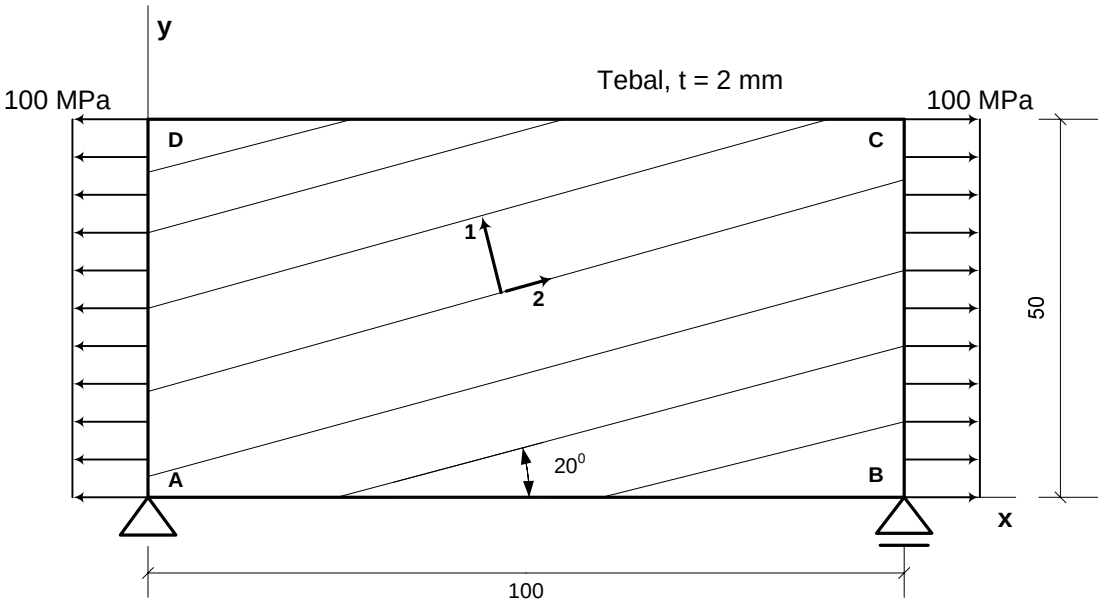
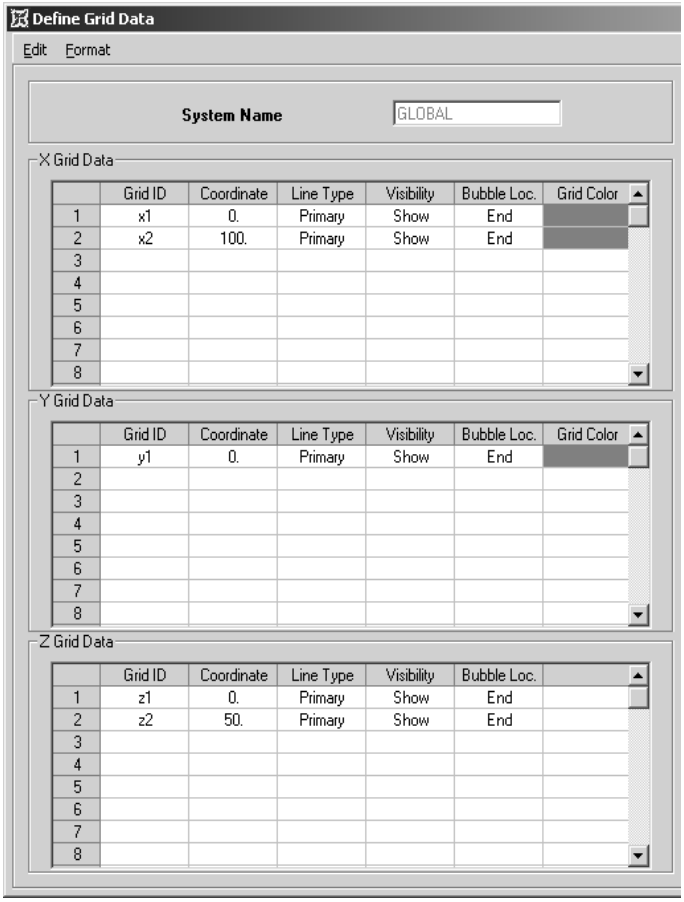
Bab 7

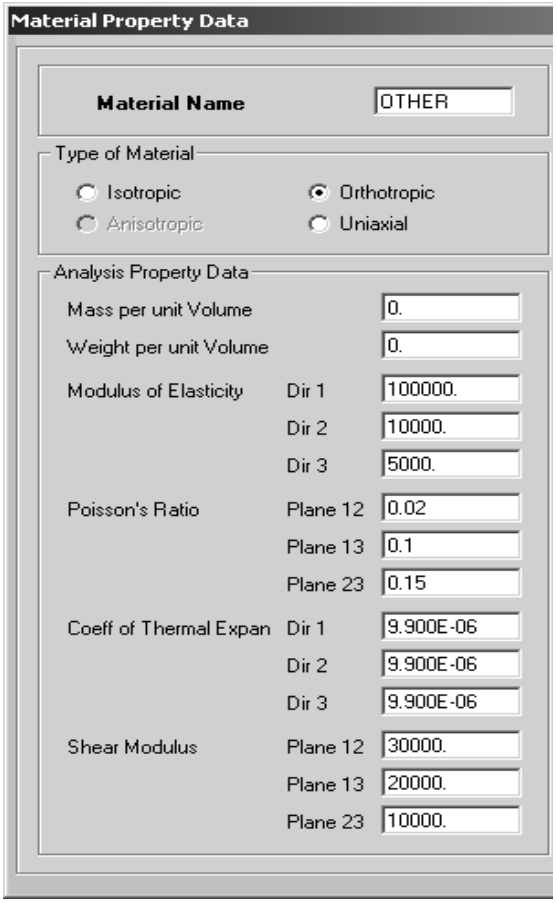
PENGGUNAAN ELEMEN SHELL



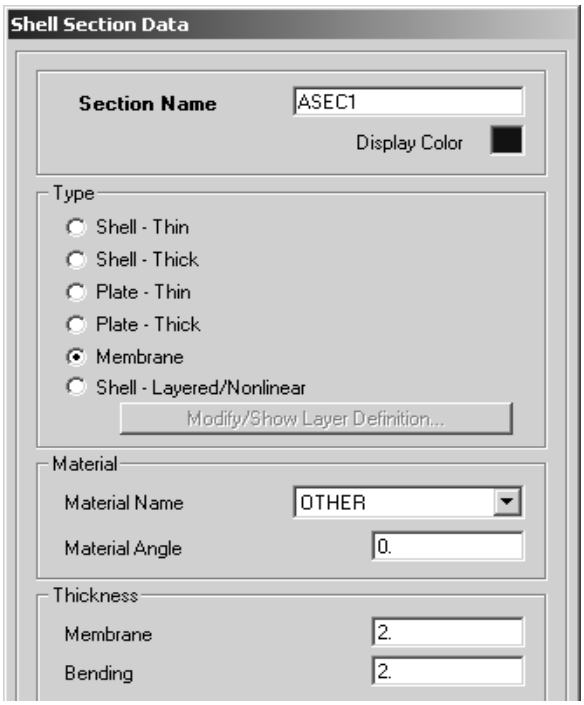
1. Satuan dalam N - mm



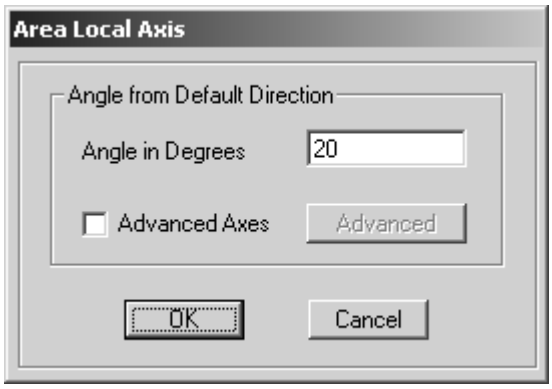
2. Input Data Geometri / Define Grid Data



3. Input Data Material Orthotropik

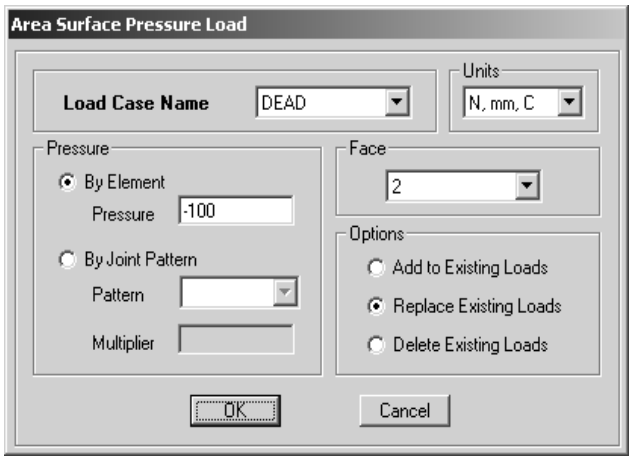


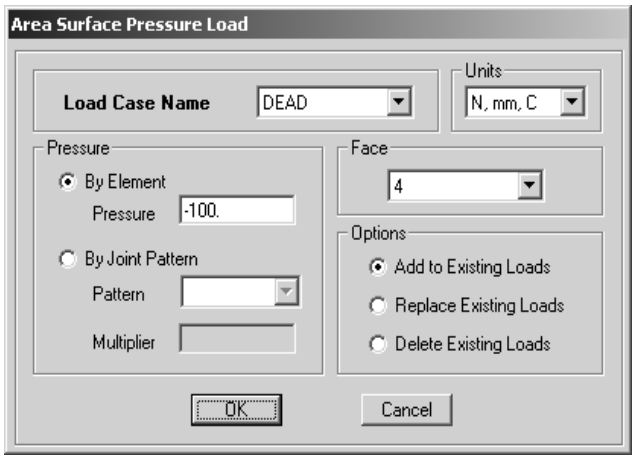
4. Define dan Assign Shell Section Data

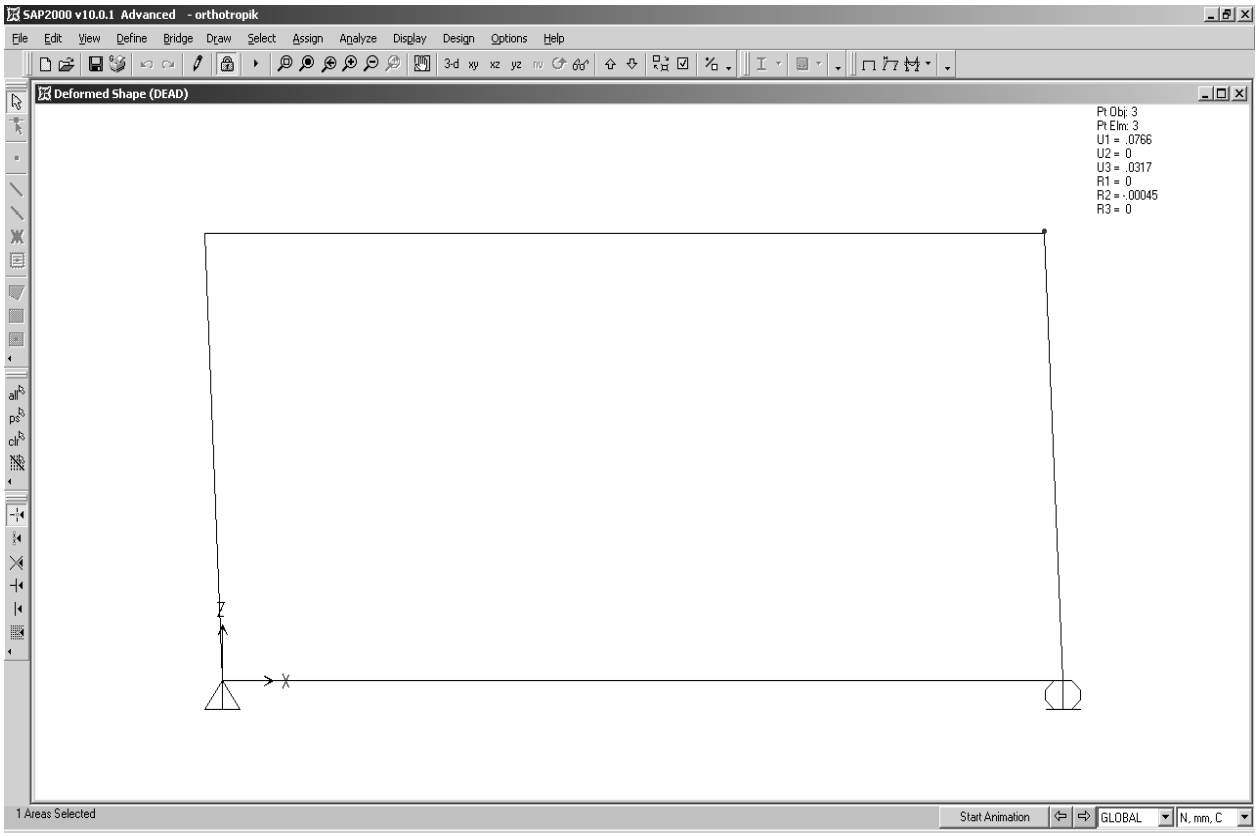


5. Merubah sumbu lokal

6. Input Beban Tegangan pada sisi kanan (2) dan sisi kiri (4)







Joint Displacements

Joint Object **3** Joint Element **3**

	1	2	3
Trans	**0.07663**	**0.00000**	**0.03166**
Rotn	**0.00000**	**-4.533E-04**	**0.00000**

Diperoleh peralihan titik C yang nilainya tidak berbeda jauh dari perhitungan dengan Math Cad, yaitu : u_c =0.07663 mm dan v_c = 0.0316 mm

Dalam sistem utama sumbu material 1,2,3 :

$$\begin{pmatrix}\varepsilon_1\\ \varepsilon_2\\ \varepsilon_3\\ \gamma_{12}\\ \gamma_{13}\\ \gamma_{23}\end{pmatrix} = \begin{pmatrix} \frac{1}{E_1} & \frac{-\nu_{21}}{E_2} & \frac{-\nu_{31}}{E_3} & 0 & 0 & 0\\ \frac{-\nu_{12}}{E_1} & \frac{1}{E_2} & \frac{-\nu_{32}}{E_3} & 0 & 0 & 0\\ \frac{-\nu_{13}}{E_1} & \frac{-\nu_{23}}{E_2} & \frac{1}{E_3} & 0 & 0 & 0\\ 0 & 0 & 0 & \frac{1}{G_{12}} & 0 & 0\\ 0 & 0 & 0 & 0 & \frac{1}{G_{13}} & 0\\ 0 & 0 & 0 & 0 & 0 & \frac{1}{G_{23}} \end{pmatrix} \cdot \begin{pmatrix}\sigma_1\\ \sigma_2\\ \sigma_3\\ \tau_{12}\\ \tau_{13}\\ \tau_{23}\end{pmatrix}$$

Untuk 2D dalam bidang 1 - 2 (dalam sumbu lokal material):

$$\begin{pmatrix}\varepsilon_1\\ \varepsilon_2\\ \gamma_{12}\end{pmatrix} = \begin{pmatrix} \frac{1}{E_1} & \frac{-\nu_{21}}{E_2} & 0\\ \frac{-\nu_{12}}{E_1} & \frac{1}{E_2} & 0\\ 0 & 0 & \frac{1}{G_{12}} \end{pmatrix} \cdot \begin{pmatrix}\sigma_1\\ \sigma_2\\ \tau_{12}\end{pmatrix}$$

Diketahui :

$\alpha := 20\,\text{deg}$ $\quad \cos(\alpha) = 0.94$ $\quad \sin(\alpha) = 0.342$

$E_1 := 100000\text{MPa}$ $\quad \nu_{12} := 0.20$ $\quad G_{12} := 30000\text{MPa}$

$E_2 := 10000\text{MPa}$ $\quad \nu_{13} := 0.10$ $\quad G_{13} := 20000\text{MPa}$

$E_3 := 5000\text{MPa}$ $\quad \nu_{23} := 0.15$ $\quad G_{23} := 10000\text{MPa}$

$\nu_{12} = \nu_{21}\cdot\frac{E_1}{E_2}$ $\quad \nu_{21} := \nu_{12}\cdot\frac{E_2}{E_1}$ $\quad \nu_{21} = 0.02$

$\sigma_x := 100\text{MPa}$ $\quad \sigma_y := 0$ $\quad \tau_{xy} := 0$

$c := 0.94$ $\quad s := 0.342$

$$(\sigma') = \left(T_\varepsilon^{-1}\right)^T \cdot (\sigma)$$

$$\begin{pmatrix}\sigma_1\\ \sigma_2\\ \tau_{12}\end{pmatrix} = \begin{pmatrix} c^2 & s^2 & 2\cdot c\cdot s\\ s^2 & c^2 & -2\cdot c\cdot s\\ -c\cdot s & c\cdot s & c^2 - s^2\end{pmatrix}\cdot\begin{pmatrix}\sigma_x\\ \sigma_y\\ \tau_{xy}\end{pmatrix} \qquad \left(T_\varepsilon^{-1}\right)^T = \begin{pmatrix} c^2 & s^2 & 2\cdot c\cdot s\\ s^2 & c^2 & -2\cdot c\cdot s\\ -c\cdot s & c\cdot s & c^2 - s^2\end{pmatrix}$$

$$\begin{pmatrix}\sigma_1\\ \sigma_2\\ \tau_{12}\end{pmatrix} = \begin{bmatrix} c^2\cdot\sigma_x + s^2\cdot\sigma_y + 2\cdot c\cdot s\cdot\tau_{xy}\\ s^2\cdot\sigma_x + c^2\cdot\sigma_y - 2\cdot c\cdot s\cdot\tau_{xy}\\ (-c)\cdot s\cdot\sigma_x + c\cdot s\cdot\sigma_y + \tau_{xy}\cdot c^2 - \tau_{xy}\cdot s^2\end{bmatrix} \rightarrow \begin{pmatrix}\sigma_1\\ \sigma_2\\ \tau_{12}\end{pmatrix} = \begin{bmatrix} 88.3600\,\text{MPa}\\ 11.696400\,\text{MPa}\\ (-32.14800)\cdot\text{MPa}\end{bmatrix}$$

$$\begin{pmatrix}\varepsilon_1\\ \varepsilon_2\\ \gamma_{12}\end{pmatrix} = \begin{pmatrix} \frac{1}{E_1} & \frac{-\nu_{21}}{E_2} & 0\\ \frac{-\nu_{12}}{E_1} & \frac{1}{E_2} & 0\\ 0 & 0 & \frac{1}{G_{12}}\end{pmatrix}\cdot\begin{bmatrix} 88.3600\,\text{MPa}\\ 11.696400\,\text{MPa}\\ (-32.14800)\cdot\text{MPa}\end{bmatrix} \rightarrow \begin{pmatrix}\varepsilon_1\\ \varepsilon_2\\ \gamma_{12}\end{pmatrix} = \begin{pmatrix} .86020720000000000000e\text{-}3\\ .99292000000000000000e\text{-}3\\ -.10716000000000000000e\text{-}2\end{pmatrix}$$

$$(\varepsilon') = (T_\varepsilon)\cdot(\varepsilon) \qquad (\varepsilon) = \left(T_\varepsilon^{-1}\right)\cdot(\varepsilon')$$

$$T_\varepsilon^{-1} = \begin{bmatrix} c^2 & s^2 & (-c)\cdot s\\ s^2 & c^2 & c\cdot s\\ 2\cdot c\cdot s & (-2)\cdot c\cdot s & c^2 - s^2\end{bmatrix} \qquad \begin{pmatrix}\varepsilon_x\\ \varepsilon_y\\ \gamma_{xy}\end{pmatrix} = \begin{bmatrix} c^2 & s^2 & (-c)\cdot s\\ s^2 & c^2 & c\cdot s\\ 2\cdot c\cdot s & (-2)\cdot c\cdot s & c^2 - s^2\end{bmatrix}\cdot\begin{pmatrix}\varepsilon_1\\ \varepsilon_2\\ \gamma_{12}\end{pmatrix}$$

$$\begin{pmatrix}\varepsilon_x\\ \varepsilon_y\\ \gamma_{xy}\end{pmatrix} = \begin{bmatrix} c^2 & s^2 & (-c)\cdot s\\ s^2 & c^2 & c\cdot s\\ 2\cdot c\cdot s & (-2)\cdot c\cdot s & c^2 - s^2\end{bmatrix}\cdot\begin{pmatrix} .860207200\text{e-}3\\ .9929200\text{e-}3\\ -.1071600\text{e-}2\end{pmatrix} \rightarrow \begin{pmatrix}\varepsilon_x\\ \varepsilon_y\\ \gamma_{xy}\end{pmatrix} = \begin{pmatrix} .12207129448000\text{e-}2\\ .633459418940800\text{e-}3\\ -.90685615948800\text{e-}3\end{pmatrix}$$

Akibat $\varepsilon_x := .12207129448000e\cdot$ $L := 100\,mm$

$u_{c1} := \varepsilon_x\cdot L$ $u_{c1} = 0.122071\,mm$ $v_{c1} := 0$

Akibat $\varepsilon_y := .633459418940800e\cdot$ $W := 50\,mm$

$u_{c2} := 0$ $v_{c2} := \varepsilon_y\cdot W$ $v_{c2} = 0.031673\,mm$

Akibat $\gamma_{xy} := -.90685615948800e\cdot$

$u_{c3} := \gamma_{xy}\cdot W$ $u_{c3} = -0.045343\,mm$ $v_{c3} := 0$

Jadi diperoleh total nilai:

$uc := u_{c1} + u_{c2} + u_{c3}$ $uc = 0.076728487\,mm$

$vc := v_{c1} + v_{c2} + v_{c3}$ $vc = 0.031673\,mm$