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Department of Civil Engineering
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ELASTIC BUCKLING OF STEEL COLUMNS UNDER THERMAL GRADIENT

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[Description]

Scope: Analytical treatment + buckling curves

Phenomena: Thermal gradient - shift of the centroid

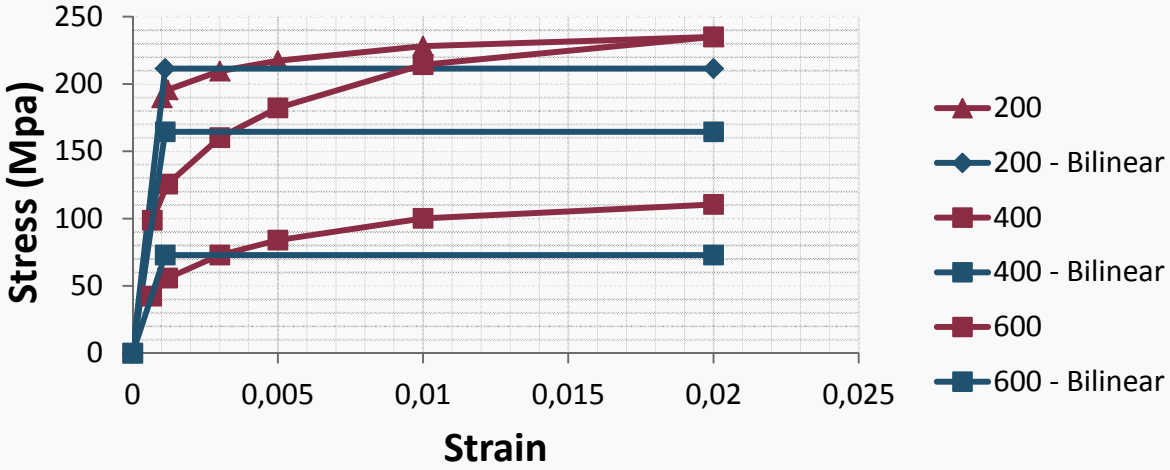
Thermal bowing

Implementation: IPE300 for several lengths

Linear temperature distribution

Bilinear material law

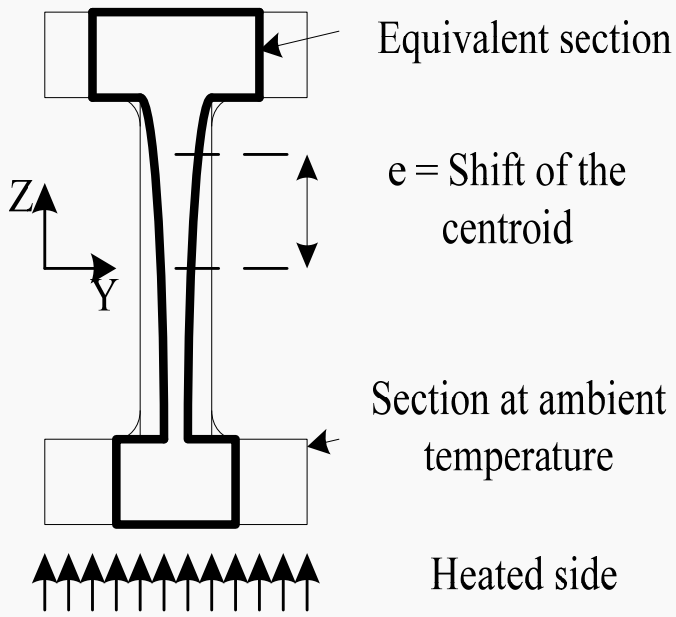
$$\frac{E_{\vartheta}}{E_{20}} = \frac{f_{y,\vartheta}}{f_{y,20}} = 2,347\sin\left(0,5275T + 2,6\right) + 0,193\sin\left(7,803T - 1,438\right)$$



Problem: Arbitrary field of modulii

Scope: Constant E_{20}

Solution: Scale the width of the section



The geometrical centroid of the equivalent section is:

$$z_g = \frac{\int_A E(\theta)\, z\, dA}{\int_A E(\theta)\, dA} \Rightarrow$$

$$z_g = \frac{\int_0^H \int_0^{Beq} z\, dy\, dz}{\int_0^H \int_0^{Beq} dy\, dz}$$

[1st approach]

Assumption: No thermal expansion

Equation: Bending of a beam-column by couples

Eccentrically applied axial force

Differential equation: $$P(e + w(x)) = -EI_{eq} w''(x)$$

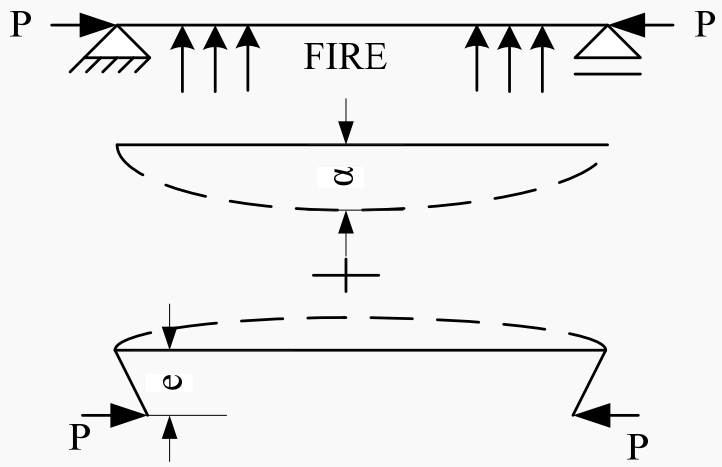
Initial yield criterion: $$\sigma_{y,\theta\max} = k_{E,\max} P\left(\frac{1}{A_{eq}} + \frac{e}{I_{eq}} c \sec\left(\frac{l}{2}\sqrt{\frac{P}{EI_{eq}}}\right)\right)$$

'The eccentricity that arises from the shift of the centroid cannot be studied independently of thermal expansion effects'

Coupled thermal gradient and thermal bowing effect

Assumption: No residual stresses

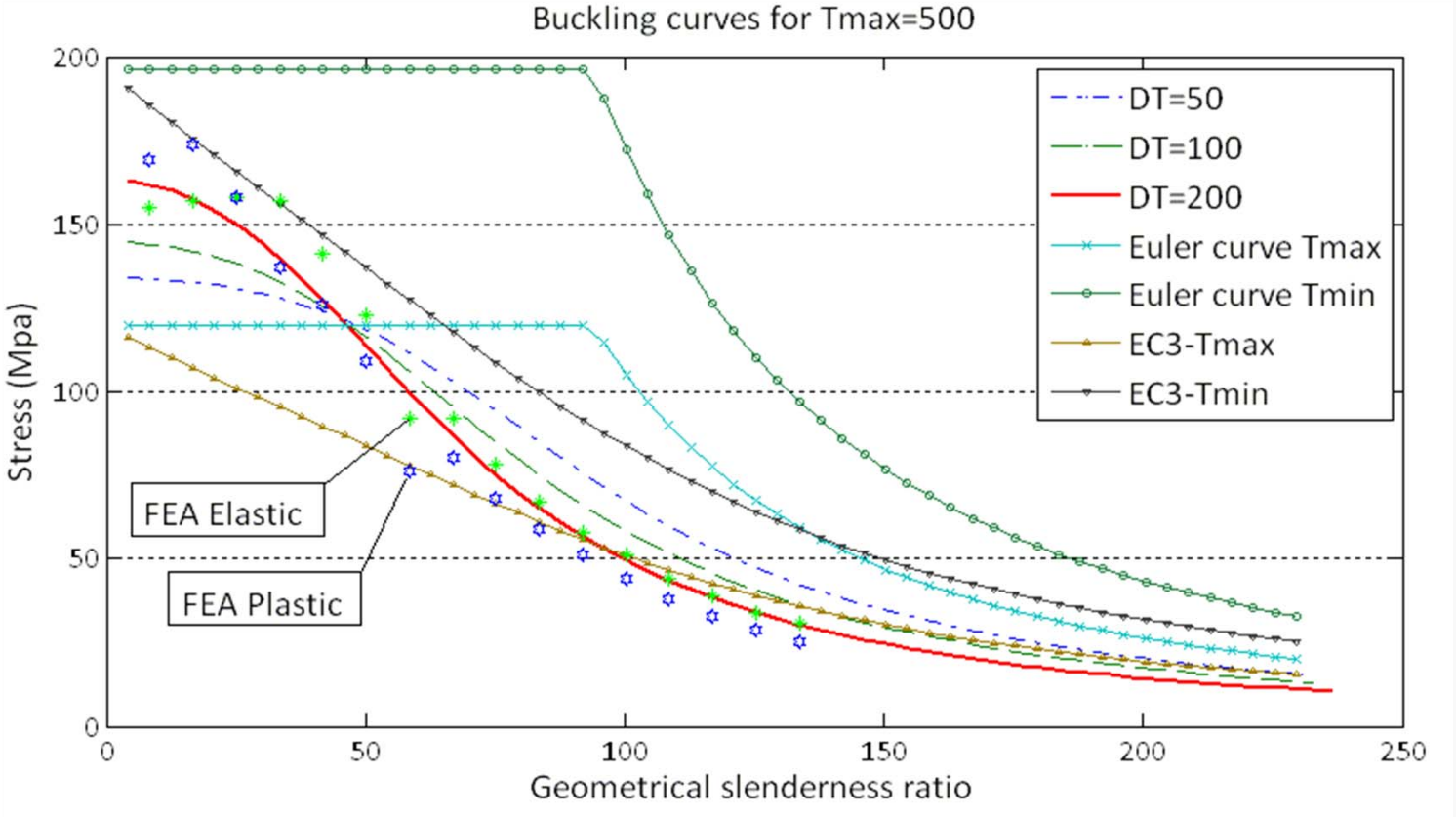
Equation: Beam-column with initial curvature



Deflection: $w(x) = U_{bow} - U_{ecc} + e \Rightarrow$

$$w(x) = \frac{a_{\Delta\vartheta}}{1 - P/P_{cr,eq}} \sin\left(\frac{\pi x}{l}\right) - \frac{M_0}{2EI_{eq}} x(l-x) + e$$

[Conclusions]



Good agreement between the analytical solution and the finite element analysis

The equation will be studied for various types of steel cross-sections and thermal cases

…thank you