

## Matrixes of DL-20

### Stiffness Matrix

$$\begin{pmatrix} C_{11} & C_{12} & C_{13} & 0 & 0 & 0 \\ C_{12} & C_{11} & C_{13} & 0 & 0 & 0 \\ C_{13} & C_{13} & C_{33} & 0 & 0 & 0 \\ 0 & 0 & 0 & C_{44} & 0 & 0 \\ 0 & 0 & 0 & 0 & C_{55} & 0 \\ 0 & 0 & 0 & 0 & 0 & C_{66} \end{pmatrix}^E = \begin{pmatrix} 17.0 & 5.6 & 5.8 & 0 & 0 & 0 \\ 5.6 & 17.0 & 5.8 & 0 & 0 & 0 \\ 5.8 & 5.8 & 12.4 & 0 & 0 & 0 \\ 0 & 0 & 0 & 5.2 & 0 & 0 \\ 0 & 0 & 0 & 0 & 5.2 & 0 \\ 0 & 0 & 0 & 0 & 0 & 5.7 \end{pmatrix}^E 10^{10} N/m^2$$

$$\begin{pmatrix} C_{11} & C_{12} & C_{13} & 0 & 0 & 0 \\ C_{12} & C_{11} & C_{13} & 0 & 0 & 0 \\ C_{13} & C_{13} & C_{33} & 0 & 0 & 0 \\ 0 & 0 & 0 & C_{44} & 0 & 0 \\ 0 & 0 & 0 & 0 & C_{55} & 0 \\ 0 & 0 & 0 & 0 & 0 & C_{66} \end{pmatrix}^D = \begin{pmatrix} 18.0 & 6.7 & 8.3 & 0 & 0 & 0 \\ 6.7 & 18.0 & 8.3 & 0 & 0 & 0 \\ 8.3 & 8.3 & 18.6 & 0 & 0 & 0 \\ 0 & 0 & 0 & 5.8 & 0 & 0 \\ 0 & 0 & 0 & 0 & 5.8 & 0 \\ 0 & 0 & 0 & 0 & 0 & 5.7 \end{pmatrix}^D 10^{10} N/m^2$$

### Elastic Matrix

$$\begin{pmatrix} S_{11} & S_{12} & S_{13} & 0 & 0 & 0 \\ S_{12} & S_{11} & S_{13} & 0 & 0 & 0 \\ S_{13} & S_{13} & S_{33} & 0 & 0 & 0 \\ 0 & 0 & 0 & S_{44} & 0 & 0 \\ 0 & 0 & 0 & 0 & S_{55} & 0 \\ 0 & 0 & 0 & 0 & 0 & S_{66} \end{pmatrix}^E = \begin{pmatrix} 7.3 & -1.5 & -2.7 & 0 & 0 & 0 \\ -1.5 & 7.3 & -2.7 & 0 & 0 & 0 \\ -2.7 & -2.7 & 10.6 & 0 & 0 & 0 \\ 0 & 0 & 0 & 19.4 & 0 & 0 \\ 0 & 0 & 0 & 0 & 19.4 & 0 \\ 0 & 0 & 0 & 0 & 0 & 17.6 \end{pmatrix}^E 10^{-12} m^2/N$$

$$\begin{pmatrix} S_{11} & S_{12} & S_{13} & 0 & 0 & 0 \\ S_{12} & S_{11} & S_{13} & 0 & 0 & 0 \\ S_{13} & S_{13} & S_{33} & 0 & 0 & 0 \\ 0 & 0 & 0 & S_{44} & 0 & 0 \\ 0 & 0 & 0 & 0 & S_{55} & 0 \\ 0 & 0 & 0 & 0 & 0 & S_{66} \end{pmatrix}^D = \begin{pmatrix} 7.3 & -1.5 & -2.6 & 0 & 0 & 0 \\ -1.5 & 7.3 & -2.6 & 0 & 0 & 0 \\ -2.6 & -2.6 & 7.7 & 0 & 0 & 0 \\ 0 & 0 & 0 & 17.4 & 0 & 0 \\ 0 & 0 & 0 & 0 & 17.4 & 0 \\ 0 & 0 & 0 & 0 & 0 & 17.6 \end{pmatrix}^D 10^{-12} m^2/N$$

### Matrix of Clamp Dielectric Constant

$$\begin{pmatrix} \epsilon_{11} & 0 & 0 \\ 0 & \epsilon_{11} & 0 \\ 0 & 0 & \epsilon_{33} \end{pmatrix}^s = \begin{pmatrix} 215 & 0 & 0 \\ 0 & 215 & 0 \\ 0 & 0 & 150 \end{pmatrix}^s$$

### Matrix of Free Dielectric Constant

$$\begin{pmatrix} \epsilon_{11} & 0 & 0 \\ 0 & \epsilon_{11} & 0 \\ 0 & 0 & \epsilon_{33} \end{pmatrix}^T = \begin{pmatrix} 240 & 0 & 0 \\ 0 & 240 & 0 \\ 0 & 0 & 205 \end{pmatrix}^T$$

### Piezoelectric Constant Matrixes

$$\begin{pmatrix} 0 & 0 & 0 & 0 & d_{15} & 0 \\ 0 & 0 & 0 & d_{24} & 0 & 0 \\ d_{31} & d_{31} & d_{33} & 0 & 0 & 0 \end{pmatrix} = \begin{pmatrix} 0 & 0 & 0 & 0 & 65.0 & 0 \\ 0 & 0 & 0 & 65.0 & 0 & 0 \\ -3.7 & -3.7 & 72.0 & 0 & 0 & 0 \end{pmatrix} 10^{-12} C/N$$

$$\begin{pmatrix} 0 & 0 & 0 & 0 & g_{15} & 0 \\ 0 & 0 & 0 & g_{24} & 0 & 0 \\ g_{31} & g_{31} & g_{33} & 0 & 0 & 0 \end{pmatrix} = \begin{pmatrix} 0 & 0 & 0 & 0 & 30.6 & 0 \\ 0 & 0 & 0 & 30.6 & 0 & 0 \\ -2.0 & -2.0 & 40.0 & 0 & 0 & 0 \end{pmatrix} 10^{-3} Vm/N$$

$$\begin{pmatrix} 0 & 0 & 0 & 0 & e_{15} & 0 \\ 0 & 0 & 0 & e_{24} & 0 & 0 \\ e_{31} & e_{31} & e_{33} & 0 & 0 & 0 \end{pmatrix} = \begin{pmatrix} 0 & 0 & 0 & 0 & 3.4 & 0 \\ 0 & 0 & 0 & 3.4 & 0 & 0 \\ -3.3 & -3.3 & 8.5 & 0 & 0 & 0 \end{pmatrix} C/m^2$$

$$\begin{pmatrix} 0 & 0 & 0 & 0 & h_{15} & 0 \\ 0 & 0 & 0 & h_{24} & 0 & 0 \\ h_{31} & h_{31} & h_{33} & 0 & 0 & 0 \end{pmatrix} = \begin{pmatrix} 0 & 0 & 0 & 0 & 17.4 & 0 \\ 0 & 0 & 0 & 17.4 & 0 & 0 \\ -28.3 & -28.3 & 71.1 & 0 & 0 & 0 \end{pmatrix} 10^8 V/m$$