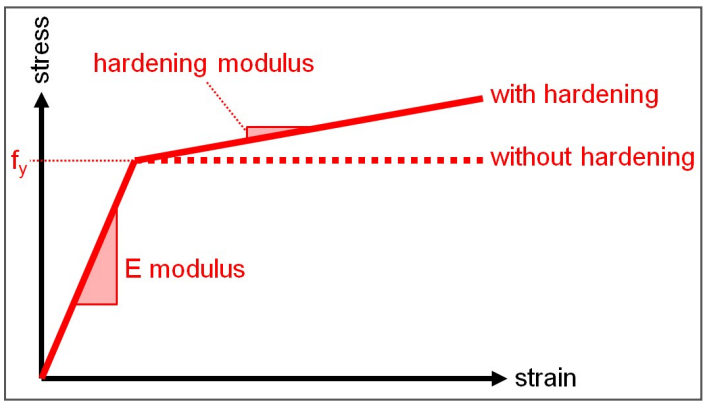
Plastic Analysis Of Surface Members

esas.47

Highlights
Non-linear material behaviour for 2D members
Can be combined with other non-linearities in SCIA Engineer

SCIA Engineer offers development related to non-linear calculations. This non-linearity lies in the behaviour of material. SCIA Engineer implements a new type of material behaviour for 2D members (plates, walls, shells) - plasticity. The plastic zone is based on the *isotropic elasto-plastic von Mises* yield condition (J2 plasticity condition). The von Mises yield condition is suitable for ductile materials in general, such as metals (steel, aluminium etc.). It corresponds to a bilinear stress- strain relationship, identical in tension and compression. The plastic branch may have a slope (hardening modulus) or not.

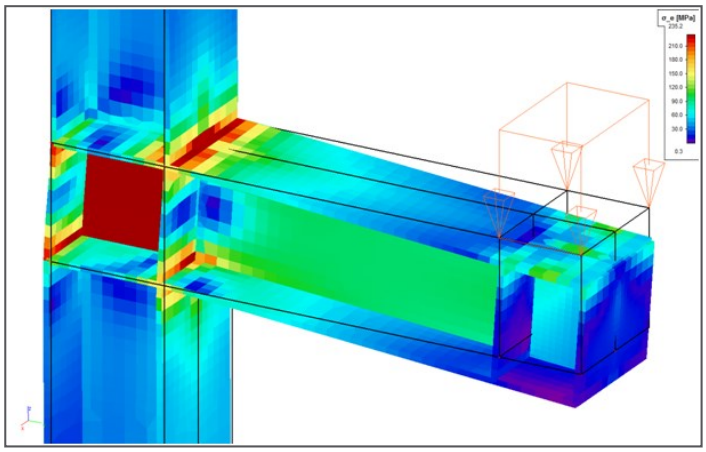


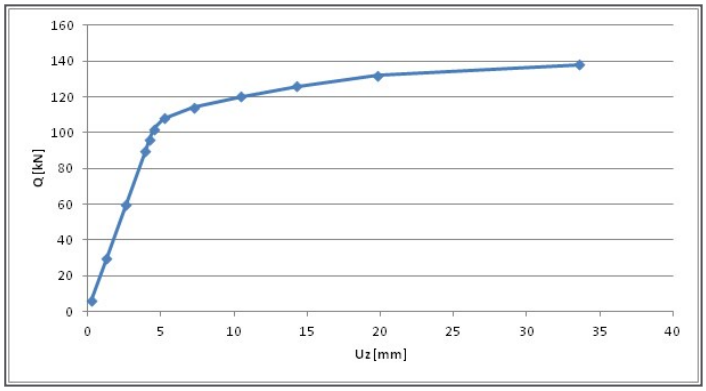
It is a symmetric behaviour, acting in the same way in tension and compression, with or without hardening in the plastic branch.

The plastic behaviour of materials may be combined with other types of non-linearity in SCIA Engineer. For instance, plasticity, press only supports and large displacement analysis can be used together. Tension only 1D members with a plastic limit forces may be used to model the behaviour of bolts in a connection.

The typical first application of general plasticity is the detailed analysis of non-standard steel construction connections, where simplified methods do not apply. It may however be applied to any structure that can be modelled using 2D members.

Plasticity is not supported yet for 1D members. Any beam or truss member that is present in the model will be considered as elastic.





Theoretical background

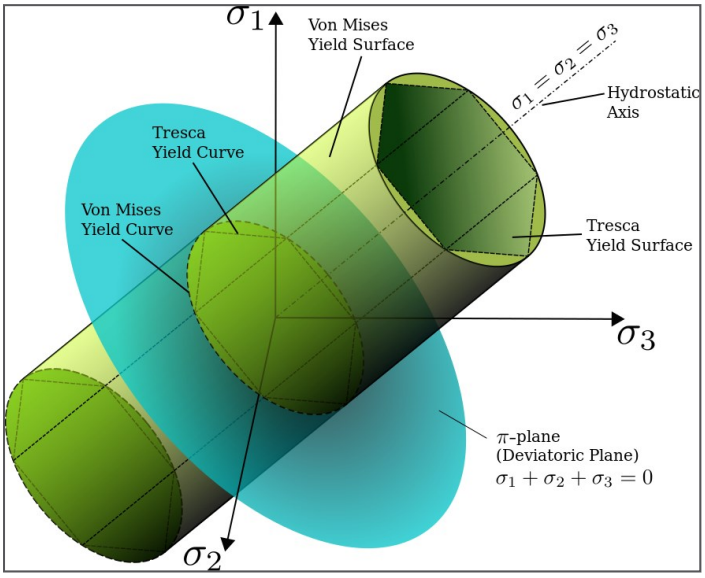
Von Mises yield criterion

The **von Mises yield criterion** suggests that the yielding of materials begins when the second deviatoric stress invariant J_2 reaches a critical value. For this reason, it is sometimes called the J2-plasticity or J2 flow theory. It is part of a plasticity theory that applies best to ductile materials, such as metals. Prior to yield, material response is assumed to be elastic.

In materials science and engineering the von Mises yield criterion can be also formulated in terms of the von Mises stress or equivalent tensile stress, σ_E, a scalar stress value that can be computed from the Cauchy stress tensor. In this case, a material is said to start yielding when its von Mises stress reaches a critical value known as the yield strength, σ_y. The von Mises stress is used to predict yielding of materials under any loading condition from results of simple uniaxial tensile tests. The von Mises stress satisfies the property that two stress states with equal distortion energy have equal von Mises stress.

Because the von Mises yield criterion is independent of the first stress invariant, I_1, it is applicable for the analysis of plastic deformation for ductile materials such as metals, as the onset of yield for these materials does not depend on the hydrostatic component of the stress tensor.

Although formulated by Maxwell in 1865, it is generally attributed to Richard Edler von Mises (1913). Tytus Maksymilian Huber (1904), in a paper in Polish, anticipated to some extent this criterion. This criterion is also referred to as the Maxwell–Huber–Hencky–von Mises theory.



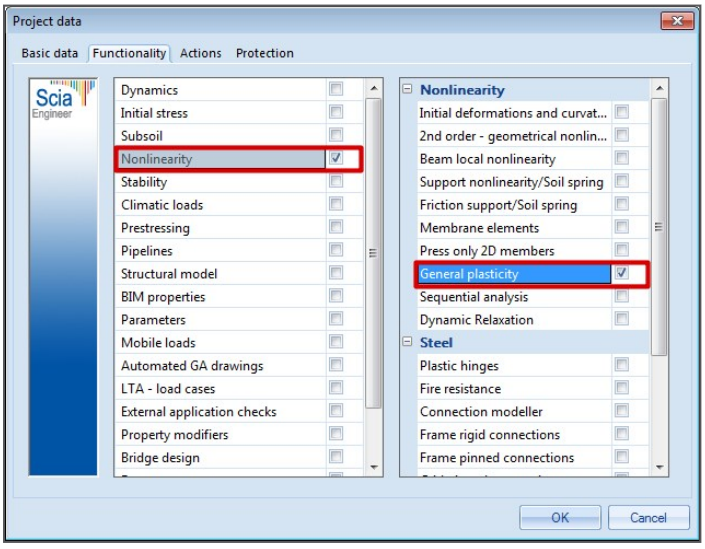
The formulation of the von Mises comparison stress in a general 3D stress-state is given by:

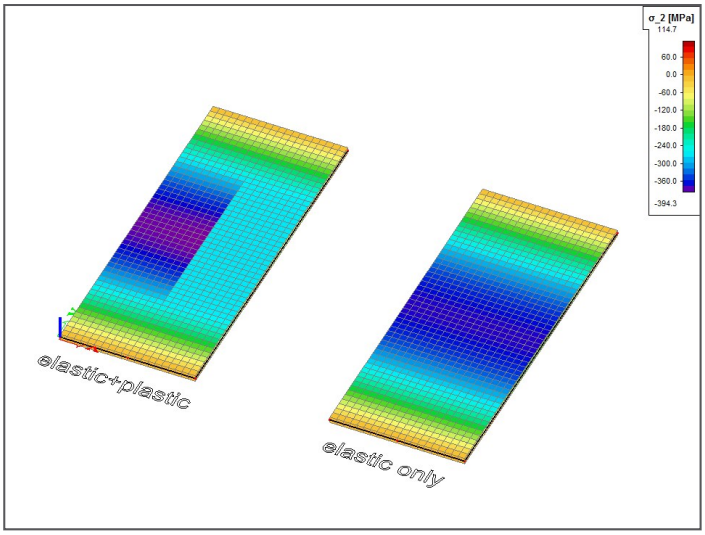
$$\sigma_E = \sqrt{\frac{1}{2} \cdot \left[(\sigma_{11} - \sigma_{22})^2 + (\sigma_{22} - \sigma_{33})^2 + (\sigma_{33} - \sigma_{11})^2 + 6 \cdot \left(\sigma_{12}^2 + \sigma_{23}^2 + \sigma_{31}^2 \right) \right]}$$

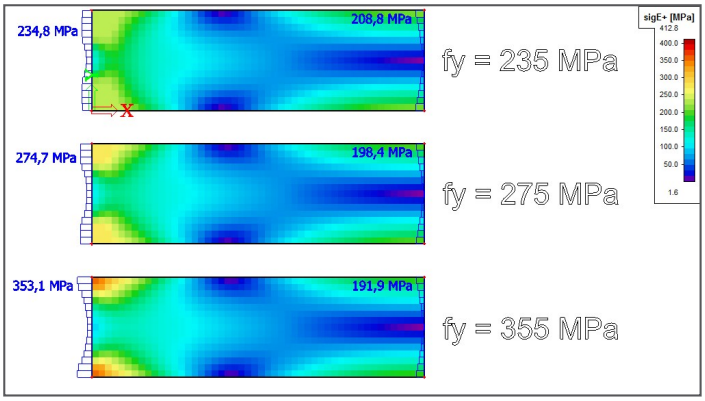
source: Wikipedia http://en.wikipedia.org/wiki/Von_ Mises_ yield_ criterion

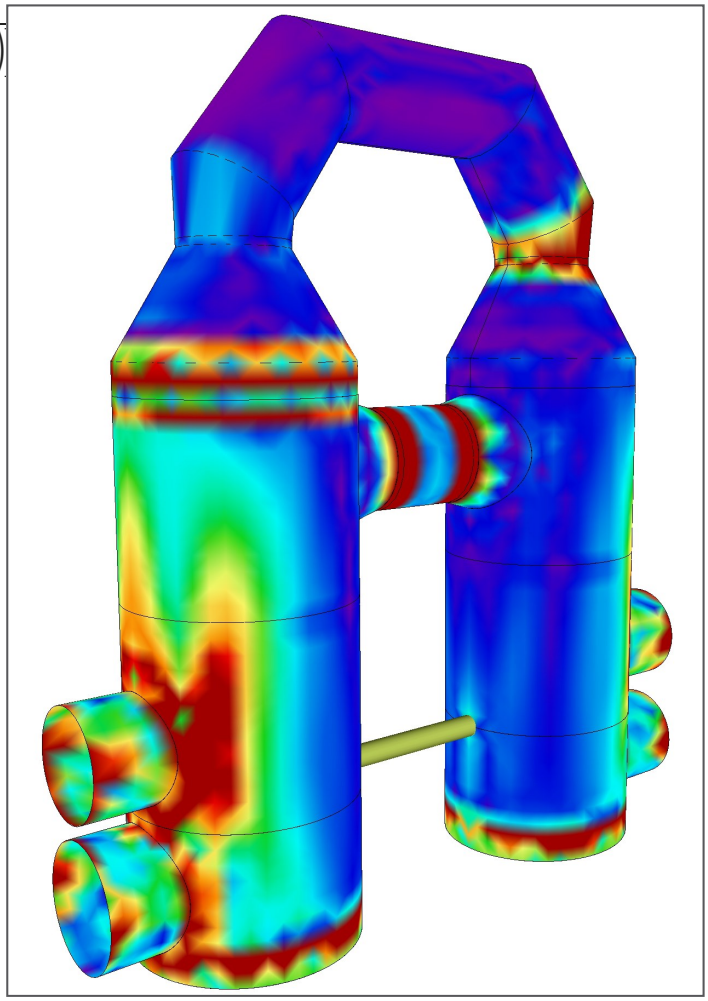
Using general plasticity in SCIA Engineer

General plasticity is a specific type of non-linearity in SCIA Engineer. After defining the suitable data in the project a non-linear analysis must be carried out to calculate the plastic behaviour of the structure. Please refer to the general information about non-linear analysis in SCIA Engineer. General plasticity is a sub-functionality of non-linear analysis. In the project settings, in the *Functionality* tab, enable *Non-linearity* and *General plasticity*.









Required modules

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