

2D plane strain plasticity

REFERENCE	Background to Material Non-Linear Benchmarks, Ref . R0049, NAFEMS, Glasgow, 1998
MODEL FILENAME	2D Plane Strain.nfx

Figure 1 shows a 2D plane strain model undergoing elastic-plastic deformation. Two plasticity models are considered; a perfect plasticity model and an isotropic hardening model. Plane strain elements are incorporated to evaluate the nonlinear response. The loading conditions are summarized in Table 1.

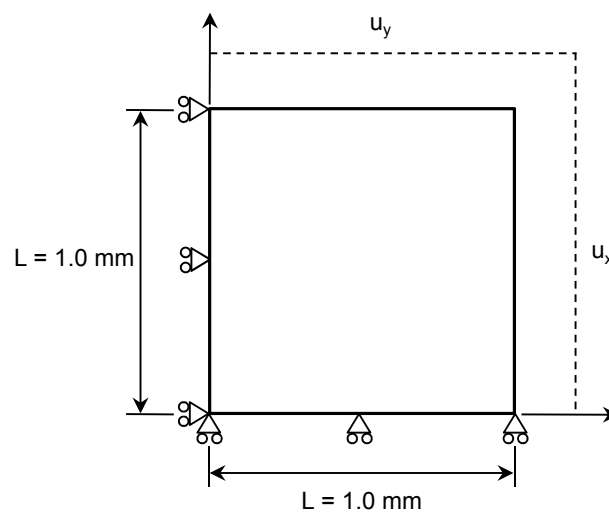
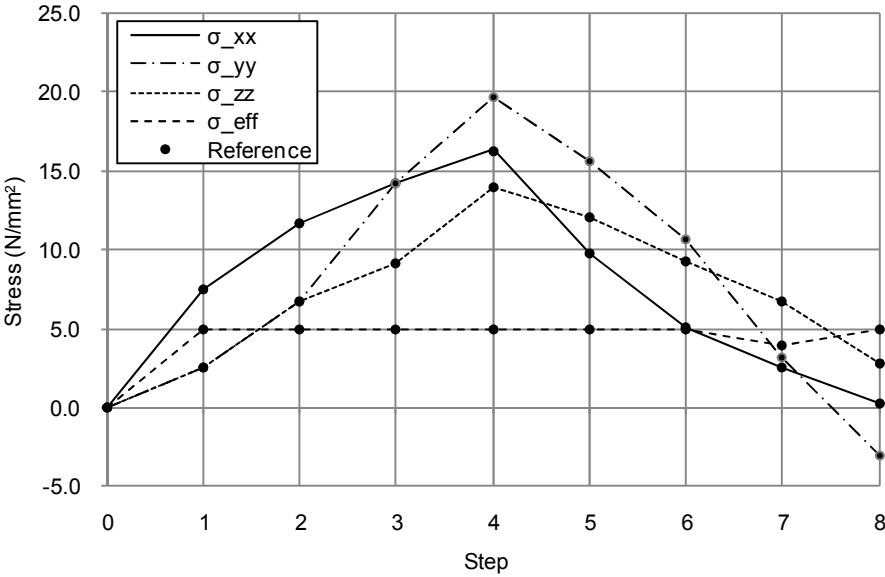
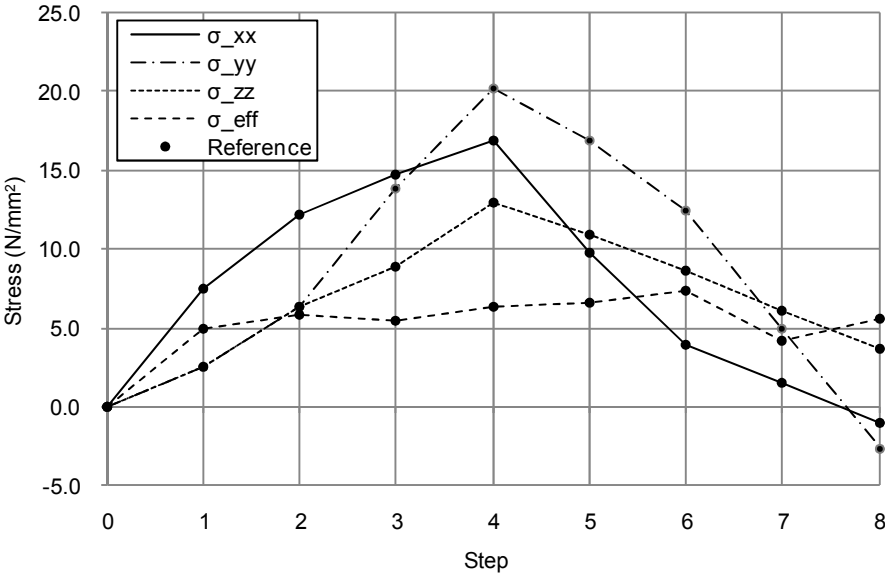


Figure 1. 2D plane strain model

Material data	Young's modulus	$E = 250.0 \times 10^3 \text{ N/mm}^2$
	Poisson's ratio	$\nu = 0.25$
	Perfect plasticity	$\sigma_Y = 5.0 \text{ N/mm}^2$
	Isotropic hardening	$E_T = 50.0 \times 10^3 \text{ N/mm}^2$

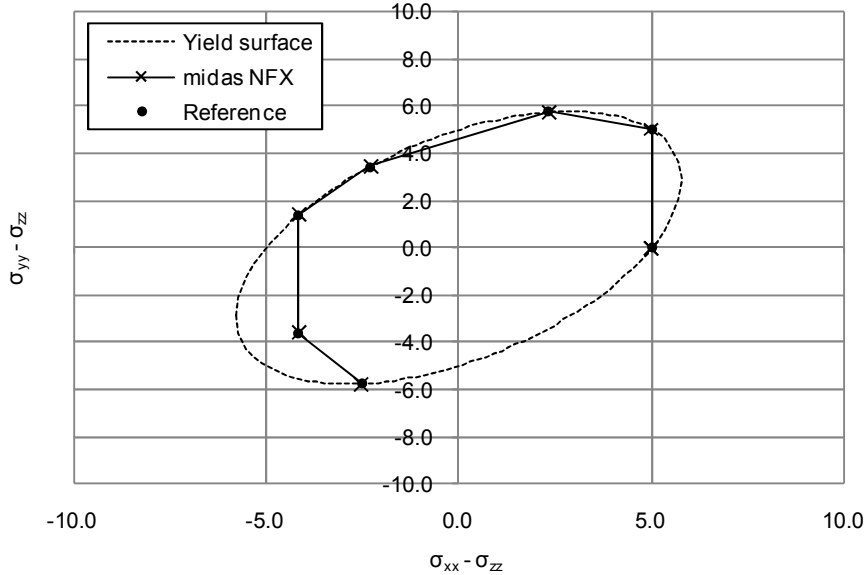


(a) Perfect plasticity

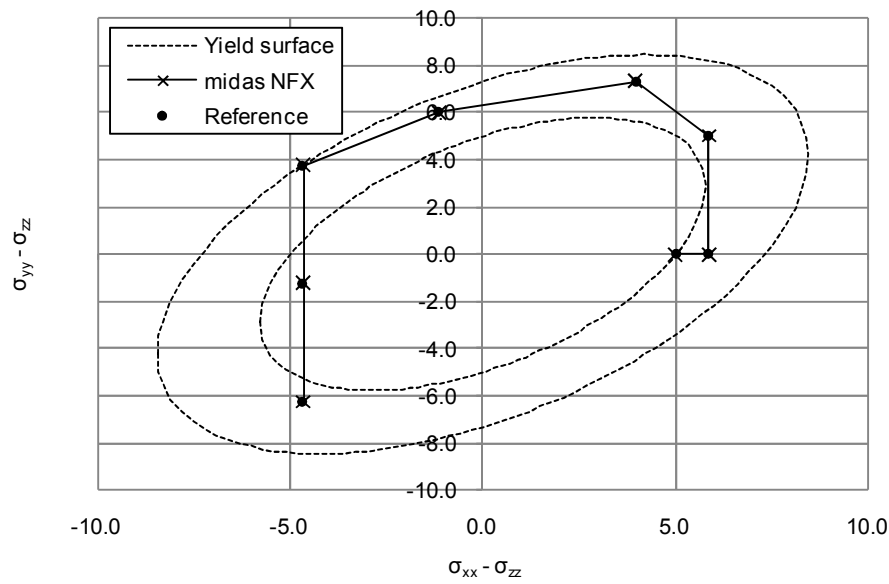


(b) Isotropic hardening

Figure 2. Stress variation obtained using plane strain elements



(a) Perfect plasticity



(b) Isotropic hardening

Figure 3. Stress path obtained using plane strain elements

Table 1. Displacements prescribed in 8 increments ($R = 2.5 \times 10^{-5}$)

Step	Disp. change	δ_x [mm]	δ_y [mm]	Stress state
Step 1	$\Delta u_x = R$	R	0.0	<i>first yield</i>
Step 2	$\Delta u_x = R$	$2R$	0.0	<i>plastic flow</i>
Step 3	$\Delta u_y = R$	$2R$	R	<i>elastic unloading</i>
Step 4	$\Delta u_y = R$	$2R$	$2R$	<i>plastic reloading</i>
Step 5	$\Delta u_x = -R$	R	$2R$	<i>plastic flow</i>
Step 6	$\Delta u_x = -R$	0.0	$2R$	<i>plastic flow</i>
Step 7	$\Delta u_y = -R$	0.0	R	<i>elastic unloading</i>
Step 8	$\Delta u_y = -R$	0.0	0.0	<i>plastic flow</i>

Table 2. Stress obtained at step 4, perfect plasticity

	No. of elements	σ_{xx} [N/mm ²]	σ_{yy} [N/mm ²]	σ_{zz} [N/mm ²]	σ_{eff} [N/mm ²]
Reference		16.31210	19.71433	13.97358	5.000000
QUAD-4	1	16.32229	19.71016	13.96755	5.000000

Table 3. Stress obtained at step 4, isotropic hardening

	No. of elements	σ_{xx} [N/mm ²]	σ_{yy} [N/mm ²]	σ_{zz} [N/mm ²]	σ_{eff} [N/mm ²]
Reference		16.85673	20.24083	12.90243	6.361633
QUAD-4	1	16.86400	20.23665	12.89935	6.361184