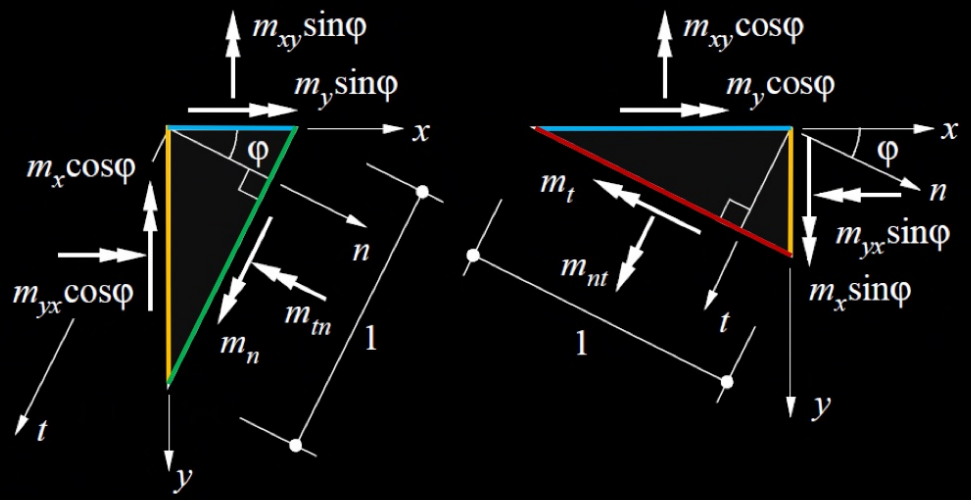
Slabs



Bending and twisting moments in any direction φ:

$$m_n = m_x \cos^2\varphi + m_y \sin^2\varphi + m_{xy} \sin 2\varphi$$

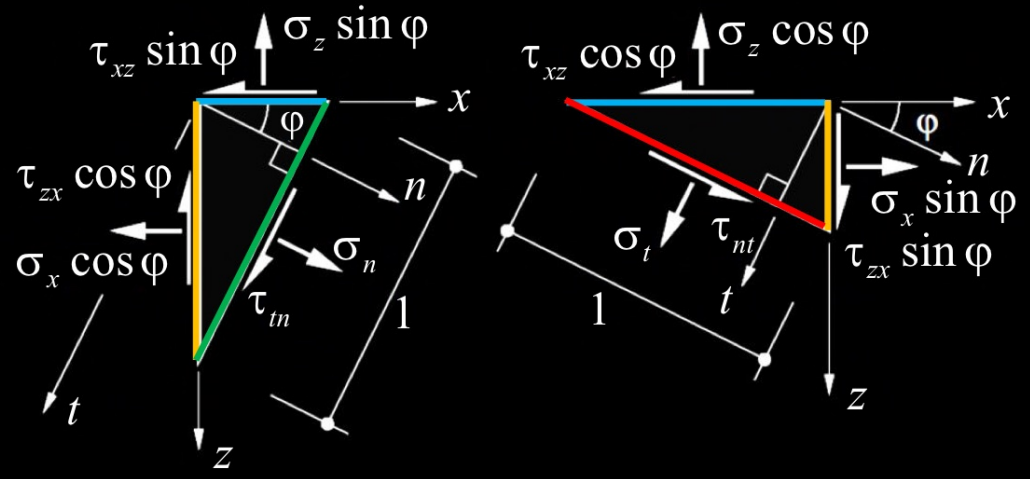
$$m_t = m_x \sin^2\varphi + m_y \cos^2\varphi - m_{xy} \sin 2\varphi$$

$$m_{tn} = (m_y - m_x)\sin\varphi\cos\varphi + m_{xy}\cos 2\varphi$$

NB: $\sin 2\varphi = 2\sin\varphi\cos\varphi$, $\cos 2\varphi = \cos^2\varphi - \sin^2\varphi$

Pr
m

Membranes



$$\sigma_n = \sigma_x \cos^2\varphi + \sigma_z \sin^2\varphi + 2\tau_{xz} \sin\varphi\cos\varphi$$

$$\sigma_t = \sigma_x \sin^2\varphi + \sigma_z \cos^2\varphi - 2\tau_{xz} \sin\varphi\cos\varphi$$

$$\tau_{nt} = (\sigma_z - \sigma_x)\sin\varphi\cos\varphi + \tau_{xz}(\cos^2\varphi - \sin^2\varphi)$$

Comparison of Normal Moment Yield Conditions for slabs and yield conditions of Regime 1 for membranes

Slabs

$$\left|\tan\varphi_u\right| = \sqrt{\frac{\left(m_{x,u} - m_x\right)}{\left(m_{y,u} - m_y\right)}}$$

$$m_{x,u} = m_x + m_{xy} \cdot \tan\varphi_u$$

$$m_{y,u} = m_y + m_{xy} \cdot \cot\varphi_u$$

resistance actions

Membranes

$$\tan\varphi_u = \frac{1}{\sqrt{\cot^2\varphi_u}} \qquad \cot^2\alpha = \frac{n_{xc}}{n_{zc}} = \frac{a_{sx} f_{sd} - n_x}{a_{sz} f_{sd} - n_z}$$

$$Y_1 = n_{xz}^2 - (a_{sx} f_{sx} - n_x)(a_{sz} f_{sz} - n_z) = 0$$

$$k = \cot\alpha \rightarrow \begin{cases} a_{sx} f_{sx} \geq n_x + k\left|n_{xz}\right| \\ a_{sz} f_{sz} \geq n_z + k^{-1}\left|n_{xz}\right| \end{cases}$$

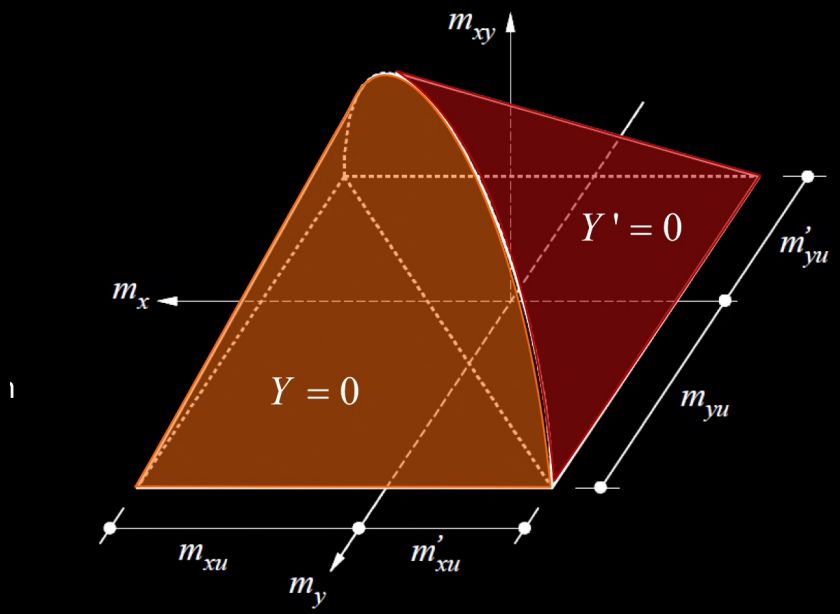
resistance loading

Comparison of Normal Moment Yield Conditions for slabs and yield conditions of Regime 1 for membranes

Slabs

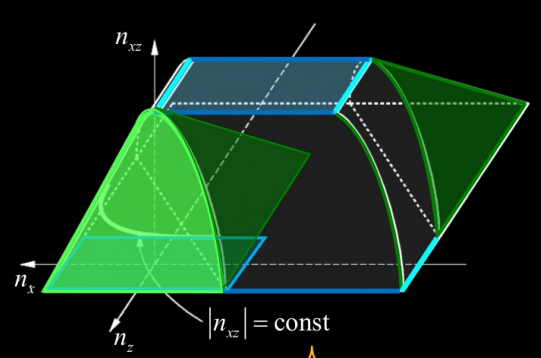
$$Y = m_{xy}^2 - (m_{x,u} - m_x)(m_{y,u} - m_y) = 0 \qquad (m_{x,u} - m_x \geq 0,\ m_{y,u} - m_y \geq 0)$$

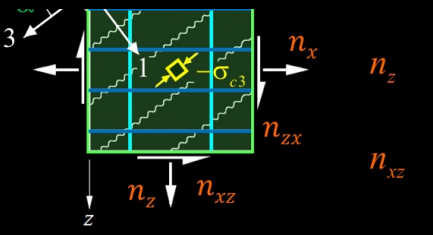
$$Y' = m_{xy}^2 - (m'_{x,u} + m_x)(m'_{y,u} + m_y) = 0 \qquad (m'_{x,u} + m_x \geq 0,\ m'_{y,u} + m_y \geq 0)$$



Membranes

$$Y_1 = n_{xz}^2 - (a_{sx} f_{sx} - n_x)(a_{sz} f_{sz} - n_z) = 0$$





Proce
Move
origin
(or vi

$-f'_s \leq \sigma_s \leq f_s$