Tangent Modulus: Steel

$E := 200000 \cdot MPa$

$F_y := 2600 \cdot \frac{kgf}{cm^2}$

Defining the modulus as the slope in the strain-stress diagram, one formulation can be taken

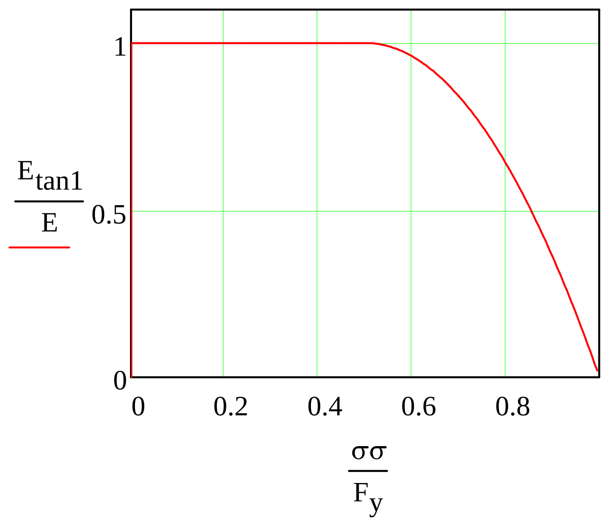
$$E_T(\sigma) := E \cdot \left| \begin{array}{ll} 4 \cdot \frac{\sigma}{F_y} \cdot \left(1 - \frac{\sigma}{F_y}\right) & \text{if } \sigma > 0.5 \cdot F_y \\ 1 & \text{otherwise} \end{array} \right.$$

$j := 1 .. 200$

$\sigma\sigma_j := F_y \cdot \left(\frac{j-1}{200}\right)$

$E_{tan1_j} := E_T\left(\sigma\sigma_j\right)$

Tangent Modulus as a Function of Stress level



$\sigma := 0.8 \cdot F_y$

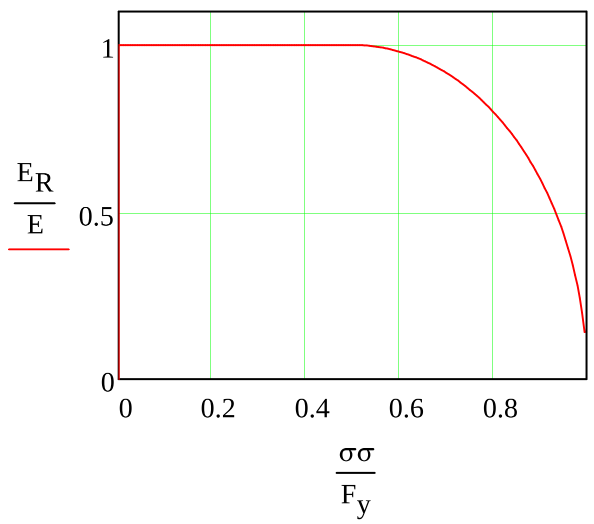
$\sigma = 2080 \cdot \frac{kgf}{cm^2}$

$E_T(\sigma) = 0.64 \cdot E$ $\qquad$ $E_T(\sigma) = 128000 \cdot MPa$

Reduced modulus sometimes used to ascertain the effects of material inelasticity while adhering to the use of elastic buckling formulations

$E_{root}(\sigma) := \sqrt{E \cdot E_T(\sigma)}$ $\qquad$ $E_{R_j} := E_{root}(\sigma\sigma_j)$

Reduced modulus to mimick inelastic effects



$E_{root}(\sigma) = 0.8 \cdot E$ $\qquad$ $E_{root}(\sigma) = 160000 \cdot MPa$

Comment: Although the root of the product of initial and tangent Young modulus is used much times to model inelastic effects in buckling, in other cases the tangent modulus itself (without modification) is used to such purpose

Strain-Stress Diagram for this steel

Now let be y represent the stress corresponding to the strain x, this in order to obtain the stress-strain diagram by ODESOLVE from what above obtained.
We have one initial value problem, where initial value and slope are known, and the differential equation is to equate slope to the value calculable from stress.

y will be the stress and x the strain

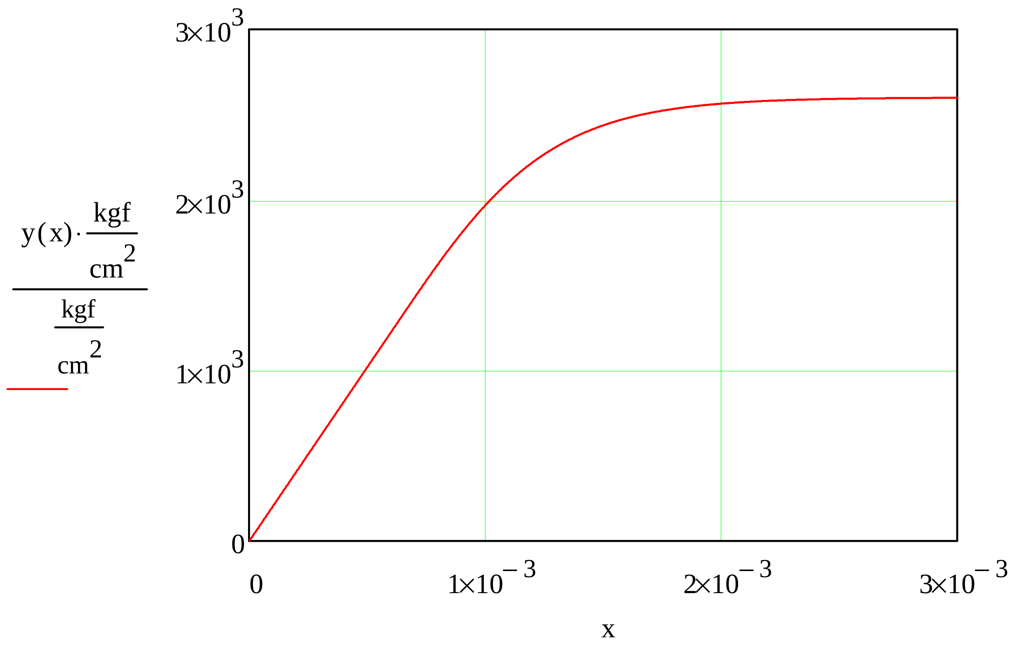
$$E_T(\text{ratio}) := \frac{E}{\frac{kgf}{cm^2}} \cdot \begin{cases} 4 \cdot \text{ratio} \cdot (1 - \text{ratio}) & \text{if ratio} > 0.5 \\ 1 & \text{otherwise} \end{cases}$$

$b := 0.003$

Given

$$\frac{d}{dx} y(x) = E_T\left(\frac{y(x)}{\frac{F_y}{\frac{kgf}{cm^2}}}\right) \qquad y(0) = 0$$

$y := \text{Odesolve}(x, b, 1000)$



$\varepsilon := 0.002$

$y(\varepsilon) = 2564.33$ implied kgf/cm2 in our solution as reduced to unitless