SSNP124 – Biaxial test drained with a behavior DRUCK_PRAGER polishing substance

Summary:

This case test makes it possible to implement a biaxial test drained according to local and not-local approaches on four different modelings during a nonlinear calculation. That makes it possible to propose the effect of the type of work hardening negative, parabolic or linear, in the case of models D_PLAN or D_PLAN_GRAD_EPSI.

Modeling A
- Model of the type "DRUCK_PRAGER" with linear negative work hardening for a containment of $2\,Mpa$.
- model D_PLAN with meshs QUAD4.

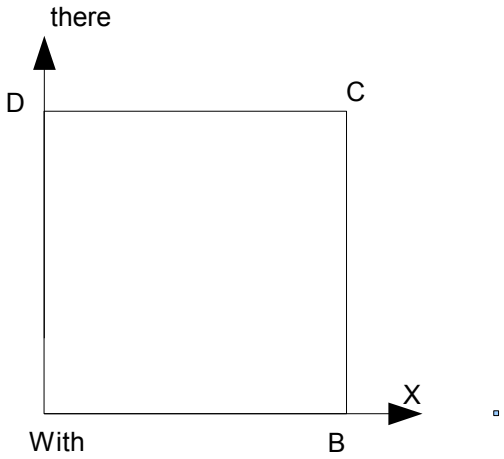
Modeling b:
- Model of the type "DRUCK_PRAGER" with parabolic negative work hardening for a containment of $2\,MPa$.
- model D_PLAN with meshs QUAD4.

Modeling C:
- Model of the type "DRUCK_PRAGER" with linear negative work hardening for a containment of $2\,MPa$.
- model D_PLAN_GRAD_EPSI with meshs QUAD8.

Modeling D:
- Model of the type "DRUCK_PRAGER" with parabolic negative work hardening for a containment of $2\,Mpa$
- model D_PLAN_GRAD_EPSI with meshs QUAD8.

1 Problem of reference

1.1 Geometry



- Dimension of the square: $1\mathrm{m}\times 1\mathrm{m}$.

1.2 Properties of material

Rubber band
- $E=5800.0\,E6\,Pa$ Young modulus
- $\nu=0.3$ Poisson's ratio

DRUCK_PRAGER with linear negative work hardening
- $\alpha=0.33$ Coefficient of dependence in pressure
- $p_{ultm}=0.01$ Ultimate cumulated plastic deformation
- $\sigma^{Y}=2.57\,E6\,Pa$ Plastic constraint
- $h=-2.\,E8\,Pa$ Module of work hardening

DRUCK_PRAGER with parabolic negative work hardening
- $\alpha=0.33$ Coefficient of dependence in pressure
- $p_{ultm}=0.01$ Ultimate cumulated plastic deformation
- $\sigma^{Y}=2.57\,E6\,Pa$ Plastic constraint
- $\sigma^{Y}_{ultm}=0.57\,E6\,Pa$ Ultimate constraint

1.3 Boundary conditions and loadings

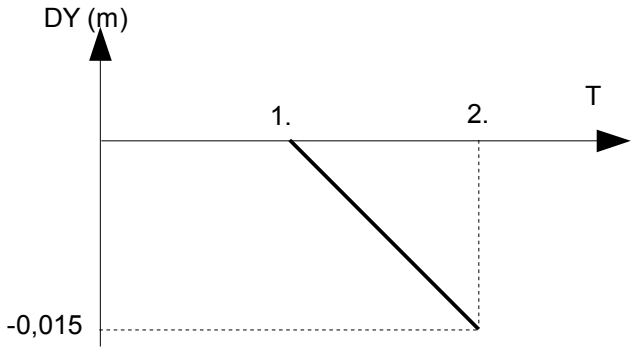
The boundary conditions and the loadings applied are the following:

Imposed loadings: the loadings are constant $t \in]1,2.]$

- Dimensioned $BC \quad p = 2.10^6 \, Pa$

Displacements imposed on:

- Dimensioned $AB \quad DY = 0.$
- Dimensioned $DA \quad DX = 0.$
- Displacements vary on CD gradually, on the interval $t \in]1,2.]$, according to a slope, as on the figure below:
  $t = 1. \quad DY = 0.$
  $t = 2. \quad DY = -0.015$



1.4 Initial conditions

- Initial conditions (Pa)

SIXX	SIYY	SIZZ	SIXY	SIXZ	SIYZ
-2. E6	-2. E6	-2. E6	0.0	0.0	0.0

SIP	M11	FH11X	FH11Y
0.0	0.0	0.0	0.0

2 Reference solution

2.1 Method of calculating used for the reference solution

- Displacement DY
  Displacement DY of reference to the point C corresponds to imposed displacement.
  $DY=-0.015(t-1)$

- Constraint $SIXX$
  The constraint $SIXX$ corresponds to the loading applied

- Constraint $SIYY$ and cumulated plastic deformation $V1$
  Values of reference of the constraint $SIYY$ and of the cumulated plastic deformation $V1$ are values of not-regression.

2.2 Reference variables

- Constraint $SIXX$ at the point C
- Constraint $SIYY$ at the point C
- Cumulated plastic deformation $V1$ at the point C
- Displacement DY at the point C

2.3 Result of reference

Size	Not	$Inst$	Référence*	Reference **
$SIXX\ (Pa)$	C	2.0	$-2.0\,E6$	$-2.0\,E6$
$SIYY\,(Pa)$	C	1.07	$-8.69\,E6$	$-8.69\,E6$
		1.16	$-1.39\,E7$	$-1.37\,E7$
		1.34	$-9.90\,E6$	$-9.90\,E6$
		1.53	$-9.91\,E6$	$-9.90\,E6$
$V1$	C	1.07	0	0
		1.16	$1.20\,E-3$	$1.26\,E-3$
		1.34	$1.12\,E-2$	$1.12\,E-2$
		1.53	$2.01\,E-2$	$2.01\,E-2$
$DY\ (m)$	C	1.07	$-1.05\,E-3$	$-1.05\,E-3$
		1.16	$-2.40\,E-3$	$-2.40\,E-3$
		1.34	$-5.10\,E-3$	$-5.10\,E-3$
		1.53	$-7.95\,E-3$	$-7.95\,E-3$

* linear work hardening ** parabolic work hardening

2.4 Uncertainty on the solution

- Analytical solution for the sizes DY and $SIXX$

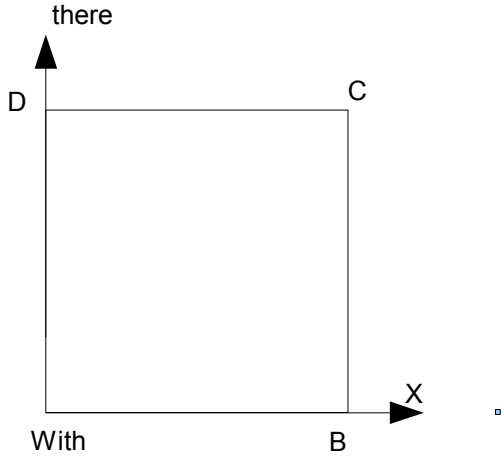
- Digital solution for the sizes $SIYY$ and VI

3 Modeling A

3.1 Characteristics of modeling A

Modeling D_PLAN.

Behavior of DRUCK_PRAGER with linear negative work hardening.



Many nodes 4

Many meshs 5 That is to say:

SEG2	4
QUAD4	1

The square is in space $[0.,1.]\times[0.,1.]$.

Coordinates of the points (m) :

$$A:(0.,0.)$$
$$B:(1.,0.)$$
$$C:(1.,1.)$$
$$D:(0.,1.)$$

Groups of nodes:

$$A, B$$

Meshs

$M1$: surface $ABDC$
$M2$: segment AB
$M3$: segment BC
$M4$: segment CD
$M5$: segment DA

3.2 Results

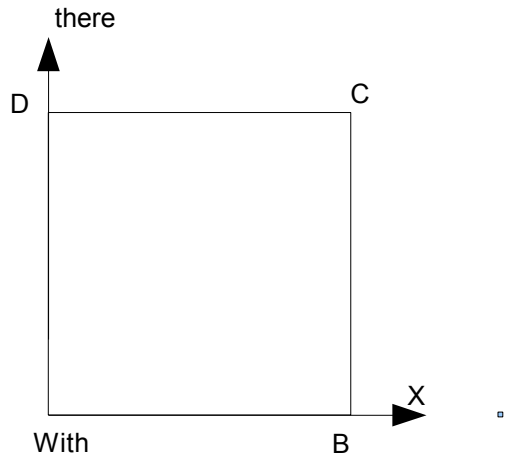
Size	Not	*Inst*	Reference	Tolerance (%)
$SIXX\ (Pa)$	C	2.0	$-2.0\ E6$	0.1
$SIYY\ (Pa)$	C	1.07	$-8.69\ E6$	0.1
		1.16	$-1.39\ E7$	0.1
		1.34	$-9.90\ E6$	0.1
		1.53	$-9.91\ E6$	0.1
$V1$	C	1.07	0	0.1
		1.16	$1.20\ E-3$	0.1
		1.34	$1.12\ E-2$	0.1
		1.53	$2.01\ E-2$	0.1
$DY\ (m)$	C	1.07	$-1.05\ E-3$	0.1
		1.16	$-2.40\ E-3$	0.1
		1.34	$-5.10\ E-3$	0.1
		1.53	$-7.95\ E-3$	0.1

4 Modeling B

4.1 Characteristics of modeling B

Modeling D_PLAN.

Behavior of DRUCK_PRAGER with parabolic negative work hardening.



Many nodes 4

Many meshs 5 That is to say:

SEG2 4

QUAD4 1

The square is in space $[0.,1.]\times[0.,1.]$.

Coordinates of the points (m) :

$A:(0.,0.)$
$B:(1.,0.)$
$C:(1.,1.)$
$D:(0.,1.)$

Groups of nodes:

A, B

Meshs

$M1$: surface $ABDC$
$M2$: segment AB
$M3$: segment BC
$M4$: segment CD
$M5$: segment DA

4.2 Sizes tested and results

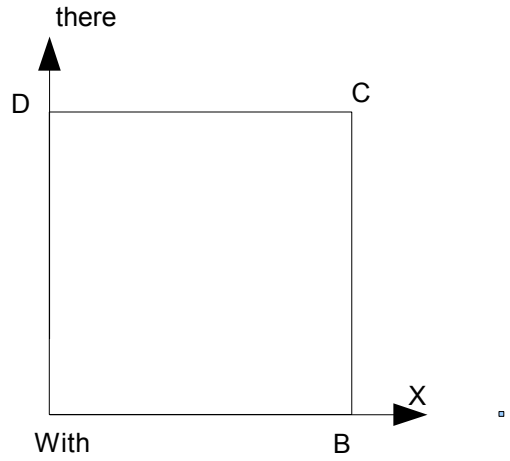
Size	Not	$Inst$	Reference	Tolerance (%)
$SIXX\ (Pa)$	C	2.0	$-2.0\ E6$	0.1
$SIYY\ (Pa)$	C	1.07	$-8.69\ E6$	0.1
		1.16	$-1.37\ E7$	0.1
		1.34	$-9.90\ E6$	0.1
		1.53	$-9.91\ E6$	0.1
$V1$	C	1.07	0	0.1
		1.16	$1.26\ E-3$	0.1
		1.34	$1.12\ E-2$	0.1
		1.53	$2.01\ E-2$	0.1
$DY\ (m)$	C	1.07	$-1.05\ E-3$	0.1
		1.16	$-2.40\ E-3$	0.1
		1.34	$-5.10\ E-3$	0.1
		1.53	$-7.95\ E-3$	0.1

5 Modeling C

5.1 Characteristics of modeling C

Modeling D_PLAN_GRAD_EPSI.

Behavior of DRUCK_PRAGER with linear negative work hardening.



Many nodes 8

Many meshs 5 That is to say:

SEG3 4

QUAD8 1

The square is in space $[0.,1.]\times[0.,1.]$.

Coordinates of the points (m) :

$A:(0.,0.)$
$B:(1.,0.)$
$C:(1.,1.)$
$D:(0.,1.)$

Groups of nodes:

A, B, C, D

Groups of meshs:

$BLOC$: surface ABCD

AB, BC, CD, DA

5.2 Sizes tested and results

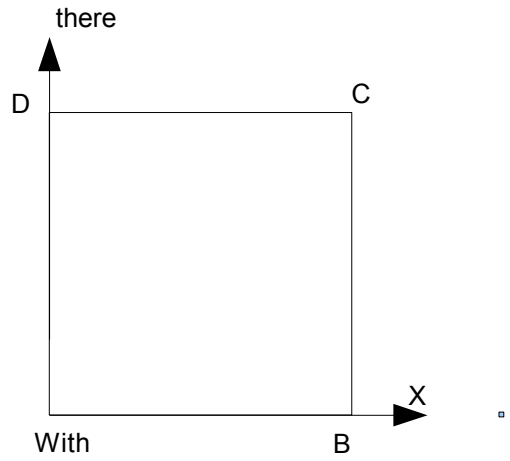
Size	Not	$Inst$	Reference	Tolerance (%)
$SIXX\ (Pa)$	C	2.0	$-2.0\,E6$	0.1
$SIYY\,(Pa)$	C	1.07	$-8.69\,E6$	0.1
		1.16	$-1.39\,E7$	0.1
		1.34	$-9.90\,E6$	0.1
		1.53	$-9.91\,E6$	0.1
$V1$	C	1.07	0	0.1
		1.16	$1.20\,E-3$	0.1
		1.34	$1.12\,E-2$	0.1
		1.53	$2.01\,E-2$	0.1
$DY\ (m)$	C	1.07	$-1.05\,E-3$	0.1
		1.16	$-2.40\,E-3$	0.1
		1.34	$-5.10\,E-3$	0.1
		1.53	$-7.95\,E-3$	0.1

6 Modeling D

6.1 Characteristics of modeling D

Modeling D_PLAN_GRAD_EPSI.

Behavior of DRUCK_PRAGER with parabolic negative work hardening.



Many nodes 8

Many meshs 5 That is to say:

SEG3 4

QUAD8 1

The square is in space $[0.,1.]\times[0.,1.]$.

Coordinates of the points (m) :

$A:(0.,0.)$
$B:(1.,0.)$
$C:(1.,1.)$
$D:(0.,1.)$

Groups of nodes:

A, B, C, D

Groups of meshs:

$BLOC$: surface $ABDC$
AB, BC, CD, DA

6.2 Sizes tested and results

Size	Not	$Inst$	Reference	Tolerance (%)
$SIXX\ (Pa)$	C	2.0	$-2.0\,E6$	0.1
$SIYY\ (Pa)$	C	1.07	$-8.69\,E6$	0.1
		1.16	$-1.37\,E7$	0.1
		1.34	$-9.90\,E6$	0.1
		1.53	$-9.91\,E6$	0.1
$V1$	C	1.07	0	0.1
		1.16	$1.26\,E-3$	0.1
		1.34	$1.12\,E-2$	0.1
		1.53	$2.01\,E-2$	0.1
$DY\ (m)$	C	1.07	$-1.05\,E-3$	0.1
		1.16	$-2.40\,E-3$	0.1
		1.34	$-5.10\,E-3$	0.1
		1.53	$-7.95\,E-3$	0.1

7 Summary of the results

The law of behavior of the type DRUCK_PRAGER with a linear negative work hardening and a parabolic negative work hardening gives satisfactory results with modelings D_PLAN and D_PLAN_GRAD_EPSI.