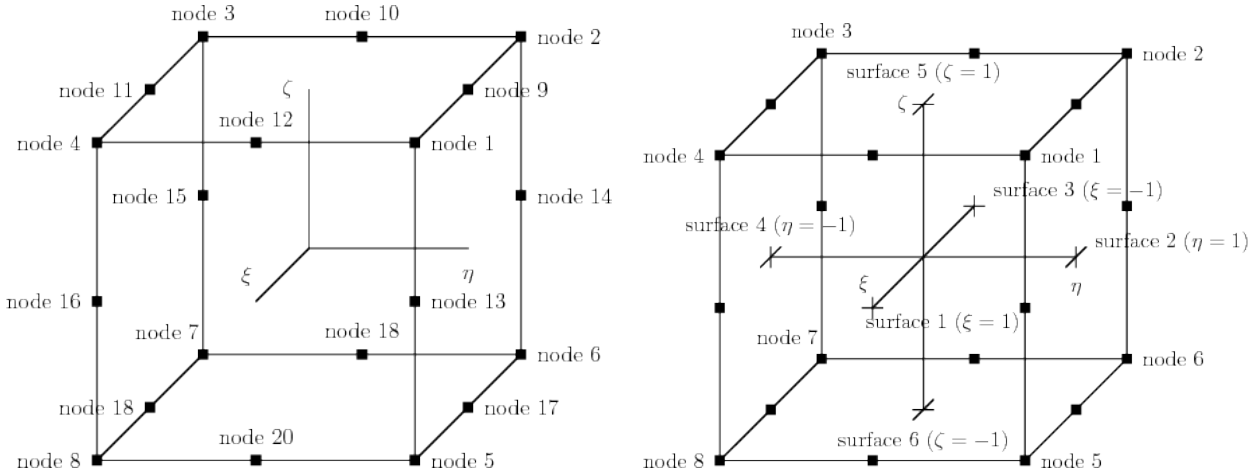
3.1.1.7 Hexahedral elements



surface number	node numbers
1	1, 4, 8, 5
2	2, 1, 5, 6
3	3, 2, 6, 7
4	4, 3, 7, 8
5	1, 2, 3, 4
6	5, 6, 7, 8

Table 3.7: Ordering of surfaces for hexahedral element with 8 nodes.

3.1.1.8 Hexahedral elements with mid-side nodes



surface number	node numbers
1	1, 4, 8, 5, 12, 16, 20, 13
2	2, 1, 5, 6, 9, 13, 17, 14
3	3, 2, 6, 7, 10, 14, 18, 15
4	4, 3, 7, 8, 11, 15, 19, 16
5	1, 2, 3, 4, 9, 10, 11, 12
6	5, 6, 7, 8, 17, 18, 19, 20

Table 3.8: Ordering of surfaces for hexahedral element with 20 nodes.

SIFEL mesh format

There are two blocks in the SIFEL mesh format. First contains nodes and second contains elements. The block containing nodes starts with the number of nodes in the mesh. A typical line of node block has the following structure
node id, x coordinate, y coordinate, z coordinate, the number of properties (np), np couples of integer numbers, where the first number in every couple is entity type (see Table 3.1) and the second integer denotes property
The block containing elements starts with the number of elements in the mesh. A typical line of element block has the following structure
element id, type of element, element nodes, surface property, edge properties and volume properties

Example of file with SIFEL mesh format

```
16
1   0.00000000000e+00   0.00000000000e+00   0.0   5   1 3   2 2   2 3   3 1   4 1
2   0.00000000000e+00   3.33333333333e+00   0.0   4   1 0   2 2   3 1   4 1
3   0.00000000000e+00   6.66666666667e+00   0.0   4   1 0   2 2   3 1   4 1
4   0.00000000000e+00   1.00000000000e+01   0.0   5   1 2   2 1   2 2   3 1   4 1
5   3.33333333333e+00   0.00000000000e+00   0.0   4   1 0   2 3   3 1   4 1
6   3.33333333333e+00   3.33333333333e+00   0.0   3   1 0   3 1   4 1
7   3.33333333333e+00   6.66666666667e+00   0.0   3   1 0   3 1   4 1
8   3.33333333333e+00   1.00000000000e+01   0.0   4   1 0   2 1   3 1   4 1
9   6.66666666667e+00   0.00000000000e+00   0.0   4   1 0   2 3   3 1   4 1
10  6.66666666667e+00   3.33333333333e+00   0.0   3   1 0   3 1   4 1
11  6.66666666667e+00   6.66666666667e+00   0.0   3   1 0   3 1   4 1
12  6.66666666667e+00   1.00000000000e+01   0.0   4   1 0   2 1   3 1   4 1
13  1.00000000000e+01   0.00000000000e+00   0.0   5   1 4   2 3   2 4   3 1   4 1
14  1.00000000000e+01   3.33333333333e+00   0.0   4   1 0   2 4   3 1   4 1
15  1.00000000000e+01   6.66666666667e+00   0.0   4   1 0   2 4   3 1   4 1
16  1.00000000000e+01   1.00000000000e+01   0.0   5   1 1   2 1   2 4   3 1   4 1
9
1  5    1   5   6   2    1  3  0  0  2  1
2  5    2   6   7   3    1  0  0  0  2  1
3  5    3   7   8   4    1  0  0  1  2  1
4  5    5   9  10   6    1  3  0  0  0  1
5  5    6  10  11   7    1  0  0  0  0  1
6  5    7  11  12   8    1  0  0  1  0  1
7  5    9  13  14  10    1  3  4  0  0  1
8  5   10  14  15  11    1  0  4  0  0  1
9  5   11  15  16  12    1  0  4  1  0  1
```

3.2 Local coordinate system in node

In mechanical analyses, a local coordinate system may be suitable. The presence of the local coordinate system is indicated by the attribute transf of the class node. Values of the attribute transf are summarized in Table 3.9.

attribute	description
transf = 0	no local coordinate system
transf = 2	2D problem, two basis vectors are required
transf = 3	3D problem, three basis vectors are required

Table 3.9: Attribute transf

3.2.1 Examples

3.2.1.1 No local coordinate system

```
0   # no local coordinate system
```

3.2.1.2 Local coordinate system in 2D

```
2   0.6 0.8   -0.8 0.6   # local coordinate system in 2D
```

3.2.1.3 Local coordinate system in 3D

```
3   0.6 0.8 0.0   -0.8 0.6 0.0   0.0 0.0 1.0   # local coordinate system in 3D
```

3.3 Nodes

Typical line of an input file describing a node is the following
id x y z NDOF crsec locsys
id is node number, x, y and z are coordinates, NDOF is the number of degrees of freedom defined in the node, crsec is description of cross section and locsys describes a local coordinate system in the node. Local coordinate system is used in mechanical problems only, it is not used in transport processes. Definition of cross section is in Section 5.1. Definition of local coordinate system is in Section 3.2.

3.3.1 Examples

3.3.1.1 Mechanical analysis, nodes in 2D, 2 DOFs in each node, no cross-section, no local coordinate system

```
4                                   # the number of nodes in mesh
1   0.0 0.0 0.0   2 0 0
2   2.0 1.0 0.0   2 0 0
3   4.0 2.0 0.0   2 0 0
4   6.0 3.0 0.0   2 0 0
```

3.3.1.2 Transport analysis, nodes in 2D, 2 DOFs in each node, no cross-section

```
4                                   # the number of nodes in mesh
1   0.0 0.0 0.0   2 0
2   2.0 1.0 0.0   2 0
3   4.0 2.0 0.0   2 0
4   6.0 3.0 0.0   2 0
```

3.3.1.3 Mechanical analysis, nodes in 2D, 2 DOFs in each node, cross-section in nodes, no local coordinate system

```
4                                   # the number of nodes in mesh
1   0.0 0.0 0.0   2 1 1 0
2   2.0 1.0 0.0   2 1 1 0
3   4.0 2.0 0.0   2 1 1 0
4   6.0 3.0 0.0   2 1 1 0
```

3.3.1.4 Mechanical analysis, nodes in 2D, 3 DOFs in each node, no cross-section, local coordinate system in node

```
4                                                   # the number of nodes in mesh
1   0.0 0.0 0.0   3 0 0
2   2.0 1.0 0.0   3 0 2 0.6 0.8 -0.8 0.6
3   4.0 2.0 0.0   3 0 0
4   6.0 3.0 0.0   3 0 0
```

3.3.1.5 Mechanical analysis, nodes in 3D, 3 DOFs in each node, no cross-section, local coordinate system in node

```
4                                                                  # the number of nodes in mesh
1  0.0 0.0 3.0   3 0 0
2  2.0 1.0 2.0   3 0 3 0.6 0.8 0.0 -0.8 0.6 0.0 0.0 0.0 1.0
3  4.0 2.0 1.0   3 0 0
4  6.0 3.0 0.0   3 0 0
```

3.4 Hanging Nodes

Hanging nodes are nodes which are linearly dependent on other nodes in a mesh. The nodes which the hanging nodes depend on are called tha master nodes. Degrees of freedom of any hanging node are defined by the master nodes. The hanging nodes are therefore indicated by negative value of the attribute ndofn of the class gnode which defines the number of degrees of freedom of the node. The absolute value of the attribute ndofn is equal to the number of master node.

3.4.1 Examples

3.4.1.1 Mechanical analysis, nodes in 3D, 3 DOFs in each node, no cross-section, local coordinate system in node, hanging node on an edge

The 132nd node is a hanging node, it is connected to an edge, its master nodes are the nodes 143 and 345, the natural coordinate on the edge is 0.4, 0.0 and 0.0. The edge is indicated by the number 1 after the natural coordinates. The last two zeros indicate the cross section and local coordinate system in the 132-nd node.

```
132   1.4 2.3 3.7   -2   143 345   0.4 0.0 0.0   1   0 0   # hanging node
```

3.4.1.2 Mechanical analysis, nodes in 3D, 3 DOFs in each node, no cross-section, local coordinate system in node, hanging node on a surface

The 132nd node is a hanging node, it is connected to a surface, its master nodes are the nodes 143, 345, 356 and 378, the natural coordinate on the surface are 0.3, 0.8 and 0.0. The surface is indicated by the number 5.

```
132   1.4 2.3 3.7   -4   143 345 356 378   0.3 0.8 0.0   5   0 0   # hanging node
```

3.4.1.3 Mechanical analysis, nodes in 3D, 3 DOFs in each node, no cross-section, local coordinate system in node, hanging node in a volume

The 132nd node is a hanging node, it is connected to a volume, its master nodes are the nodes 143, 345, 356, 378, 412, 456, 478 and 567 the natural coordinate in the volume are 0.5, 0.4 and 0.9.

```
132   1.4 2.3 3.7   -8   143 345 356 378 412 456 478 567   0.5 0.4 0.9   13   0 0   # hanging node
```

Chapter 4

Materials

4.1 Tentative material parameters of selected materials

List of material parameters

notation	unit	parameter
E	Pa	Young modulus of elasticity
G	Pa	shear modulus of elasticity
μ	-	Poisson ratio
ϱ	kg/m^3	density
α	K^{-1}	coefficient of thermal expansion (thermal extensibility
λ	J/m/s	coefficient of heat conductivity
c	J/kg/K	heat capacity coefficient

4.2 Materials for mechanical analyses

4.2.1 Linear elastic isotropic mechanical model

Linear elastic isotropic model requires definition of two material parameters: the Young modulus os elasticity E (Pa) and the Poisson ratio μ (-).

Example without keywords

```
1              # there is single type of material model
1 2            # first material model is linear elastic isotropic model and there are two instances of s
1 20.e9 0.1    # first instance of the elastic model (Young modulus of elasticity, Poisson ratio)
2 30.0e9 0.13  # second instance of the elastic model (Young modulus of elasticity, Poisson ratio)
```

material	materiál	E GPa	G GPa	ν	ϱ kg/m^3	α 10^{-6} K^{-1}
aluminium	hliník	66 - 68	26 - 28	0.33	2 650 - 2 800	20 - 24
asphalt	asfalt				1 300	
bricks	cihly	8 - 12			1 400 - 2 200	5
concrete	beton	15 - 40		0.08 - 0.18	1 800 - 2 500	12
conc. cellular	pórobeton	0.8 - 4			400 - 900	7 - 8
copper	měď	120 - 130	42 - 47	0.34	8 930	17
cork	korek				200-350	
glass	sklo	70			2 400 - 4 700	6 - 9
granite	žula	27 - 51			2 600 - 2 900	7.89
ice	led				917	50
iron	železo				7 860	12
paper	papír				700 - 1 100	
polystyrene	polystyrén	0.0028 - 0.015	-	-	14 - 100	50 - 80
PVC	PVC	2.5 - 3.6			1 360 - 1 400	80
rubber	guma				1 150 - 1 350	
snow	sníh				125 - 800	
steel	ocel	210	85	0.3	7 400 - 8 000	12
wood	dřevo	10 - 15	0.3 - 0.6	-	400 - 1 000	3 - 32
wool (glass)	vlna (skelná)	-	-	-	12	-

4.3 Materials for trasport analyses

4.3.1 Linear isotropic transport model

Linear isotropic transport model requires definition of the coefficient of heat conductivity λ (J/m/s). In the case on non-stationary transport, also the heat capacity c (J/kg/K) is required.

4.3.1.1 Stationary problem, linear isotropic transport model

Example without keywords

```
1       # there is single type of material model
100 2   # first material model is linear isotropic model and there are two instances of such type
1 1.5   # first instance of the isotropic model (the coefficient of conductivity)
2 1.9   # second instance of the isotropic model (the coefficient of conductivity)
```

4.3.1.2 Non-stationary problem, linear isotropic transport model

Example without keywords

```
1             # there is single type of material model
100 2         # first material model is linear isotropic model and there are two instances of such type
1 1.5 900.0   # first instance of the isotropic model (the coefficient of conductivity, capacity coefficien
2 1.9 980.0   # second instance of the isotropic model (the coefficient of conductivity, capacity coeffic
```

4.3.2 Künzel model of coupled heat and moisture transport

2. the bulk density of the sample ρ (kg/m^3), 3. porosity 4. water vapour diffusion resistance factor μ, 5. the moisture diffusivity κ (m^2/s), 9. specific heat capacity of the building material c_s (J/kg/K), 10. thermal conductivity λ (W/m/K)

w is the volumetric moisture content (m^3/m^3), T is the temperature (K), κ is the moisture diffusivity (m^2/s), δ is the water vapour diffusion permeability (s), ρ_w is the density of water (kg/m^3), p_v is the partial pressure of water vapour (Pa), c is the specific heat capacity (J/kg/K), λ is the thermal conductivity (W/m/K) and L_v is the latent heat of evaporation of water (J/kg).

list of material parameters used in the model: position CORD: 2 - density 3 - porosity 4 - water vapour diffusion resistance factor 5 - moisture diffusivity 6 - sorption isoterm 7 - saturated moisture 8 - none 9 - specific heat capacity 10 - thermal conductivity 11 - 13 - none 14 Dcoef 15 - binding isotherm 16 - cfmax 17 ws 18 - none 19 - kunzeltype

Chapter 5

Cross Section

Cross section is notation for the width and height in the case of beams and for the thickness in the case of walls, plates and shells. The cross section can be defined in a node or on an element. The type of cross section is stored in the attribute crst of the class element or in the class node. The attribute crst is of enumeration data type crsectype. Values of the attribute crst are summarized in Table 5.1.

attribute	enumerator	description
crst=0	nocrosssection	no cross section
crst=1	csbar2d	cross section for bar element
crst=2	csbeam2d	cross section for 2D beams
crst=4	csbeam3d	cross section for 3D beams
crst=10	csplanestr	cross section for plane strain and plane stress problems
crst=20	cs3dprob	cross section for three-dimensional problems

Table 5.1: Attribute crst

5.1 Setting of cross section in node or on element

If the cross section is not defined in connection with a quantity (node or element), 0 or nocrosssection is put into appropriate position. On the other hand, if the cross section is defined, two values are required. The first is the type of the cross section and the second is the id of the appropriate instance of the cross section type.

5.1.1 Examples

5.1.1.1 No cross section

Example without keywords

```
0   # the cross section is not defined on element or node
```

5.1.1.2 Cross section for 2D beams

Example without keywords

```
2  # the cross section for 2D beam is defined
3  # third instance of all 2D beam cross sections is selected
```

5.2 Definition of cross sections

All cross sections are summarized in one list.

5.2.1 Examples

5.2.1.1 List of cross sections for linear statics

Example without keywords

```
2                       # there are two types of cross sections
1 3                     # first cross section type is for 2D bar elements and there are 3 instances of su
1 0.03                  # first instance of the bar cross section
2 0.02                  # second instance of the bar cross section
3 0.06                  # third instance of the bar cross section
2 2                     # second cross section type is for 2D beam elements and there are 2 instances
1 0.04 0.0005 0.8333    # first instance of the beam cross section
2 0.05 0.0004 0.8333    # second instance of the beam cross section
```

Chapter 6

Definitions–Output and Graphics

6.1 Class sel

The class is used in outdriverm and outdrivert classes (MEFEL, TRFEL) and it contains the selection of variety items such as load cases, time steps, nodes, elements, particular quantities defined at nodes or elements, etc. Depending on the selected items or quantities, integer indeces or real numbers are used for the selection. Type of sel is given by the st attribute whose values are defined by enumeration seltype (see galias.h) which is described in the following table.

attribute	enumerator	description
st = 0	sel_no	nothing is selected
st = 1	sel_all	all values/indeces are selected
st = 2	sel_range	selection by ranges of indeces
st = 3	sel_list	selection by list of individual indeces
st = 4	sel_period	selection by constant period (each n-th index is selected)
st = 5	sel_realrange	selection by range of real values
st = 6	sel_reallist	selection by list of real values
st = 7	sel_mtx	selection of all components of a tensorial quantity for GiD
st = 8	sel_range_mtx	selection of all components of a tensorial quantity for GiD by range of indeces, the quantity is stored in larger array (e.g. eqother)
st = 9	sel_range_vec	selection of a vector quantity for GiD by range of indeces - the quantity is stored inside larger array (e.g. eqother)
st = 10	sel_realperiod	option used for selection of time steps with real period r
st = 11	sel_impvalues	option used for selection of time steps according to important times defined in time controller (class timecontr)

The class sel has also attribute n which represents the number of selected ranges or items depending on the type of selection (st attribute).

st = 0	n = 0
st = 1	n = 1
st = 2	n = number of selected ranges
st = 3	n = number of list items
st = 4	n = 1
st = 5	n = number of selected real ranges
st = 6	n = number of real items in the list
st = 7	n = 1
st = 8	n = 1
st = 9	n = 1
st = 10	n = number is calculated from the time interval length and given period
st = 11	n = 1

6.1.1 Conjugated selection

The class sel was designed for the selection of output data and there is often required the output of different quantities for given selection of elements or nodes. The typical case represents output of selected internal variables stored in the eqother array on integration points of elements. If the problem domain is heterogeneous and different material models are used then the order of internal variables is not the same for all integration points and consequently, the selection of required internal variables differs on particular elements. This case can be solved by using of conjugated selections where the main selection is connected with required elements/nodes and conjugated selection is connected with the required internal variables. The number of conjugated selections is given by the number of items in the main selection, i.e., attribute n of main selection is the number of conjugated selections.

In the cases of stress or strain selection, the conjugated selection consists of main selection of nodes/elements, conjugated selections of stress/strain components and conjugated flags for output of principal stresses/strains. Similarly, the number of conjugated selections and conjugated flags is given by the number of items in the main selection (attribute n).

6.1.2 Examples of input record for basic selection types

This section describes basic selections used for selection of list of integer identifiers or indeces (ids), e.g. nodes, elements, load cases, strain components, time steps, etc.

6.1.2.1 Definition of empty list

Example without keywords

```
0   # type of selection = no selection or empty list
```

Example with keywords

```
sel_no   # type of selection = no selection or empty list
```

6.1.2.2 Definition of list of all ids

Example without keywords

```
1   # type of selection = all ids are selected
```

Example with keywords

```
sel_all   # type of selection = all ids are selected
```

6.1.2.3 Definition of id ranges

Example without keywords

```
2    # type of selection = integer ranges
2    # two ranges will be specified
     # first range <1, 5>
1    # initial id - range 1.
5    # number of selected ids - range 1.
     # second range <23, 24>
23   # initial id - range 2.
2    # number of selected ids - range 2.
```

Example with keywords

```
sel_range        # type of selection = integer ranges
num_ranges 2     # two ranges will be specified
                 # first range <1, 5>
1                # initial id - range 1.
5                # number of selected ids - range 1.
                 # second range <23, 24>
23               # initial id - range 2.
2                # number of selected ids - range 2.
```

6.1.2.4 Definition of list of individual ids

Example without keywords

```
3              # type of selection = integer list
4              # number of selected ids
8 15 17 11     # list of selected ids
```

Example with keywords

```
sel_list           # type of selection = integer list
numlist_items 4    # number of selected ids
8 15 17 11         # list of selected ids
```

6.1.3 Examples of input record for selections of periodic indeces and real values

This section describes examples of input records of for periodic selection of indeces and selection of real values. They are used only in the cases of time step selection.

6.1.3.1 Integer periodic selection type

Example without keywords

```
4   # type of selection = integer periodic
5   # period
```

Example with keywords

```
sel_period   # type of selection = integer periodic
5            # period
```

6.1.3.2 Selection of real ranges

Example without keywords

```
5       # type of selection = real ranges
2       # number of ranges
        # range 1. = <1.0, 5.0>
1.0     # lower limit of range 1.
5.0     # upper limit of range 1.
        # range 2. = <50.0, 65.2>
50.0    # initial limit of range 2.
65.2    # end limit of range 2.
```

Example with keywords

```
sel_realrange   # type of selection = real ranges
numranges 2     # number of ranges
                # range 1. = <1.0, 5.0>
1.0             # lower limit of range 1.
5.0             # upper limit of range 1.
                # range 2. = <50.0, 65.2>
50.0            # lower limit of range 2.
65.2            # upper limit of range 2.
```

6.1.3.3 Selection of real list

Example without keywords

```
6              # type of selection = list of real values
3              # number of selected values
5.8 7.5 12.4   # list of selected real values
1.0e-3         # required error of real lists;
               # selected time steps may be different
               # from the above ones about 1.0e-3
```

Example with keywords

```
sel_reallist         # type of selection = list of real values
numlist_items 3      # number of selected values
5.8 7.5 12.4         # list of selected real values
1.0e-3               # required error of selected items;
                     # selected time steps may be different
                     # from the above ones about 1.0e-3
```

6.1.3.4 Periodic selection from real range

Example without keywords

```
             # time steps 3.0, 4.0 and 5.0 will be selected
10           # type of selection = real periodic selection
3.0          # lower limit of range
5.0          # upper limit of range
1.0          # period
1.0e-2       # required error of selected items
             # selected time steps may be different
             # from the above ones about 1.0e-2
```

Example with keywords

```
                 # time steps 3.0, 4.0 and 5.0 will be selected
sel_realperiod   # type of selection = real periodic selection
ini_time 3.0     # lower limit of range
fin_time 5.0     # upper limit of range
period 1.0       # period
err 1.0e-2       # required error of selected items
                 # selected time steps may be different
                 # from the above ones about 1.0e-2
```

6.1.3.5 Periodic selection from real range

Example without keywords

```
    # selects important time steps defined in time controler
11  # type of selection = sel_impvalues
```

Example with keywords

```
                # selects important time steps defined in time controler
sel_impvalues   # type of selection = selection of important values
```

6.1.4 Examples of input record of selections used for GiD

This section describes examples of input records used for the selections of quantity components that will be written to GiD post-processor file in the tensorial or vector formats.

6.1.4.1 Selection of tensorial quantity stored as vector

Example without keywords

```
    # select all component of the given quantity
    # write them in the GiD tensorial format
7   # type of selection = sel_mtx
```

Example with keywords

```
            # select all component of the given quantity
            # write them in the GiD tensorial format
sel_mtx     # type of selection = sel_mtx
```

6.1.4.2 Selection of tensorial quantity stored as vector in larger array

Example without keywords

```
    # select n component of the given quantity
    # write them in the GiD tensorial format
8   # type of selection = sel_range_mtx
3   # initial id of large array
4   # number of quantity components
```

Example with keywords

```
                # select n component of the given quantity
                # write them in the GiD tensorial format
sel_range_mtx   # type of selection = sel_range_mtx
3               # initial id of the first component in large array
4               # number of quantity components
```

6.1.4.3 Selection of vector quantity stored in larger array

Example without keywords

```
    # select n component of the given quantity
    # write them in the GiD vector format
9   # type of selection = sel_range_vec
3   # initial id of large array
3   # number of vector components
```

Example with keywords

	# select n component of the given quantity
	# write them in the GiD tensorial format
sel_range_vec	# type of selection = sel_mtx
3	# initial id of the first component in large array
3	# number of vector components

6.1.5 Input record for conjugated selections

The input record of conjugated selections contains input record of the main selection mainsel according to section 6.1.2 followed by input records of conjugated selections consel$_1$, consel$_2$, ..., consel$_n$ where n is given by the value specified for attribute n of mainsel. Input records of particular conjugated selections consel$_i$ have the same format as the main selection mainsel. Formally, the format can be written as follows

mainsel (consel)×mainsel.n

In the case of conjugated selections for stress/strain output, the format reads

mainsel (consel)×mainsel.n (flag)×mainsel.n

6.1.6 Example of ordinary conjugated selection

In this example, an ordinary conjugated selection will be showed. The main selection is connected for example with element ids 1-10 and 40-60 and the conjugated selection is connected for example with the point/component ids 1,5,9. Should be noted that in the case of specific conjugated selections such as selection of eqother components at nodes, some additional keywords have to be specified but the example without keywords remains the same. The more details about specific conjugated selections can be found in Section 7.5.

Example without keywords

```
        # SELECTION OF REQUIRED ELEMENTS
2       # type of selection = integer range
2       # two ranges will be specified
        # first range <1, 10>
1       # initial id - range 1.
10      # number of selected ids - range 1.
        # second range <40, 60>
40      # initial id - range 2.
20      # number of selected ids - range 2.

        # SELECTION OF CONJUGATED IDS
3       # type of conjugated selection for range 1. =
        # = integer list
3       # number of list items
1 5 9   # selected ids for range 1.

3       # type of conjugated selection for range 2. =
        # = integer list
3       # number of list items
1 5 9   # selected ids for range 2.
```

Example with keywords

```
                # SELECTION OF REQUIRED ELEMENTS
sel_range       # type of selection = integer range
num_ranges 2    # two ranges will be specified
                # the first range <1, 10>
1               # initial id - range 1.
10              # number of selected ids - range 1.
                # the second range <40, 60>
40              # initial id - range 2.
20              # number of selected ids - range 2.

                # SELECTION OF CONJUGATED IDS
sel_list        # type of conjugated selection for range 1. =
                # = integer list
numlist_items 3 # number of list items
1 5 9           # selected ids for range 1.

sel_list        # type of conjugated selection for range 2. =
                # = integer list
numlist_items 3 # number of list items
1 5 9           # selected ids for range 2.
```

Chapter 7

MEFEL Input Files

7.1 Description of Mechanical Analyses

Type of mechanical analysis is stored in the attribute tprob of the class probdesc. The appropriate keyword is problemtype. Values of the attribute tprob are summarized in Table 7.1.

attribute	enumerator	description
tprob = 1	linear_statics	linear statics
tprob = 2	eigen_dynamics	eigenvibration
tprob = 3	forced_dynamics	forced dynamics
tprob = 5	linear_stability	linear stability
tprob = 10	mat_nonlinear_statics	static material non-linearity
tprob = 11	geom_nonlinear_statics	geometrically non-linear statics
tprob = 15	mech_timedependent_prob	time dependent problems with negligible inertial forces
tprob = 17	growing_mech_structure	mechanical problem with changing number of nodes and elements

Table 7.1: Attribute tprob

Array name contains name or description of problem solved. The name is defined by user.

The attribute Mespr describes the detailness of the auxiliary prints on screen. The appropriate keyword is mespr.

attribute	description
Mespr = 0	no auxiliary print on screen
Mespr = 1	auxiliary print on screen

Table 7.2: Attribute Mespr

The attribute reactcomp describes whether the reactions are computed. The appropriate keyword is reactcomp.

attribute	description
reactcomp = 0	reactions are not computed
reactcomp = 1	reactions are computed

Table 7.3: Attribute reactcomp

The attribute adaptivityflag describes whether the adaptivity is applied. The appropriate keyword is adaptivity.

attribute	description
adaptivityflag = 0	adaptivity is not applied (default value)
adaptivityflag = 1	adaptivity is applied (not described now)

Table 7.4: Attribute adaptivityflag

The attribute stochasticcalc describes the type of analysis with respect to deterministic or non-deterministic feature. The appropriate keyword is stochasticcalc.

attribute	description
stochasticcalc = 0	deterministic approach/computation (default value)
stochasticcalc = 1	stochastic/fuzzy computation, data are read all at once
stochasticcalc = 2	stochastic/fuzzy computation, data are read sequentially
stochasticcalc = 3	stochastic/fuzzy computation, data are generated in the code

Table 7.5: Attribute stochasticcalc

The attribute homog describes whether homogenization is applied. The appropriate keyword is homogenization.

Storage of the stiffness matrix is located in the attribute tstorsm of the class probdesc. The appropriate keyword is stiffmatstor. Storage of the mass matrix is located in the attribute tstormm of the class probdesc. The appropriate keyword is massmatstor.

7.2 Linear Static Analysis

7.2.1 General description

Every linear static problem is described by the following scheme.

attribute	description
homog = 0	homogenization is not applied (default value)
homog = 1	homogenization is applied (not described now)

Table 7.6: Attribute homog

name of problem solved by user	
message printing	Table 7.2
tprob = linear_statics=1	Table 7.1
strains computation	described in Section 2.7
stresses computation	described in Section 2.8
internal variables computation	described in Section 2.9
computation of reactions	Table 7.3
adaptivity	Table 7.4
deterministic/stochastic computation	Table 7.5
homogenization	Table 7.6
node renumbering	described in Section 2.6
storage of the stiffness matrix	described in Section 2.2
solver of linear equations	described in Section 2.3

7.2.2 Examples

7.2.2.1 Linear statics

Example without keywords

```
simply supported beam
1  # detail output
1  # linear statics
0  # strains are not computed
0  # stresses are not computed
0  # internal variables are not computed
1  # reactions are computed
0  # adaptivity is not used
0  # deterministic computation
0  # homogenization is not applied
0  # nodes are not renumbered
2  # the stiffness matrix is stored in skyline
2  # system of linear algebraic equations is solved by LDL factorization
```

Example with keywords

```
simply supported beam
mespr 1                          # detail output
problemtype linear_statics       # linear statics
straincomp 0                     # strains are not computed
stresscomp 0                     # stresses are not computed
othercomp 0                      # internal variables are not computed
reactcomp 1                      # reactions are computed
adaptivity 0                     # adaptivity is not used
stochasticcalc 0                 # deterministic computation
homogenization 0                 # homogenization is not applied
noderenumber no_renumbering      # nodes are not renumbered
stiffmatstor skyline_matrix      # the stiffness matrix is stored in skyline
typelinsol ldl                   # system of linear algebraic equations is
                                 # solved by LDL factorization
```

7.3 Eigenvibration

Example without keywords

```
eigenvibration analysis
1               # detail output
2               # eigenvibration analysis
1               # strains are computed
2               # strains are computed in nodes
1               # strains are averaged
1               # stresses are computed
2               # stresses are computed in nodes
1               # stresses are averaged
0               # other values are not computed
1               # reactions are computed
0               # adaptivity is not used
0               # deterministic computation
0               # homogenization is not applied
0               # nodes are not renumbered
140             # the stiffness matrix is stored in sparse storage scheme
140             # the mass matrix is stored in sparse storage scheme
5               # type of eigensolver - subspace iteration with Gram-Schmidt ortonormalization
10              # the number of required eigenvectors
15              # the number of vectors used in computation
1000            # the maximum number of iterations
1.000000e-06    # the required residual
140             # type of solver of algebraic equations - sparse solver is selected
```

Example with keywords

```
eigenvibration analysis
mespr 1                                  # detail output
problemtype eigen_dynamics               # eigenvibration analysis
straincomp 0                             # strains are not computed
stresscomp 0                             # stresses are not computed
othercomp 0                              # internal variables are not computed
reactcomp 1                              # reactions are computed
adaptivity 0                             # adaptivity is not used
stochasticcalc 0                         # deterministic computation
homogenization 0                         # homogenization is not applied
noderenumber no_renumbering              # nodes are not renumbered
stiffmatstor skyline_matrix              # the stiffness matrix is stored in skyline
massmatstor skyline_matrix               # the mass matrix is stored in skyline
type_of_eig_solver subspace_it_gsortho   # type of eigensolver - subspace iteration with Gram-Schmidt
10                                       # the number of required eigenvectors
15                                       # the number of vectors used in computation
1000                                     # the maximum number of iterations
1.000000e-06                             # the required residual
typelinsol ldl                           # system of linear algebraic equations is
                                         # solved by LDL factorization
```

7.4 Non-linear Static Analysis

7.4.1 General description

Every non-linear static problem is described by the following scheme.

name of problem solved by user	
message printing	Table 7.2
tprob = linear_statics=1	Table 7.1
strains computation	described in Section 2.7
stresses computation	described in Section 2.8
internal variables computation	described in Section 2.9
computation of reactions	Table 7.3
adaptivity	Table 7.4
deterministic/stochastic computation	Table 7.5
homogenization	Table 7.6
node renumbering	described in Section 2.6
non-linear solver	described in Section 2.4
back-up	
storage of the stiffness matrix	described in Section 2.2
solver of linear equations	described in Section 2.3

7.4.2 Examples

7.4.2.1 Non-linear statics, Newton-Raphson method

Example without keywords

```
simply supported beam
1          # detail output
10         # non-linear statics
1          # strains are computed
1          # strains are computed in integration points
0          # strains are not averaged
1          # stresses are computed
1          # stresses are computed in integration points
0          # stresses are not averaged
1          # internal variables are not computed
1          # internal variables are computed in integration points
0          # internal variables are not averaged
1          # reactions are computed
0          # adaptivity is not used
0          # deterministic computation
0          # homogenization is not applied
0          # nodes are not renumbered
2          # the Newton-Raphson method is used
1          # the initial stiffness matrix is used
300        # the number of increments
30         # the number of iterations within increment
1.0e-02    # the required norm of residual
1.0e-01    # the initial increment
1.0e-08    # the minimum increment
1.0e+03    # the maximum increment
0          # no back-up is required (default value)
2          # the stiffness matrix is stored in skyline
2          # system of linear algebraic equations is solved by LDL factorization
```

Example with keywords

```
simply supported beam
mespr 1                                 # detail output
problemtype mat_nonlinear_statics       # non-linear statics
straincomp 1                            # strains are computed
strainpos 1                             # strains are computed in integration points
strainaver 0                            # strains are not averaged
stresscomp 1                            # stresses are computed
stresspos 1                             # stresses are computed in integration points
stressaver 0                            # stresses are not averaged
othercomp 1                             # internal variables are not computed
otherpos 1                              # internal variables are computed in integration points
otheraver 0                             # internal variables are not averaged
reactcomp 1                             # reactions are computed
adaptivity 0                            # adaptivity is not used
stochasticcalc 0                        # deterministic computation
homogenization 0                        # homogenization is not applied
noderenumber no_renumbering             # nodes are not renumbered
tnlinsol newton                         # the Newton-Raphson method is used
stiffmat_type initial_stiff             # the initial stiffness matrix is used
nr_num_steps 300                        # the number of increments
nr_num_iter 30                          # the number of iterations within increment
nr_error 1.0e-02                        # the required norm of residual
nr_init_incr 1.0e-01                    # the initial increment
nr_minincr 1.0e-08                      # the minimum increment
nr_maxincr 1.0e+03                      # the maximum increment
hdbackup nohdb                          # no back-up is required (default value)
stiffmatstor skyline_matrix             # the stiffness matrix is stored in skyline
typelinsol ldl                          # system of linear algebraic equations is
                                        # solved by LDL factorization
```

7.4.2.2 Non-linear statics, arc-lenght method

Example without keywords

```
2D rectangular domain, rectangular elements, isotropic scalar damage model, arc-length
1          # message printing
10         # non-linear statics
1          # strains are computed
1          # strains are computed in integration points
0          # no averaging
1          # stresses are computed
1          # stresses are computed in integration points
0          # no averaging
1          # other values are computed
1          # other values are computed in integration points
0          # no averaging
1          # reactions are computed
0          # no adaptivity
0          # deterministic computation
0          # no homogenization
0          # no renumbering
1          # type of non-linear solver - ar-length
1          # type of the stiffness matrix - initial stiffness is used
4          # type of lambda determination - linearized method
50         # the number of increments
30         # the maximum number of iterations in one increment
1.0e-02    # required norm or the residual
3.5e-02    # the inital lengt of arc
3.5e-09    # the minimum length of arc
3.5e-01    # the maximum length of arc
0.0        # the psi parameter
1          # displacement control
0          # no backup
2          # the stiffness matrix is stored in skyline
2          # the system of linear algebraic equations are solved by LDL factorization
```

7.5 Outdriver section

The output from the MEFEL module is controled by the setup stored in the class outdriverm. There are three basic types of result output produced by outdriverm

- Plain text file with results at nodes, elements and user defined points.
- Result and mesh files in various format of graphical post-processors (GiD, FemCAD, VTK, Open DX). Should be noted that only GiD format is the most developed and it supports all features of result selection implemented in outdriverm.
- Plain text file with tabular output compatible with programs such as X-Grace, GNU-Plot, MS-Excel or similar. This output is used for ceration of diagrams capturing evolution of some quantity in dependence on the time or load steps and therefor the

table output may be specified for the nonlinear statics or time dependent problems only.

The plain text output is controlled by the attribute textout, graphical output is controlled by the attribute gf and number of files with tabular output is stored in the attribute ndiag.

The values of attribute textout are defined by enumeration flagsw (see galias.h) which is described in the following table.

attribute	enumerator	description
textout = 0	off	no text output will be performed
textout = 1	on	plain text output will be performed

The values of attribute gf are defined by enumeration graphfmt (see alias.h) which is described in the following table.

attribute	enumerator	description
gf = 0	grfmt_no	no text output will be performed
gf = 1	grfmt_open_dx	result/mesh files in the OpenDX format are created
gf = 2	grfmt_femcad	result/mesh files in the FemCAD format are created
gf = 3	grfmt_gid	one result file + mesh file in the GiD format are created
gf = 4	grfmt_gid_sep	several result files with separated selected quantities and mesh file in the GiD format are created
gf = 5	grfmt_vtk	result/mesh files in the VTK format are created

If the number of required diagram files ndiag is nonzero then the additional configurations have to be specified. These configurations are stored for each diagram file in the attribute odiag. The attribute odiag is array of of instances of class outdiagm where each array element stores configuration for one diagram file.

General scheme of the outdriverm input record is captured in the following table.

Attribute value	Additional configuration
textout = 0	–
textout > 0	see Section 7.5.1
gf = 0	–
gf > 0	see Section 7.5.2
ndiag = 0	–
ndiag > 0	see Section 7.5.5

7.5.1 Configuration of plain text output

After the value of the attribute textout=1, configuration of the output values for praticular qunatities follows. The output can be configured separately for quantities stored at nodes, integration points and user defined points. Configuration for nodal quantities is stored in the attribute no which is instance of the class nodeoutm. Configuration of output

for quantities stored on the integration points of elements is stored in the attribute eo which is instance of the class elemoutm. Finally, there is attribute po (instance of the class pointoutm) intended for storage of output configuration for user defined points (UDPs) on elements. Should be noted that the configuration can be specified but the implementation of quantity recalculation to the user defined point is not yet finished. Each of classes nodeoutm, elemoutm and pointoutm has attribute dstep type of sel which defines selection of time steps in which the output will be performed. If the dstep is set to the value sel_no then no selection of the quantities follows. Generally, the content of the section configuring the text output can be summarized in the following table

Attribute value	Description or additional configuration
`outfn`	Output file name (`%s`)
`no.dstep` $= 0$	–
`no.dstep` > 0	see Section 7.5.1.1
`eo.dstep` $= 0$	–
`eo.dstep` > 0	see Section 7.5.1.2
`po.dstep` $= 0$	–
`po.dstep` > 0	see Section 7.5.1.3

In the above table, the name of the plain text output file (attribute `outfn`) can be arbitrary file name which may involve path and suffix (usually, the `.out` is used). If the stochastic calculation is performed then the suffix is changed automatically so that it precedes the simulation number.

7.5.1.1 Configuration of plain text output of nodal values

Every configuration of nodal values output in the plain text format can be described by the following table.

Attribute	Attribute value	Selection of quantities	Used types of selection
`no.dstep =`	0	–	–
	1-6, 10, 11 (see Sect.6.1.2 and 6.1.3)	load case	see Sect.6.1.2
		displacements	conjugated selection of nodal ids and displacement component ids - see Sect.6.1.1,6.1.5 and 7.5.1.4
		strains	conjugated selection of nodal ids, strain component ids and strain transformation flag (see Sect.6.1.1, 6.1.5 and 7.5.1.5)
		stresses	conjugated selection of nodal ids, stress component ids and stress transfromation flag (see Sect.6.1.1, 6.1.5 and 7.5.1.6)
		eqother array	conjugated selection of nodal ids and eqother array component ids - see Sect.6.1.1, 6.1.5 and 7.5.1.7
		reactions	0 = no output of reactions 1 = print all reactions

7.5.1.2 Configuration output values for elements in plain text format

The output configuration of element integration point values in the plain text format can be described by the following table.

Attribute	Attribute value	Selection of quantities	Used types of selection
`eo.dstep =`	0	–	–
	1-6, 10, 11 (see Sect.6.1.2 and 6.1.3)	load case	see Sect.6.1.2
		strains	conjugated selection of element ids, strain component ids and strain transformation flag (see Sect.6.1.1, 6.1.5 and 7.5.1.8))
		stresses	conjugated selection of element ids, stress component ids and stress transfromation flag (see Sect.6.1.1, 6.1.5 and 7.5.1.9)
		eqother array	conjugated selection of nodal ids and eqother array component ids - see Sect.6.1.1, 6.1.5 and 7.5.1.10

7.5.1.3 Configuration output values for UDPs in plain text format

Configuration of UDP output in the plain text format can be described by the following table.

Attribute	Attribute value	Selection of quantities	Used types of selection
`po.dstep =`	0	–	–
	1-6, 10, 11 (see Sect.6.1.2 and 6.1.3)	number of UDPs npnt	%ld
		natural coordinates ξ, η and ζ of UDPs	(%le %le %le)×npnt
		elements	conjugated selection of element ids and UDP ids - see Sect.6.1.1, 6.1.5 and 6.1.6
		strains, strain transformation, stresses, stress transformation, eqother array	(selection of strain component ids - Sect.6.1.2, strain transfromation flag - {0—-1}, selection of stress component ids - Sect.6.1.2, stress transfromation flag - {0—-1}, selection of eqother array component ids - Sect.6.1.2)×npnt

7.5.1.4 Example of conjugated selection for displacement components at nodes

In this example, the output of all displacement components will be specified for all nodes.

Example without keywords

```
   # SELECTION OF REQUIRED NODES
1  # type of selection = all nodes

   # SELECTION OF DISPLACEMENT COMPONENTS
1  # type of conjugated selection for all nodes =
   # = all displacement components selected
```

Example with keywords

```
displ_nodes      # SELECTION OF REQUIRED NODES
sel_all          # type of selection = all nodes

noddispl_comp    # SELECTION OF DISPLACEMENT COMPONENTS
sel_all          # type of conjugated selection for all nodes =
                 # = all displacement components selected
```

7.5.1.5 Example of conjugated selection for strains at nodes

In this example, the output of all strain components will be specified for nodes 8 and 11. No output of principal strains will be required.

Example without keywords

```
     # SELECTION OF REQUIRED NODES
3    # type of selection = integer list
2    # two items of list will be specified
8    # node 8 = item 1.
11   # node 11 = item 2.

     # SELECTION OF REQUIRED STRAIN COMPONENTS
1    # type of conjugated selection for item 1. =
     # = all components selected for node 8

1    # type of conjugated selection for item 2. =
     # = all components selected for node 11

     # FLAGS FOR PRINCIPAL STRESSES
0    # item 1. = node 8 -¿ no principal strain
0    # item 2. = node 11 -¿ no principal strain
```

Example with keywords

```
strain_nodes      # SELECTION OF REQUIRED NODES
sel_list          # type of selection = integer list
numlist_items 2   # two items of list will be specified
8                 # node 8 = item 1.
11                # node 11 = item 2.

nodstrain_comp    # SELECTION OF REQUIRED STRAIN COMPONENTS
sel_all           # type of conjugated selection for item 1. =
                  # = all components selected for node 8

sel_all           # type of conjugated selection for item 2. =
                  # = all components selected for node 11

nodstre_transfid  # FLAGS FOR PRINCIPAL STRESSES
0                 # 1.item = node 8 -¿ no principal strain
0                 # 2.item = node 11 -¿ no principal strain
```

7.5.1.6 Example of conjugated selection for stresses at nodes

In this example, the output of stress components σ_x and σ_z will be specified for nodes 8 and 11. Output of principal stresses will be required at node 11.

Example without keywords

```
      # SELECTION OF REQUIRED NODES
3     # type of selection = integer list
2     # two items of list will be specified
8     # node 8 = item 1.
11    # node 11 = item 2.

      # SELECTION OF REQUIRED STRESS COMPONENTS
3     # type of conjugated selection for item 1. = integer list
2     # number of selected stress components
1 3   # indeces of stress vector components

3     # type of conjugated selection for item 2. = integer list
2     # number of selected stress components
1 3   # indeces of stress vector components

      # FLAGS FOR PRINCIPAL STRESSES
0     # item 1. = node 8 -¿ no principal stresses
-1    # item 2. = node 11 -¿ print principal stresses
```

Example with keywords

```
stress_nodes        # SELECTION OF REQUIRED NODES
sel_list            # type of selection = integer list
numlist_items 2     # two items of list will be specified
8                   # node 8 = 1. item
11                  # node 11 = 2. item

nodstress_comp      # SELECTION OF REQUIRED STRESS COMPONENTS
sel_list            # type of conjugated selection for item 1.
numlist_items 2     # number of selected stress components
1 3                 # ids of stress vector components

sel_list            # type of conjugated selection for item 2.
numlist_items 2     # number of selected stress components
1 3                 # ids of stress vector components

nodstre_transfid    # FLAGS FOR PRINCIPAL STRESSES
0                   # 1.item = node 8 -¿ no principal stresses
-1                  # 2.item = node 11 -¿ print principal stresses
```

7.5.1.7 Example of conjugated selection for plastic strains at nodes

In this example, the output of plastic strain components ε_x^p, ε_y^p and ε_{xy}^p will be specified for all nodes of the domain calculated.

Example without keywords

```
        # SELECTION OF REQUIRED NODES
1       # type of selection = sel_all
        # all nodes will be specified

        # SELECTION OF PLASTIC STRAIN COMPONENTS
3       # type of conjugated selection for all nodes =
        # = integer list
3       # number of selected plastic strain components
1 2 3   # indeces of eqother array corresponding to
        # required pl. strain components epsˆp_x and epsˆp_y
```

Example with keywords

```
other_nodes       # SELECTION OF REQUIRED NODES
sel_all           # type of selection = sel_all
                  # all nodes will be specified

nodother_comp     # SELECTION OF PLASTIC STRAIN COMPONENTS
sel_list          # type of conjugated selection for all nodes =
                  # = integer list
numlist_items 3   # number of selected plastic strain components
1 2 3             # indeces of eqother array corresponding to
                  # required pl. strain components epsˆp_x and epsˆp_y
```

7.5.1.8 Example of conjugated selection for strains on elements

In this example, the output of all strain components will be specified for integration points of elements 1 and 40-60. Output of principal strains will be required for element 1.

Example without keywords

```
     # SELECTION OF REQUIRED ELEMENTS
2    # type of selection = integer range
2    # two ranges will be specified
     # first range <1, 1>
1    # initial id - range 1.
1    # number of selected ids - range 1.
     # second range <40, 60>
40   # initial id - range 2.
20   # number of selected ids - range 2.

     # SELECTION OF REQUIRED STRAIN COMPONENTS
1    # type of conjugated selection for range 1. =
     # = all strain components

1    # type of conjugated selection for range 2. =
     # = all strain components

     # FLAGS FOR PRINCIPAL STRAINS
-1   # range 1. -¿ print principal strains
0    # range 2. -¿ no principal strains
```

Example with keywords

```
strain_elems        # SELECTION OF REQUIRED ELEMENTS
sel_range           # type of selection = integer range
num_ranges 2        # two ranges will be specified
                    # first range <1, 1>
1                   # initial id - range 1.
1                   # number of selected ids - range 1.
                    # second range <40, 60>
40                  # initial id - range 2.
20                  # number of selected ids - range 2.

elemstrain_comp     # SELECTION OF REQUIRED STRAIN COMPONENTS
sel_all             # type of conjugated selection for range 1. =
                    # = all strain components

sel_all             # type of conjugated selection for range 2. =
                    # = all strain components

elemstra_transfid   # FLAGS FOR PRINCIPAL STRAINS
-1                  # range 1. -¿ print principal strains
0                   # range 2. -¿ no principal strains
```

7.5.1.9 Example of conjugated selection for stresses on elements

In this example, the output of all stress components will be specified for integration points of all elements. Output of principal stresses will be required for all elements.

Example without keywords

```
     # SELECTION OF REQUIRED ELEMENTS
1    # type of selection = all ids

     # SELECTION OF REQUIRED STRESS COMPONENTS
1    # type of conjugated selection for all elements =
     # = all stress components

     # FLAGS FOR PRINCIPAL STRAINS
-1   # print principal stresses for all elements
```

Example with keywords

```
stress_elems        # SELECTION OF REQUIRED ELEMENTS
sel_all             # type of selection = all ids

elemstress_comp     # SELECTION OF REQUIRED STRESS COMPONENTS
sel_all             # type of conjugated selection for all elements =
                    # = all stress components

                    # FLAGS FOR PRINCIPAL STRAINS
-1                  # print principal stresses for all elements
```

7.5.1.10 Example of conjugated selection for plastic strains on elements

In this example, the output of plastic strain components ε_x^p and ε_y^p will be specified for integration points of elements 1-25 and 36-40 .

Example without keywords

```
      # SELECTION OF REQUIRED ELEMENTS
2     # type of selection = integer ranges
2     # two ranges will be specified
      # first range <1, 25>
1     # initial id - range 1.
25    # number of selected ids - range 1.
      # second range <36, 40>
36    # initial id - range 2.
5     # number of selected ids - range 2.

      # SELECTION OF PLASTIC STRAIN COMPONENTS
3     # type of conjugated selection for range 1.
2     # number of selected pl. strain components
1 2   # indeces of eqother array corresponding to
      # required pl. strain components epsˆp_x and epsˆp_y

3     # type of conjugated selection for range 2.
2     # number of selected pl. strain components
1 2   # indeces of eqother array corresponding to
      # required pl. strain components epsˆp_x and epsˆp_y
```

Example with keywords

```
other_elems       # SELECTION OF REQUIRED ELEMENTS
sel_range         # type of selection = integer ranges
num_ranges 2      # two ranges will be specified
                  # first range <1, 25>
1                 # initial id - range 1.
25                # number of selected ids - range 1.
                  # second range <36, 40>
36                # initial id - range 2.
5                 # number of selected ids - range 2.

elemother_comp    # SELECTION OF PLASTIC STRAIN COMPONENTS
sel_list          # type of conjugated selection for range 1.
numlist_items 2   # number of selected pl. strain components
1 2               # indeces of eqother array corresponding to
                  # required pl. strain components epsp̂_x and epsp̂_y

sel_list          # type of conjugated selection for range 2.
numlist_items 2   # number of selected pl. strain components
1 2               # indeces of eqother array corresponding to
                  # required pl. strain components epsp̂_x and epsp̂_y
```

7.5.2 Configuration of graphical output

After the value of the attribute gf={1,2,3,4} the configuration of the output values for praticular qunatities follows. The graphical output can be configured separately for quantities stored at nodes and integration points on elements. Configuration for nodal quantities is stored in the attribute nog which is instance of the class nodeoutgm. Configuration of output for quantities connected with the integration points on elements is stored in the attribute eog which is instance of the class elemoutgm. Both classes nodeoutgm and elemoutm have attribute dstep type of sel which defines selection of time steps in which the output will be performed. If the dstep is set to the value sel_no then no selection of the quantities follows. Generally, the content of the section configuring the graphical output can be summarized in the following table

Attribute value	Description or additional configuration
`outgrfn`	Output file name (`%s`)
`nog.dstep` $= 0$	–
`nog.dstep` > 0	see Section 7.5.2.1
`eog.dstep` $= 0$	–
`eog.dstep` > 0	see Section 7.5.2.2

In the above table, the name of the graphical output file (attribute `outgrfn`) can be arbitrary file name which may involve path. The suffix should be chosen with respect to graphical format given by the outdriverm attribute `gf`. If the `gf` $= 3 =$ grfmt_gid then the default suffices `.res` and `.msh` are appended to the file name specified.

If the `gf` $= 4 =$ grfmt_gid_sep then the for each quantity is generated separate file name which starts with the given file name (`outgrfn`) followed by the quantity specifier Additionally, the default suffix `.res` is appended to the generated file names. The mesh file name is generated in the same way as for the single file format. The following table describes file name generation for the nodal values in the GiD separated file format.

If the stochastic calculation is performed then the generated suffix precedes the simulation number.

Quantitity	Quantity specifier and suffix appended to the graphical output file name
nodal displacement	.displ.res
nodal strains (selected by components)	.nodal_eps%ld.res %ld = strain component id
nodal principal strains (selected by components)	.nodal_peps%ld.res %ld = principal strain component id
nodal stress (selected by components)	.nodal_sig%ld.res %ld = stress component id
nodal principal stesses (selected by components)	.nodal_psig%ld.res %ld = principal stress component id
nodal other values (selected by components)	.nodal_other%ld.res %ld = eqother array component id
nodal strains (selected as vector)	.nodal_eps_v%ld-%ld_s%ld.res _v%ld = initial strain component id -%ld = number of vector components _s%ld = strain selection id
nodal stress (selected as vector)	.nodal_sig_v%ld-%ld_s%ld.res _v%ld = initial stress component id -%ld = number of vector components _s%ld = stress selection id
nodal other values (selected as vector)	.nodal_other_v%ld-%ld_s%ld.res _v%ld = initial eqother component component id -%ld = number of vector components _s%ld = other value selection id
nodal strains (selected as tensor)	.nodal_eps_m_s%ld.res _s%ld = strain selection id
nodal stress (selected as tensor)	.nodal_sig_m_s%ld.res _s%ld = stress selection id
nodal other values (selected as tensor)	.nodal_other_m%ld-%ld_s%ld.res _m%ld = initial eqother component component id -%ld = number of tensor components _s%ld = other value selection id
nodal forces	.force.res

In the above table, the strain/stress/other selection id represents the order of the conjugated selection of strain/stress/other components. For example, if the nodal stress output configuration described in Section 7.5.2.4 was used for GiD separated format, then the name of the output file for the node 8 would have the suffix .nodal_eps_m_s1.res and for the node 11, the suffix would be .nodal_eps_m_s2.res.

The following table describes file name generation for the values on integration point of elements in the GiD separated file format.

Quantitity	Quantity specifier and suffix appended to the graphical output file name
element strains (selected by components)	`.elem_eps%ld.res` `%ld` = strain component id
element stresses (selected by components)	`.elem_sig%ld.res` `%ld` = stress component id
element other values (selected by components)	`.elem_other%ld.res` `%ld` = eqother array component id
element strains (selected as vector)	`.elem_eps_v%ld-%ld_s%ld.res` `_v%ld` = initial strain component id `-%ld` = number of vector components `_s%ld` = strain selection id
element stresses (selected as vector)	`.elem_sig_v%ld-%ld_s%ld.res` `_v%ld` = initial stress component id `-%ld` = number of vector components `_s%ld` = stress selection id
element other values (selected as vector)	`.elem_other_v%ld-%ld_s%ld.res` `_v%ld` = initial eqother component component id `-%ld` = number of vector components `_s%ld` = other value selection id
element strains (selected as tensor)	`.elem_eps_m_s%ld.res` `_s%ld` = strain selection id
element stresses (selected as tensor)	`.elem_sig_m_s%ld.res` `_s%ld` = stress selection id
element other values (selected as tensor)	`.elem_other_m%ld-%ld_s%ld.res` `_m%ld` = initial eqother component component id `-%ld` = number of vector components `_s%ld` = other value selection id

In the above table, the strain/stress/other selection id represents the order of the conjugated selection of strain/stress/other components. For example, if the output configuration of element plastic strain described in Section 7.5.2.9 was used for GiD separated format, then the name of the output file for the first range of elements 1-25 would have the suffix .elem_other_v1-3_s1.res and for the second range of elements 36-40, the suffix would be .elem_other_v1-3_s2.res.

7.5.2.1 Configuration of nodal graphical output

Every configuration of nodal values output in the graphical format can be described by the following table.

Attribute	Attribute value	Selection of quantities	Used types of selection
`nog.dstep =`	0	–	–
	1-6, 10, 11 (see Sect.6.1.2 and 6.1.3)	load case	see Sect.6.1.2
		displacements	conjugated selection of nodal ids and displacement component ids - see Sect.6.1.1,6.1.5 and 7.5.1.4
		strains	conjugated selection of nodal ids, strain component ids and strain transformation flag (see Sect.6.1.1, 6.1.5, 7.5.1.5, 7.5.2.4)
		stresses	conjugated selection of nodal ids, stress component ids and stress transfromation flag (see Sect.6.1.1, 6.1.5, 7.5.1.6 and 7.5.2.5)
		eqother array	conjugated selection of nodal ids and eqother array component ids - see Sect.6.1.1, 6.1.5 and 7.5.1.7 or 7.5.2.6
		nodal forces	conjugated selection of nodal ids and nodal force component ids - see Sect.6.1.1,6.1.5 and 7.5.2.3

7.5.2.2 Configuration of graphical output for elements

The output configuration of element integration point values in the graphical format can be described by the following table.

Attribute	Attribute value	Selection of quantities	Used types of selection
`eog.dstep =`	0	–	–
	1-6, 10, 11 (see Sect.6.1.2 and 6.1.3)	load case	see Sect.6.1.2
		strains	conjugated selection of element ids, strain component ids and strain transformation flag (see Sect.6.1.1, 6.1.5, 7.5.1.8) and 7.5.2.7)
		stresses	conjugated selection of element ids, stress component ids and stress transfromation flag (see Sect.6.1.1, 6.1.5, 7.5.1.9 and 7.5.2.8)
		eqother array	conjugated selection of nodal ids and eqother array component ids - see Sect.6.1.1, 6.1.5, 7.5.1.10 and 7.5.2.9

Should be noted that the output of principal strains and stresses on elements has not been implemented yet and the transformation flags are ignored in this case.

7.5.2.3 Example of conjugated selection for nodal force components at nodes

In this example, the output of all nodal force components will be specified for all nodes.

Example without keywords

```
    # SELECTION OF REQUIRED NODES
1   # type of selection = all nodes

    # SELECTION OF NODAL FORCE COMPONENTS
1   # type of conjugated selection for all nodes =
    # = all nodal force components selected
```

Example with keywords

```
force_nodes   # SELECTION OF REQUIRED NODES
sel_all       # type of selection = all nodes

force_comp    # SELECTION OF NODAL FORCE COMPONENTS
sel_all       # type of conjugated selection for all nodes =
              # = all nodal force components selected
```

7.5.2.4 Example of conjugated selection for strain tensor at nodes

In this example, the output of all strain components to GiD in tensorial format will be specified for nodes 8 and 11. No output of principal strains will be required.

Example without keywords

```
    # SELECTION OF REQUIRED NODES
3   # type of selection = integer list
2   # two items of list will be specified
8   # node 8 = item 1.
11  # node 11 = item 2.

    # SELECTION OF REQUIRED STRAIN COMPONENTS
7   # type of conjugated selection for item 1. =
    # = all components in tensorial format for node 8

7   # type of conjugated selection for item 2. =
    # = all components in tensorial format for node 11

    # FLAGS FOR PRINCIPAL STRESSES
0   # item 1. = node 8 -¿ no principal strain
0   # item 2. = node 11 -¿ no principal strain
```

Example with keywords

```
strain_nodes        # SELECTION OF REQUIRED NODES
sel_list            # type of selection = integer list
numlist_items 2     # two items of list will be specified
8                   # node 8 = item 1.
11                  # node 11 = item 2.

nodstrain_comp      # SELECTION OF REQUIRED STRAIN COMPONENTS
sel_mtx             # type of conjugated selection for item 1. =
                    # = all components in tensorial format for node 8

sel_mtx             # type of conjugated selection for item 2. =
                    # = all components in tensorial format for node 11

nodstre_transfid    # FLAGS FOR PRINCIPAL STRESSES
0                   # 1.item = node 8 -¿ no principal strain
0                   # 2.item = node 11 -¿ no principal strain
```

7.5.2.5 Example of conjugated selection for stress tensor at nodes

In this example, the output of all stress components in GiD tensorial format will be specified for all nodes. Output of principal stresses will not be required.

Example without keywords

```
    # SELECTION OF REQUIRED NODES
1   # type of selection = all nodes

    # SELECTION OF REQUIRED STRESS COMPONENTS
7   # type of conjugated selection for all nodes =
    # = all components in GiD tensorial format

    # FLAGS FOR PRINCIPAL STRESSES
-1  # for all nodes -¿ print principal stresses
```

Example with keywords

```
stress_nodes        # SELECTION OF REQUIRED NODES
sel_all             # type of selection = all nodes

nodstress_comp      # SELECTION OF REQUIRED STRESS COMPONENTS
sel_mtx             # type of conjugated selection for all nodes =
                    # = all components in GiD tensorial format

nodstre_transfid    # FLAGS FOR PRINCIPAL STRESSES
-1                  # for all nodes -¿ print principal stresses
```

7.5.2.6 Example of conjugated selection for plastic strain tensor at nodes

In this example, the output of plastic strain components ε_x^p, ε_y^p, ε_{xy}^p and ε_z^p in GiD tensorial format will be specified for all nodes. It is assumed the plain-stress state and therefor only four nonzero components are store in the eqother array.

Example without keywords

```
   # SELECTION OF REQUIRED NODES
1  # type of selection = all nodes
   # all nodes will be specified

   # SELECTION OF PLASTIC STRAIN COMPONENTS
8  # type of conjugated selection for all nodes =
   # = tensorial components selected from large array
1  # initial id in eqother array
4  # number of indeces in eqother array corresponding
   # to the number of plastic strain components for
   # the plane-stress state
```

Example with keywords

```
other_nodes      # SELECTION OF REQUIRED NODES
sel_all          # type of selection = all nodes
                 # all nodes will be specified

nodother_comp    # SELECTION OF PLASTIC STRAIN COMPONENTS
sel_range_mtx    # type of conjugated selection for all nodes =
                 # = tensorial components selected from large array
1                # initial id in eqother array
4                # number of indeces in eqother array corresponding
                 # to the number of plastic strain components for
                 # the plane-stress state
```

7.5.2.7 Example of conjugated selection for strain tensor on elements

In this example, the output of all strain components in GiD tensorial format will be specified for integration points of elements 40-60 and ε_x component will be specified for integration point of elements 1-39. Output of principal strains will not be.

Example without keywords

```
     # SELECTION OF REQUIRED ELEMENTS
2    # type of selection = integer range
2    # two ranges will be specified
     # first range <1, 39>
1    # initial id - range 1.
39   # number of selected ids - range 1.
     # second range <40, 60>
40   # initial id - range 2.
20   # number of selected ids - range 2.

     # SELECTION OF REQUIRED STRAIN COMPONENTS
3    # type of conjugated selection for range 1. =
     # = integer list
1    # number of list items
1    # first component eps_x is selected

7    # type of conjugated selection for range 2. =
     # = all strain components in GiD tensorial format

     # FLAGS FOR PRINCIPAL STRAINS
-1   # range 1. -¿ print principal strains
0    # range 2. -¿ no principal strains
```

Example with keywords

```
strain_elems        # SELECTION OF REQUIRED ELEMENTS
sel_range           # type of selection = integer range
num_ranges 2        # two ranges will be specified
                    # first range <1, 39>
1                   # initial id - range 1.
39                  # number of selected ids - range 1.
                    # second range <40, 60>
40                  # initial id - range 2.
20                  # number of selected ids - range 2.

elemstrain_comp     # SELECTION OF REQUIRED STRAIN COMPONENTS
sel_list            # type of conjugated selection for range 1. =
                    # = integer list
numlist_items 1     # number of selected items
1                   # the first strain component selected for range 1.

sel_mtx             # type of conjugated selection for range 2. =
                    # = all strain components in GiD tensorial format

elemstra_transfid   # FLAGS FOR PRINCIPAL STRAINS
0                   # range 1. -¿ no principal strains
0                   # range 2. -¿ no principal strains
```

7.5.2.8 Example of conjugated selection for stress tensor on elements

In this example, the output of all stress components will be specified in GiD tensorial format for integration points of all elements. Output of principal stresses will not be required for all elements.

Example without keywords

```
    # SELECTION OF REQUIRED ELEMENTS
1   # type of selection = all ids

    # SELECTION OF REQUIRED STRESS COMPONENTS
7   # type of conjugated selection for all elements =
    # = all stress components in GiD tensorial format

    # FLAGS FOR PRINCIPAL STRAINS
0   # do not print principal stresses for all elements
```

Example with keywords

```
stress_elems        # SELECTION OF REQUIRED ELEMENTS
sel_all             # type of selection = all ids

elemstress_comp     # SELECTION OF REQUIRED STRESS COMPONENTS
sel_mtx             # type of conjugated selection for all elements =
                    # = all stress components in GiD tensorial format

                    # FLAGS FOR PRINCIPAL STRAINS
0                   # do not print principal stresses for all elements
```

7.5.2.9 Example of conjugated selection for plastic strain vector on elements

In this example, the output of plastic strain components ε_x^p, ε_y^p and ε_z^p will be specified in GiD vector format for integration points of elements 1-25 and 36-40. The space stress state is assumed in the following examples.

Example without keywords

```
    # SELECTION OF REQUIRED ELEMENTS
2   # type of selection = integer ranges
2   # two ranges will be specified
    # first range <1, 25>
1   # initial id - range 1.
25  # number of selected ids - range 1.
    # second range <36, 40>
36  # initial id - range 2.
5   # number of selected ids - range 2.

    # SELECTION OF PLASTIC STRAIN COMPONENTS
9   # type of conjugated selection for range 1.
1   # initial id of of epsˆp_x in eqother array
3   # number of vector components

9   # type of conjugated selection for range 2.
1   # initial id of of epsˆp_x in eqother array
3   # number of vector components
```

Example with keywords

```
other_elems       # SELECTION OF REQUIRED ELEMENTS
sel_range         # type of selection = integer ranges
num_ranges 2      # two ranges will be specified
                  # first range <1, 25>
1                 # initial id - range 1.
25                # number of selected ids - range 1.
                  # second range <36, 40>
36                # initial id - range 2.
5                 # number of selected ids - range 2.

elemother_comp    # SELECTION OF PLASTIC STRAIN COMPONENTS
sel_range_vec     # type of conjugated selection for range 1.
1                 # initial id of of epsˆp_x in eqother array
3                 # number of vector components

sel_range_vec     # type of conjugated selection for range 2.
1                 # initial id of of epsˆp_x in eqother array
3                 # number of vector components
```

7.5.3 Configuration of tabular output

The configuration of the tabular output is given by the file name and `ndiag` times repeated configuration of the particular diagram files.

The file name may be arbitrary including path and suffix. If the number of diagram files is greater than one then the user defined suffix precedes the diagram file number generated automatically. If the stochastic calculation is performed then the user defined suffix including eventual generated diagram file number precedes the simulation number separated by a dot.

Generally, the configuration can be described by the following table.

Attribute	Description or additional configuration
`outdiagfn`	Output file name (`%s`)
`odiag`×`ndiag`	See Table 7.9

The attribute odiag is type of class outdiagm which stores the configuration of the diagram file. It contains attribute npun which represents the number of printed unknowns, attribute nif which is array of enumeration nodip (see galias.h) and attribute pu which is array of enumeration prunk (see alias.h). Elements of nif array represents type of points (node/integration point) in which the required unknown will be printed out. Type of points involved in the enumeration nodip are summarized in Table 7.7.

Elements of array pu represents types of printed unknown. Type of printed unknowns involved in the enumeration prunk are described in Table 7.8.

attribute	enumerator	description
nif[i] = 0	no_point	no point selected
nif[i] = 1	atnode	point is given by node id
nif[i] = 2	atip	point is given by integration point on element
nif[i] = 3	atxyz	point is given by coordinates, the nearest node is selected

Table 7.7: nodip enumeration type

attribute	enumerator	description
pu[i] = 1	pr_displ	print displacement component
pu[i] = 2	pr_strains	print strain component
pu[i] = 3	pr_stresses	print stress component
pu[i] = 4	pr_forces	print nodal force vector component
pu[i] = 5	pr_react	print reaction
pu[i] = 6	pr_stepid	print integer step id
pu[i] = 7	pr_appload	print load coefficient/time of the actual step
pu[i] = 8	pr_other	print eqother array component

Table 7.8: prunk enumeration type

Attribute value	Description or additional configuration
`odiag.npun`	number of printed unknowns (`%ld`)
`odiag.dstep` $= 0$	–
`odiag.dstep` > 0	`npun` $\times$ (Table 7.10)

Table 7.9: General outdiagm input record

The record for one odiag instance is summarized in Table 7.9.

If the attribute dstep of outdiagm class is set to sel_no option then no additional configuration is necessary otherwise the input record for one required unknown is repeated npun times. Description of the input record for one unknown is captured in Table 7.10 and it depeneds on the point type specified. Depending on the point type, the different types of unknowns can be specified - see Table 7.11.

Attribute	Attribute value (see Table 7.7)	Selected point record	Selection of unknown
`odiag.nif[i] =`	0	–	–
`odiag.nif[i] =`	1	node id (`%ld`)	See Table 7.11, options 1-8
`odiag.nif[i] =`	2	element id (`%ld`) local int. point id (`%ld`)	See Table 7.11, options 2,3,6-8
`odiag.nif[i] =`	3	x coordinate (`%le`) y coordinate (`%le`) z coordinate (`%le`)	See Table 7.11, options 1-8

Table 7.10: outdiagm input record for praticular types of point

Attribute	Attribute value (see Table 7.8)	Selected unknown component id
`odiag.pu[i] =`	1	displacement component id (`%ld`)
`odiag.pu[i] =`	2	strain component id (`%ld`)
`odiag.pu[i] =`	3	stress component id (`%ld`)
`odiag.pu[i] =`	4	nodal force component id (`%ld`)
`odiag.pu[i] =`	5	reaction component id (`%ld`)
`odiag.pu[i] =`	6	–
`odiag.pu[i] =`	7	–
`odiag.pu[i] =`	8	eqother array component id (`%ld`)

Table 7.11: outdiagm input record for praticular type of uknowns

7.5.3.1 Example of configuration for tabular output

In this example, the J2 flow plasticity material will be assumed. Two table output files will be configured. The first file j2beam.1.dat will contain five columns with step id, horizontal displacement, strain component ε_y, stress component σ_x and reaction in vertical direction. The second file j2beam.2.dat will contain two columns with the load coefficient and consistency parameter γ. Each row of the table will contain the value of the given unknown in dependence on all performed time steps either for node 8 or the second integration point of element 12 or the nearest node to point with coordinates [2.3, -5.1, 8.5].

Example without keywords

```
2              # number of generated table output files
j2beam.dat     # basic name of generated the files
               # the file number will be added automatically
               #
               # CONFIGURATION OF THE FIRST FILE
5              # number of printed unknowns
1              # type of time step selection = all time steps
               # 1. column
1              # point type = node
8              # point id = 8. node
6              # unknown type = step id
               # 2. column
3              # point type = point with coordinates
2.3 -5.1 8.5   # x, y, z coordinates of point,
               # the nearset node will be selecetd
1              # unknown type = displacement
1              # component id 1 = horizontal displacement
               # 3. column
2              # point type = integration point
12 2           # point id = 12. element, 2. int. point
2              # unknown type = strain
2              # the second strain component = eps_y
               # 4. column
2              # point type = integration point
12 2           # point id = 12. element, 2. int. point
3              # unknown type = stress
1              # the first stress component = sig_x
               # 5. column
1              # point type = node
8              # point id = 8. node
5              # uknown type = reaction
2              # the second component = vertical reaction
               #
               # CONFIGURATION OF THE SECOND FILE
2              # number of printed unknowns
1              # type of time step selection = all time steps
               # 1. column
2              # point type = integration point
12 2           # point id = 12. element, 2. int. point
7              # unknown type = load coefficient
               # 2. column
2              # point type = integration point
12 2           # point id = 12. element, 2. int. point
8              # unknown type = eqother array value
5              # component id 5 = consistency parameter
```

Example with keywords

```
numdiag 2                  # number of generated table output files
j2beam.dat                 # basic name of generated the files
                           # the file number will be added automatically
                           #
                           # CONFIGURATION OF THE FIRST FILE
numunknowns 5              # number of printed unknowns
sel_all                    # type of time step selection = all time steps
                           # 1. column
point atnode               # point type = node
node 8                     # point id = 8. node
quant_type step_id         # unknown type = step id
                           # 2. column
point atxyz                # point type = point with coordinates
x 2.3 y -5.1 z 8.5         # x, y, z coordinates of point,
                           # the nearset node will be selecetd
quant_type pr_displ        # unknown type = displacement
compid 1                   # component id 1 = horizontal displacement
                           # 3. column
point atip                 # point type = integration point
elem 12 ip 2               # point id = 12. element, 2. int. point
quant_type pr_strain       # unknown type = strain
compid 2                   # the second strain component = eps_y
                           # 4. column
point atip                 # point type = integration point
elem 12 ip 2               # point id = 12. element, 2. int. point
quant_type pr_stress       # unknown type = stress
compid 1                   # the first stress component = sig_x
                           # 5. column
point atnode 1             # point type = node
node 8                     # point id = 8. node
quant_type pr_react        # uknown type = reaction
compid 2                   # the second component = vertical reaction
                           # CONFIGURATION OF THE SECOND FILE
numunknowns 2              # number of printed unknowns
sel_all                    # type of time step selection = all time steps
                           # 1. column
point atip                 # point type = integration point
elem 12 ip 2               # point id = 12. element, 2. int. point
quant_type pr_appload      # unknown type = load coefficient
                           # 2. column
point atip                 # point type = integration point
elem 12 ip 2               # point id = 12. element, 2. int. point
quant_type pr_other        # unknown type = eqother array value
compid 5                   # component id 5 = consistency parameter
```

7.5.4 Examples of outdriverm input section

In the following subsections, various types of outdriverm configurations are presented. Their parts can be swapped mutually but the user should be carefull becuase of used material modells and the problem solved. For example in the linear statics problem, the outdiag can be specified but the diagram files are not reasonable in this case because there is no dependence of unknowns on time or load coefficient. Also the output of internal variables stored in the eqother array is not allowed because the linear elastic materials have no internal variables. In such cases, the user should select no elements or nodes for eqother output and zero number of diagram files.

If the output of eqother values such as plastic strains, damage parameters or creep strains is required then the index of variable has to be specified. The order of the internal variables stored in the eqother depeneds on the material model used and it can be found and checked in the source files describing the given model. Usually, the header file should contain description of the appropriate class for material model and the order of the internal varibles should be involved. Definitely, the user can find the order of the internal variables in the member function nlstresses of the given material model.

If the user decides for using of keywords in the outdriver section of the input file for MEFEL then it is necessary to use switch -kwd=2 in the case of no keywords in probdesc section or -kwd=3 in the case of keywords both in probdesc and outdriverm sections.

7.5.4.1 Example of linear statics problem

In this example, the output of all displacements, nodal strains, nodal stresses and reactions will be set to the plain text file and all strains and stresses on elements in tensorial form to the GiD result file. Additionally, nodal displacement will be printed to the GiD result file.

Example without keywords

```
                # PLAIN TEXT OUTPUT
1               # plain text output is produced
linstat.out     # file name for the plain text output
                # Output configuration of nodal values
1               # nodal values in all time steps are printed
1               # nodal values for all load cases are printed
1               # displacements are printed at all nodes
1               # all displacement components are printed
1               # strains are printed at all nodes
1               # all strain components are printed
0               # no nodal strain transformation is performed
1               # stresses are printed at all nodes
1               # all stress components are printed
0               # no nodal stress transformation is performed
0               # no nodes selected =¿ no nodal other value output
1               # all reactions are printed
                # Output configuration for elements
0               # no time step for elements is selected =¿
                # no output on elements
                # OUTPUT IN GRAPHICAL FORMATS
3               # single GiD file with results is produced
linstat         # file name for GiD output (without suffix)
                # Output configuration of nodal values
1               # nodal values in all time steps are printed
1               # nodal values for all load cases are printed
1               # displacements are printed at all nodes
1               # all displacement components are printed
0               # no node selected =¿ no nodal strain output
0               # no node selected =¿ no nodal stress output
0               # no node selected =¿ no nodal other values output
0               # no node selected =¿ no nodal forces output
                # Output configuration of element values
1               # element values in all time steps are printed
1               # element values for all load cases are printed
1               # strains for all elements are printed
7               # all strain components are printed as tensors
0               # no strain transformation is performed
1               # stresses for all elements are printed
7               # all stress components are printed as tensors
0               # no stress transformation is performed
0               # no elements selected =¿ no other values output
                # OUTPUT OF TABULAR FILE
0               # zero number of tabular files =¿ no tabular output
```

Example with keywords

```
                                # PLAIN TEXT OUTPUT
textout                 on      # plain text output is produced
linstat.out                     # file name for the plain text output
                                # Output configuration of nodal values
sel_nodstep             sel_all # nodal values in all time steps are printed
sel_nodlc               sel_all # nodal values for all load cases are printed
displ_nodes             sel_all # displacements are printed at all nodes
displ_comp              sel_all # all displacement components are printed
strain_nodes            sel_all # strains are printed at all nodes
nodstrain_comp          sel_all # all strain components are printed
nodstra_transfid        0       # no nodal strain transformation is performed
stress_nodes            sel_all # stresses are printed at all nodes
nodstress_comp          sel_all # all stress components are printed
nodstre_transfid        0       # no nodal stress transformation is performed
other_nodes             sel_no  # no nodes selected =¿ no other value output
reactions               1       # all reactions are printed
                                # Output configuration for elements
sel_elemstep            sel_no  # no time step for elements is selected =¿
                                # no output on elements
                                # OUTPUT IN GRAPHICAL FORMATS
outgr_format            grfmt_gid # single GiD file with results is produced
linstat                         # file name for GiD output (without suffix)
                                # Output configuration of nodal values
sel_nodstep             sel_all # nodal values in all time steps are printed
sel_nodlc               sel_all # nodal values for all load cases are printed
displ_nodes             sel_all # displacements are printed at all nodes
displ_comp              sel_all # all displacement components are printed
strain_nodes            sel_no  # no node selected =¿ no nodal strain output
stress_nodes            sel_no  # no node selected =¿ no nodal stress output
other_nodes             sel_no  # no node selected =¿ no other values output
force_nodes             sel_no  # no node selected =¿ no nodal forces output
                                # Output configuration of element values
sel_elemstep            sel_all # element values in all time steps are printed
sel_elemlc              sel_all # element values for all load cases are printed
strain_elems            sel_all # strains for all elements are printed
elemstrain_comp         sel_mtx # all strain components are printed as tensors
elemstra_transfid       0       # no strain transformation is performed
stress_elems            sel_all # stresses for all elements are printed
elemstress_comp         sel_mtx # all stress components are printed as tensors
elemstre_transfid       0       # no stress transformation is performed
other_elems             0       # no elements selected =¿
                                # no other values output
                                # OUTPUT OF TABULAR FILE
numdiag                 0       # zero number of tabular files =¿ no tabular output
```

7.5.4.2 Example of nonlinear statics problem

In this example, the output of all nodal displacements, element strains, element stresses and element other values will be printed to the plain text file and all strains and stresses at nodes in tensorial form to the GiD result file. Additionally, nodal displacement, damage parameter ω stored in the eqother array and all element stress components will be printed to the GiD result file. The tabular output file will contain required values from the node 9, i.e., horizontal component of displacement in the first column, load coefficent in the second column and the damage parameter ω in the third column.

Example without keywords

```
                # PLAIN TEXT OUTPUT
1               # plain text output is produced
scdam.out       # file name for the plain text output
                # Output configuration of nodal values
1               # nodal values in all time steps are printed
1               # nodal values for all load cases are printed
1               # displacements are printed at all nodes
1               # all displacement components are printed
0               # no node is selected =¿ no strain output
0               # no node is selected =¿ no stress output
0               # no node is selected =¿ no other values output
0               # no reactions are printed
                # Output configuration for elements
1               # element values in all time steps are printed
1               # element values for all load cases are printed
1               # strains are printed at all elements
1               # all strain components are printed
0               # no element strain transformation is performed
1               # stresses are printed at all elements
1               # all stress components are printed
0               # no element stress transformation is performed
1               # other values are printed at all elements
1               # all components of eqother array are printed
                # OUTPUT IN GRAPHICAL FORMATS
3               # single GiD file with results is produced
scdam           # file name for GiD output (without suffix)
                # Output configuration of nodal values
1               # nodal values in all time steps are printed
1               # nodal values for all load cases are printed
1               # displacements are printed at all nodes
1               # all displacement components are printed
0               # no nodes selected =¿ no nodal strain output
0               # no nodes selected =¿ no nodal stress output
1               # all nodes selected for other values output
3               # eqother components are selected by list
1               # one component is specified in the list
2               # damage parameter is the second in eqother array
0               # no node selected =¿ no nodal forces output
                # Output configuration of element values
1               # element values in all time steps are printed
1               # element values for all load cases are printed
0               # no elements selected =¿ no strain output
1               # stresses for all elements are printed
1               # all stress components are printed as scalars
0               # no stress transformation is performed
0               # no elements selected =¿ no other values output
                # OUTPUT OF TABULAR FILE
1               # one tabular file is created
scdam.dat       # file name for tabular output
3               # number of printed unknowns
```

Example with keywords

```
                                # PLAIN TEXT OUTPUT
textout             on          # plain text output is produced
scdam.out                       # file name for the plain text output
                                # Output configuration of nodal values
sel_nodstep         sel_all     # nodal values in all time steps are printed
sel_nodlc           sel_all     # nodal values for all load cases are printed
displ_nodes         sel_all     # displacements are printed at all nodes
displ_comp          sel_all     # all displacement components are printed
strain_nodes        sel_no      # no nodes selected =¿ no strain output
stress_nodes        sel_no      # no nodes selected =¿ no stress output
other_nodes         sel_no      # no nodes selected =¿ no other value output
reactions           0           # no reactions are printed
                                # Output configuration for elements
sel_elemstep        sel_all     # element values in all time steps are printed
sel_elemlc          sel_all     # element values for all load cases are printed
strain_elems        sel_all     # strains for all elements are printed
elemstrain_comp     sel_all     # all strain components are printed as tensors
elemstra_transfid   0           # no strain transformation is performed
stress_elems        sel_all     # stresses for all elements are printed
elemstress_comp     sel_all     # all stress components are printed
other_elems         sel_all     # no elements are selected =¿ no other values output
elemoth_comp        sel_all     # all eqother components are printed
                                # OUTPUT IN GRAPHICAL FORMATS
outgr_format        grfmt_gid   # single GiD file with results is produced
scdam                           # file name for GiD output (without suffix)
                                # Output configuration of nodal values
sel_nodstep         sel_all     # nodal values in all time steps are printed
sel_nodlc           sel_all     # nodal values for all load cases are printed
displ_nodes         sel_all     # displacements are printed at all nodes
displ_comp          sel_all     # all displacement components are printed
strain_nodes        sel_no      # no node selected =¿ no nodal strain output
stress_nodes        sel_no      # no node selected =¿ no nodal stress output
other_nodes         sel_no      # all nodes selected for other values output
nodoth_comp         sel_list    # eqother components are selected by list of ids
1                               # one component is specified in the list
2                               # damage parameter is the second in eqother array
force_nodes         sel_no      # no node selected =¿ no nodal forces output
                                # Output configuration of element values
sel_elemstep        sel_all     # element values in all time steps are printed
sel_elemlc          sel_all     # element values for all load cases are printed
strain_elems        sel_no      # no element selected =¿ no strain output
stress_elems        sel_all     # stresses for all elements are printed
elemstress_comp     sel_all     # all stress components are printed as scalars
elemstre_transfid   0           # no stress transformation is performed
other_elems         0           # no elements are selected =¿ no other values output
                                # OUTPUT OF TABULAR FILES
numdiag             1           # one tabular file is created
scdam.dat                       # file name for tabular output
numunknowns         3           # number of printed unknowns
                    1           # values will be printed in all time steps
```

7.5.5 Configuration of tabular output

Chapter 8

TRFEL Input Files

8.1 Types of Transport Analyses

Type of tansport analysis is stored in the attribute tprob of the class probdesct. The appropriate keyword is problemtype. Values of the attribute tprob are summarized in Table 8.1.

attribute	enumerator	description
tprob = 50	stationary_problem	linear stationary problem
tprob = 51	nonlinear_stationary_problem	non-linear stationary problem
tprob = 60	nonstationary_problem	non-stationary problem
tprob = 61	nonlinear_nonstationary_problem	non-linear non-stationary problem
tprob = 62	discont_nonstat_problem	discontinuous non-stationary problem
tprob = 63	discont_nonlin_nonstat_problem	discontinuous non-linear non-stationary problem
tprob = 70	growing_np_problem	non-stationary problem with changing number of nodes

Table 8.1: Attribute tprob

Array name contains name or description of problem solved. The name is defined by user.

The attribute Mesprt describes the detailness of the auxiliary prints on screen. The appropriate keyword is mesprt.

attribute	description
Mesprt = 0	no auxiliary print on screen
Mesprt = 1	auxiliary print on screen

Table 8.2: Attribute Mesprt

The attribute tmatt describes the type of transport. The keyword is transmatter. Values of the attribute tmatt are summarized in Table 8.3.

attribute	enumerator	description
tmatt = 0	nomedium	no transport
tmatt = 1	onemedium	transport of a single material/medium
tmatt = 10	twomediacoup	coupled transport of two media
tmatt = 30	threemediacoup	coupled transport of three media
tmatt = 40	fourmediacoup	coupled transport of four media

Table 8.3: Attribute tmatt

The attribute mednam describes the type of transport. The keyword is mednames. Values of the attribute mednam are summarized in Table 8.4.

attribute	enumerator	description
mednam = 1	heat	heat transport
mednam = 2	moisture	transport of moisture
mednam = 10	heat_moisture	coupled heat and moisture transport
mednam = 20	moisture_salt	coupled salt and moisture transport

Table 8.4: Attribute mednam

The attributes scale1, scale2, scale3 and scale4 with the keywords scale1, scale2, scale3 and scale4 are used for scaling of all quantities conected with the appropriate medium. These attributes are usually equal to 1.

The attribute tgravity with the keyword gravityacceleration describes whether the gravity acceleration is taken into account. The values of the attribute tgravity is summarized in Table 8.5.

attribute	enumerator	description
tgravity = 0	gr_no	the gravity acceleration is not taken into account
tgravity = 1	gr_yes	the gravity acceleration is taken into account

Table 8.5: Attribute tgravity

The attribute adaptivityflag describes whether the adaptivity is applied. The appropriate keyword is adaptivity.

The attribute stochasticcalc describes the type of analysis with respect to deterministic or non-deterministic feature. The appropriate keyword is stochasticcalc.

The attribute homogt describes whether homogenization is applied. The appropriate keyword is homogenization.

Storage of the conductivity matrix is located in the attribute tstorkm of the class probdesct. The appropriate keyword is conductmatstor. Storage of the capacity matrix is located in the attribute tstorcm of the class probdesct. The appropriate keyword is capacmatstor.

attribute	description
adaptivityflag = 0	adaptivity is not applied (default value)
adaptivityflag = 1	adaptivity is applied (not described now)

Table 8.6: Attribute adaptivityflag

attribute	description
stochasticcalc = 0	deterministic approach/computation (default value)
stochasticcalc = 1	stochastic/fuzzy computation, data are read all at once
stochasticcalc = 2	stochastic/fuzzy computation, data are read sequentially
stochasticcalc = 3	stochastic/fuzzy computation, data are generated in the code

Table 8.7: Attribute stochasticcalc

The attribute tprt with the keyword timetypeprint describes time units used in output.

The attribute diagcap with the keyword diagonalization determines whether the capacity matrix is diagonalized.

8.2 Linear Stationary Analysis

8.2.1 General description

Every linear stationary problem is described by the following scheme.

name of problem solved by user	
message printing	Table 8.2
tprob = stationary_problem = 50	Table 7.1
type of transport	Table 8.3
medium names	Table 8.4
scales	default value i s1
gradients computation	described in Section 2.10
fluxes computation	described in Section 2.11
internal variables computation	described in Section 2.9
internal variables computation	described in Section 2.9
gravity acceleration	Table 8.5
adaptivity	Table 8.6
deterministic/stochastic computation	Table 8.7
homogenization	Table 8.8
node renumbering	described in Section 2.6
storage of the conductivity matrix	described in Section 2.2
solver of linear equations	described in Section 2.3

attribute	description
homogt = 0	homogenization is not applied (default value)
homogt = 1	homogenization is applied on a single processor
homogt = 2	homogenization is applied on a parallel computer

Table 8.8: Attribute homogt

attribute	enumerator	description
tprt = 1	secondst	output in seconds
tprt = 2	minutest	output in minutes
tprt = 3	hourst	output in hours
tprt = 4	dayst	output in days

Table 8.9: Attribute tprt

8.2.2 Examples

8.2.2.1 Linear stationary analysis

Example without keywords

```
heat transfer
1     # message printing
50    # linear stationary problem
1     # type of transport - one medium
1     # name of the medium - heat
1.0   # scale
1     # gradients are computed and stored
2     # gradients computed in nodes
1     # the final gradients are average values of gradients from adjacent elements
1     # fluxes are computed and stored
2     # fluxes are computed in nodes
1     # the final fluxes are average values of fluxes from adjacent elements
0     # internal variables are not computed
0     # internal variables are not computed
0     # the gravity is not taken into account
0     # adaptivity is not applied
0     # deterministic computation
0     # homogenization is not used
0     # no node renumbering
2     # the conductivity matrix is stored in skyline storage scheme
2     # system of linear equations is solved by the LDL^T factorization
```

Example with keywords

attribute	description
diagcap = 0	the capacity matrix is not diagonalized
diagcap = 1	the capacity matrix is diagonalized

Table 8.10: Attribute diagcap

```
heat transfer
mesprt 1                          # message printing
problemtype stationary_problem    # linear stationary problem
transmatter nomedium              # type of transport - one medium
mednames heat                     # name of the medium - heat
scale1 1.0                        # scale
gradcomp 1                        # gradients are computed and stored
gradpos 2                         # gradients computed in nodes
gradaver 1                        # the final gradients are average values of gradients from adjacent
fluxcomp 1                        # fluxes are computed and stored
fluxpos 2                         # fluxes are computed in nodes
fluxaver 1                        # the final fluxes are average values of fluxes from adjacent elemen
othercomp 0                       # internal variables are not computed
eqothercomp 0                     # internal variables are not computed
gravityacceleration gr_no         # the gravity is not taken into account
adaptivity 0                      # adaptivity is not applied
stochasticcalc 0                  # deterministic computation
homogenization 0                  # homogenization is not used
noderenumber no_renumbering       # no node renumbering
conductmatstor skyline_matrix     # the conductivity matrix is stored in skyline storage scheme
typelinsol ldl                    # system of linear equations is solved by the LDL^T factorization
```

8.3 Linear Non-stationary Analysis

8.3.1 General description

Every linear non-stationary problem is described by the following scheme.

name of problem solved by user	
message printing	Table 8.2
tprob = nonstationary_problem = 60	Table 7.1
type of transport	Table 8.3
medium names	Table 8.4
scales	default value i s1
gradients computation	described in Section 2.10
fluxes computation	described in Section 2.11
internal variables computation	described in Section 2.9
internal variables computation	described in Section 2.9
gravity acceleration	Table 8.5
adaptivity	Table 7.4
deterministic/stochastic computation	Table 7.5
homogenization	Table 8.8
node renumbering	described in Section 2.6
time controller	described in Section 2.5
time print	Table 8.9
back-up	
parameter of the generalized trapezoidal rule	
storage of the conductivity matrix	described in Section 2.2
storage of the capacity matrix	described in Section 2.2
solver of linear equations	described in Section 2.3
diagonalization of the capacity matrix	Table 8.10

8.3.2 Examples

8.3.2.1 Linear non-stationary analysis

Example without keywords

```
heat transfer
1       # message printing
60      # linear non-stationary problem
1       # type of transport - one medium
1       # name of the medium - heat
1.0     # scale
1       # gradients are computed and stored
2       # gradients computed in nodes
1       # the final gradients are average values of gradients from adjacent elements
1       # fluxes are computed and stored
2       # fluxes are computed in nodes
1       # the final fluxes are average values of fluxes from adjacent elements
0       # internal variables are not computed
0       # internal variables are not computed
0       # the gravity is not taken into account
0       # adaptivity is not applied
0       # deterministic computation
0       # homogenization is not used
0       # no node renumbering
0       # the type of time controller - fixed
0.0     # the starting time
123.0   # the end time
0       # the number of important times
0       # the type of general function governing the time step
        # the constant value
2.5     # the time step
1       # time units in output are seconds
0       # no back-up (default value)
0.5     # parameter alpha in the generalized trapezoidal method
2       # the conductivity matrix is stored in skyline storage scheme
2       # the capacity matrix is stored in skyline storage scheme
2       # system of linear equations is solved by the LDL^T factorization
0       # the capacity matrix is not diagonalized
```

Example with keywords

```
heat transfer
mesprt 1                              # message printing
problemtype nonstationary_problem     # linear non-stationary problem
transmatter onemedium                 # type of transport - one medium
mednames heat                         # name of the medium - heat
scale1 1.0                            # scale
gradcomp 1                            # gradients are computed and stored
gradpos 2                             # gradients computed in nodes
gradaver 1                            # the final gradients are average values of gradients from adjac
fluxcomp 1                            # fluxes are computed and stored
fluxpos 2                             # fluxes are computed in nodes
fluxaver 1                            # the final fluxes are average values of fluxes from adjacent ele
othercomp 0                           # internal variables are not computed
eqothercomp 0                         # internal variables are not computed
gravityacceleration gr_no             # the gravity is not taken into account
adaptivity 0                          # adaptivity is not applied
stochasticcalc 0                      # deterministic computation
homogenization 0                      # homogenization is not used
noderenumber no_renumbering           # no node renumbering
time_contr_type fixed                 # the type of time controller - fixed
0.0                                   # the starting time
123.0                                 # the end time
0                                     # the number of important times
funct_type stat                       # the type of general function - the constant value
const_val 2.5                         # the time step
timetypeprint secondst                # time units in output are seconds
hdbackup nohdb                        # no back-up (default value)
alpha_integration 0.5                 # parameter alpha in the generalized trapezoidal method
conductmatstor skyline_matrix         # the conductivity matrix is stored in skyline storage scheme
capacmatstor skyline_matrix           # the capacity matrix is stored in skyline storage scheme
typelinsol ldl                        # system of linear equations is solved by the LDL^T factorizati
diagcap 0                             # the capacity matrix is not diagonalized
```