MATERIAL ELASTIC ANISOTROPIC

Synopsis:
The **MATERIAL ELASTIC ANISOTROPIC** command is used to specify the parameters associated with an anisotropic linear elastic material idealization.

Syntax:

```
MATerial ELAstic ANIsotropic NUMber ##
( DEScription "string")
( C11 #.#) ( C12 #.#) ( C13 #.#) ( C14 #.#) ( C15 #.#)
( C16 #.#) ( C22 #.#) ( C23 #.#) ( C24 #.#)
( C25 #.#) ( C26 #.#) ( C33 #.#) ( C34 #.#)
( C35 #.#) ( C36 #.#) ( C44 #.#) ( C45 #.#)
( C46 #.#) ( C55 #.#) ( C56 #.#) ( C66 #.#)
```

Explanatory Remarks:
The **NUMBER** keyword is used to specify the (global) number of the material associated with the anisotropic elastic idealization. For a three-dimensional state of stress, this constitutive law is written in the form

```
\begin{bmatrix}
\sigma_{11} \\
\sigma_{22} \\
\sigma_{33} \\
\sigma_{12} \\
\sigma_{13} \\
\sigma_{23}
\end{bmatrix} =
\begin{bmatrix}
c_{11} & c_{12} & c_{13} & c_{14} & c_{15} & c_{16} \\
c_{22} & c_{23} & c_{24} & c_{25} & c_{26} \\
c_{33} & c_{34} & c_{35} & c_{36} \\
c_{44} & c_{45} & c_{46} \\
c_{55} & c_{56} \\
c_{66}
\end{bmatrix}
\begin{bmatrix}
\varepsilon_{11} \\
\varepsilon_{22} \\
\varepsilon_{33} \\
2\varepsilon_{12} \\
2\varepsilon_{13} \\
2\varepsilon_{23}
\end{bmatrix}
```

Associated with the **DESCRIPTION** keyword is a string that is used to describe the material. This is included solely for the benefit of the analyst; the associated string is printed in the “echo” of the material.
SPECIAL CASE: “stratified” axisymmetric material

For such a case, the constitutive relations simplify to

\[
\begin{pmatrix}
\sigma_{11} \\
\sigma_{22} \\
\sigma_{33} \\
\sigma_{12}
\end{pmatrix} = \begin{bmatrix}
c_{11} & c_{12} & c_{13} & 0 \\
c_{12} & c_{22} & c_{23} & 0 \\
c_{13} & c_{23} & c_{33} & 0 \\
0 & 0 & 0 & c_{44}
\end{bmatrix} \begin{pmatrix}
e_{11} \\
e_{22} \\
e_{33} \\
2e_{12}
\end{pmatrix}
\]

where

\[
c_{11} = c_{33} = Cn[1 - n^2(v_2)^2]
\]

\[
c_{12} = Cn v_2 (1 + v_1)
\]

\[
c_{13} = Cn v_1 + n(v_2)^2
\]

\[
c_{22} = C[1 - (v_1)^2]
\]

\[
c_{23} = Cn v_2 (1 + v_1)
\]

\[
c_{44} = G_2
\]

and

\[
C \equiv \frac{E_2}{(1 + v_1)[1 - v_1 - 2n(v_2)^2]} \quad ; \quad n \equiv \frac{E_1}{E_2}
\]
Special Case: Isotropic Material

For an isotropic linear elastic material the constitutive relations simplify in that only two constants are required to completely describe the material behavior; e.g., the elastic (Young’s) modulus $E$ and Poisson’s ratio $\nu$. The matrix of stiffness coefficients now becomes

$$ [C] = \frac{E}{(1 + \nu)(1 - 2\nu)} \begin{bmatrix} 1 - \nu & \nu & \nu & 0 & 0 & 0 \\ \nu & 1 - \nu & \nu & 0 & 0 & 0 \\ \nu & \nu & 1 - \nu & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{(1 - 2\nu)}{2} & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{(1 - 2\nu)}{2} & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{(1 - 2\nu)}{2} \end{bmatrix} $$

The default values for the above parameters correspond to an isotropic elastic material with elastic modulus equal to 300000 and Poisson’s ration equal to 0.30. This implies that the only non-zero parameters are: $c_{11} = c_{22} = c_{33} = 4.00e + 05$, $c_{12} = c_{13} = c_{23} = 1.730e + 05$, and $c_{44} = c_{55} = c_{66} = 1.15e + 05$.

For conditions of plane stress, plane strain and/or torsionless axisymmetry, the stress and strain vectors reduce to

$$ \begin{bmatrix} \sigma_{11} \\ \sigma_{22} \\ \sigma_{33} \\ \sigma_{12} \end{bmatrix} \quad \text{and} \quad \begin{bmatrix} \varepsilon_{11} \\ \varepsilon_{22} \\ \varepsilon_{33} \\ 2\varepsilon_{12} \end{bmatrix} $$

and only the principal (4 x 4) sub-matrix of constants is applicable. Here loading has been assumed to be applied only in the 1-2 plane. Note that in the above expressions, the engineering measure of shearing strains, which is twice the tensoral values, has been employed.
If the principal directions of the anisotropic material differ from the global ones, suitable transformations must be performed using the TRANSFORM command.

**Example**:

The following commands are sufficient to specify an anisotropic elastic material

```plaintext
material elastic aniso num 2 desc "hybrid" &
  c11 4.038e+07  c12 1.731e+07  c13 1.731e+07  c14 0.0 &
  c22 4.038e+07  c23 1.731e+07 &
  c24 0.0  c33 4.038e+07  c34 0.0  c44 1.154e+07
```

**See also**:

The DIMENSION, MATERIAL ELASTIC ISOTROPIC, the MATERIAL ELASTIC ORTHOTROPIC, and the TRANSFORM commands.