The General Element (GENEL)

The GENEL entry is used to define general elements whose properties are defined in terms of deflection influence coefficients or stiffness matrices which can be connected between any number of grid points. One of the important uses of the general element is the representation of part of a structure by means of experimentally measured data. No output data is prepared for the general element. Detailed information on the general element is given in General Element Capability (GENEL).

General Element Capability (GENEL)

The input required for the general element is the GENEL Bulk Data entry. The description of GENEL in the *MSC Nastran Quick Reference Guide* contains a complete description of the input options and an example.

The principal application of the GENEL element is to represent the stiffness of a substructure which has an arbitrary number of connected grid point components and/or scalar points. The input data may be obtained either from another computer run or from test data.

The general element is a structural stiffness element connected to any number of degrees of freedom, as specified by the user. In defining the form of the externally generated data on the stiffness of the element, two major options are provided to the user.

1. Instead of supplying the stiffness matrix for the element directly, the user provides the deflection influence coefficients for the structure supported in a nonredundant manner. The associated matrix of the restrained rigid body motions may be input or may be generated internally by the program.
2. The stiffness matrix of the element may be input directly. This stiffness matrix may be for the unsupported body, containing all the rigid body modes, or it may be for a subset of the body's degrees of freedom from which some or all of the rigid body motions are deleted. In the latter case, the option is given for automatic inflation of the stiffness matrix to reintroduce the restrained rigid body terms, provided that the original support conditions did not constitute a redundant set of reactions. An important advantage of this option is that, if the original support conditions restrain all rigid body motions, the reduced stiffness matrix need not be specified by the user to high precision in order to preserve the rigid body properties of the element.

The defining equation for the general element when written in the flexibility form is

$$\begin{Bmatrix} u_i \\ f_d \end{Bmatrix} = \begin{bmatrix} Z & S \\ -S^T & 0 \end{bmatrix} \begin{Bmatrix} f_i \\ u_d \end{Bmatrix} \tag{3-65}$$

where:

$[Z]$	=	is the matrix of deflection influence coefficients for coordinates $\{u_i\}$ when coordinates $\{u_d\}$ are rigidly restrained.
$[S]$	=	is a rigid body matrix whose terms are the displacements $\{u_i\}$ due to unit motions of the coordinates $\{u_d\}$, when all $f_i = 0$.
$[f_i]$	=	are the forces applied to the element at the $\{u_i\}$ full coordinates.
$[f_d]$	=	are the forces applied to the element at the $\{u_d\}$ coordinates. They are assumed to be statically related to the $\{f_i\}$ forces, i.e., they constitute a nonredundant set of reactions for the element.

The defining equation for the general element when written in the stiffness form is

$$\begin{Bmatrix} f_i \\ f_d \end{Bmatrix} = \begin{bmatrix} k & -k\,S \\ -S^T k & S^T k\,S \end{bmatrix} \begin{Bmatrix} u_i \\ u_d \end{Bmatrix} \tag{3-66}$$

where all symbols have the same meaning as in (3-65) and $[k] = [Z]^{-1}$, when $[k]$ is nonsingular. Note, however, that it is permissible for $[k]$ to be singular. (3-66) derivable from (3-65) when $[k]$ is nonsingular.

Input data for the element consists of lists of the u_i and u_d coordinates, which may occur at either geometric or scalar grid points; the values of the elements of the $[Z]$ matrix, or the values of the elements of the $[k]$ matrix; and (optionally) the values of the elements of the $[S]$ matrix.

The user may request that the program internally generate the $[S]$ matrix. If so, the $\{u_i\}$ and coordinates occur only at geometric grid points, and there must be six or less $\{u_d\}$ coordinates that provide a nonredundant set of reactions for the element as a three-dimensional body.

The $[S]$ matrix is internally generated as follows. Let $\{u_b\}$ be a set of six independent motions (three translations and three rotations) along coordinate axes at the origin of the basic coordinate system. Let the relationship between $\{u_d\}$ and $\{u_b\}$.

$$\{u_d\} = [D_d]\{u_b\} \tag{3-67}$$

The elements of $[D_d]$ are easily calculated from the basic (x,y,z) geometric coordinates of the grid points at which the elements of $\{u_d\}$ occur, and the transformations between basic and global (local) coordinate systems. Let the relationship between $\{u_i\}$ and $\{u_b\}$ be

$$\{u_i\} = [D_i]\{u_b\} \tag{3-68}$$

where $[D_i]$ is calculated in the same manner as $[D_d]$. Then, if $[D_d]$ is nonsingular,

$$[S] = [D_i][D_d]^{-1} \tag{3-69}$$

Note that, if the set $\{u_d\}$ is not a sufficient set of reactions, $[D_d]$ is singular and $[S]$ cannot be computed in the manner shown. When $\{u_d\}$ contains fewer than six elements, the matrix $[D_d]$ is not directly invertible but a submatrix $[a]$ of rank r, where r is the number of elements of $\{u_d\}$, can be extracted and inverted.

A method which is available only for the stiffness formulation and not for the flexibility formulation will be described. The flexibility formulation requires that $\{u_d\}$ have six components. The method is as follows. Let $\{u_d\}$ be augmented by 6-*r* displacement components $\{u_d'\}$ which are restrained to zero value. We may then write

$$\begin{Bmatrix} u_d \\ \hline d_d' \end{Bmatrix} = \begin{bmatrix} D_d \\ \hline D_d' \end{bmatrix}\{u_b\} = [\bar{D}]\{u_b\} \tag{3-70}$$

The matrix $[D_d]$ is examined and a nonsingular subset $[a]$ with r rows and columns is found. $\{u_b\}$ is then reordered to identify its first r elements with $\{u_d\}$. The remaining elements of $\{u_b\}$ are equated to the elements of $\{u_d\}$. The complete matrix $[\bar{D}]$ then has the form

$$[\bar{D}] = \left[\begin{array}{c|c} a & b \\ \hline 0 & I \end{array}\right] \tag{3-71}$$

with an inverse

$$[\bar{D}]^{-1} = \left[\begin{array}{c|c} a^{-1} & -a^{-1}b \\ \hline 0 & I \end{array}\right] \tag{3-72}$$

Since the members of $\{u_d'\}$ are restrained to zero value,

$$\{u_b\} = [D_r]\{u_d\} \tag{3-73}$$

where $[D_r]$ is the $(6 \times r)$ partitioned matrix given by

$$[D_r] = \begin{bmatrix} a^{-1} \\ \hline 0 \end{bmatrix} \tag{3-74}$$

The $[D_i]$ matrix is formed as before and the $[S]$ matrix is then

$$[S] = [D_i][D_r] \tag{3-75}$$

Although this procedure will replace all deleted rigid body motions, it is not necessary to do this if a stiffness matrix rather than a flexibility matrix is input. It is, however, a highly recommended procedure because it will eliminate errors due to nonsatisfaction of rigid body properties by imprecise input data.

The stiffness matrix of the element written in partitioned form is

$$[K_{ee}] = \left[\begin{array}{c|c} K_{ii} & K_{id} \\ \hline K_{id}^T & K_{dd} \end{array}\right] \tag{3-76}$$

The stiffness matrix of the element written in partitioned form is

$$[K_{ee}] = \begin{bmatrix} K_{ii} & K_{id} \\ - & - \\ K_{id}^T & K_{dd} \end{bmatrix} \tag{3-76}$$

When the flexibility formulation is used, the program evaluates the partitions of $[K_{ee}]$ from $[Z]$ and $[S]$ as follows:

$$[K_{ii}] = [Z]^{-1} \tag{3-77}$$

$$[K_{id}] = [Z]^{-1}[S] \tag{3-78}$$

$$[K_{dd}] = [S]^T[Z]^{-1}[S] \tag{3-79}$$

If a stiffness matrix, $[k]$, rather than a flexibility matrix is input, the partitions of $[K_{ee}]$ are

$$[K_{ii}] = [k] \tag{3-80}$$

$$[K_{id}] = -[k][S] \tag{3-81}$$

$$[K_{dd}] = -[S]^T[k][S] \tag{3-82}$$

No internal forces or other output data are produced for the general element.

Direct Matrix Input on Grid Points (DMIG)

The Bulk Data entry DMIG can be used to input a stiffness (or mass) matrix which connects specified degrees of freedom. The matrix so defined will be added to the stiffness (or mass) matrix computed from finite element properties.

The DMIG entry includes provisions for unsymmetric terms and complex values, both of which are useful in dynamic analysis. These provisions should not be used in static or normal modes. Note that an entry in the Case Control Section is required (K2GG = NAME for a stiffness matrix or M2GG = NAME for a mass matrix). See Case Control Commands in the *MSC Nastran Quick Reference Guide* for general instructions regarding the Case Control Section.

The primary application of the DMIG Bulk Data entry is to enter stiffness and mass data for parts of the structure which are obtained from another computer run. The format is cumbersome (two matrix terms per continuation entry) and the matrix should be input to high precision (see Use of Parameters for a discussion of double-field entries). For stiffness matrices only, the GENEL Bulk Data entry is an alternative for manually inputting data.

Defines a general element.

Format:

1	2	3	4	5	6	7	8	9	10
GENEL	EID		UI1	CI1	UI2	CI2	UI3	CI3	
	UI4	CI4	UI5	CI5	-etc.-				

UIm -- The last item in the UI list will appear in one of fields 2, 4, 6, or 8.

	“UD”		UD1	CD1	UD2	CD2	-etc.-		

UDn -- The last item in the UD list will appear in one of fields 2, 4, 6, or 8.

	“K” or “Z”	KZ11	KZ21	KZ31	-etc.-	KZ22	KZ32		
	-etc.-		KZ33	KZ43	-etc.-				

KZmm -- The last item in the K or Z matrix will appear in one of fields 2 through 9.

	“S”	S11	S12	-etc.-		S21	-etc.-		

Smn -- The last item in the S matrix will appear in one of fields 2 through 9.

Example:

GENEL	629		1	1	13	4	42	0	
	24	2							
	UD		6	2	33	0			
	Z	1.0	2.0	3.0	4.0	5.0	6.0	7.0	
	8.0	9.0	10.0						
	S	1.5	2.5	3.5	4.5	5.5	6.5	7.5	
	8.5								

Describer	Meaning
EID	Unique element identification number. (Integer > 0)
Uli, Cli UDj, CDj	Identification numbers of degrees-of-freedom in the UI or UD list, in sequence corresponding to the [K], [Z], and [S] matrices. UIi and UDi are grid point numbers, and CIi and CDj are the component numbers. If a scalar point is given, the component number is zero. (Integer ≥ 0)
KZij	Values of the [K] or [Z] matrix ordered by columns from the diagonal, according to the UI list. (Real)

Describer	Meaning
Sij	Values of the [S] matrix ordered by rows according to the UD list. (Real)
"UD", "K", "Z", and "S"	Character strings that indicate the start of data belonging to the UD list or the [K], [Z], or [S] matrices.

Remarks:

1. The stiffness approach:

$$\begin{Bmatrix} f_i \\ \hline f_d \end{Bmatrix} = \left[\begin{array}{c|c} K & -KS \\ \hline -S^T K & S^T KS \end{array}\right] \begin{Bmatrix} u_i \\ \hline u_d \end{Bmatrix}$$

The flexibility approach:

$$\begin{Bmatrix} u_i \\ \hline f_d \end{Bmatrix} = \left[\begin{array}{c|c} Z & S \\ \hline -S^T & O \end{array}\right] \begin{Bmatrix} f_i \\ \hline u_d \end{Bmatrix}$$

where

$$\{u_i\} = [u_{i1}, u_{i2}, \ldots, u_{im}]^T$$

$$\{u_d\} = [u_{d1}, u_{d2}, \ldots, u_{dn}]^T$$

$$[KZ] =$$

$$[K] \text{ or } [Z] = \begin{bmatrix} KZ11 & \ldots & \ldots & \ldots \\ KZ21 & KZ22 & \ldots & \ldots \\ KZ31 & KZ32 & \ldots & \ldots \\ \vdots & \vdots & \vdots & \vdots \\ KZ_{m1} & \ldots & \ldots & KZ_{mm} \end{bmatrix} \text{ and } [KZ]^T = [KZ]$$

$$[S] = \begin{bmatrix} S11 & \ldots & S_{1n} \\ S21 & \ldots & \ldots \\ S31 & \ldots & \ldots \\ \vdots & \vdots & \vdots \\ S_{m1} & \ldots & S_{mn} \end{bmatrix}$$

The required input is the $\{u_i\}$ list and the lower triangular portion of [*K*] or [*Z*]. Additional input may include the $\{u_d\}$ list and [*S*]. If [*S*] is input, $\{u_d\}$ must also be input. If $\{u_d\}$ is input but [*S*] is omitted, [*S*] is internally calculated. In this case, $\{u_d\}$ must contain six and only six degrees-of-freedom.

The forms shown above for both the stiffness and flexibility approaches assume that the element is a free body with rigid body motions that are defined by $\{u_i\} = [S]\{u_d\}$. See General Element Capability (GENEL) (Ch. 3) in the *MSC Nastran Reference Guide* for further discussion.

2. When the stiffness matrix K is input, the number of significant digits should be the same for all terms.
3. Double-field format may be used for input of K or Z.
4. The DMIG entry or the INPUTT4 module offer alternative methods for inputting large matrices.
5. The general element entry in the example above defines the following:

$$[u_i] = [1–1, 13 – 4, 42, 24 – 2]^T$$

$$\{u_d\} = [6 – 2, 33]^T$$

where i-j means the j-th component of grid point i. Points 42 and 33 are scalar points.

$$[Z] = \begin{bmatrix} 1.0 & 2.0 & 3.0 & 4.0 \\ 2.0 & 5.0 & 6.0 & 7.0 \\ 3.0 & 6.0 & 8.0 & 9.0 \\ 4.0 & 7.0 & 9.0 & 10.0 \end{bmatrix} \qquad [S] = \begin{bmatrix} 1.5 & 2.5 \\ 3.5 & 4.5 \\ 5.5 & 6.5 \\ 7.5 & 8.5 \end{bmatrix}$$