SSNV233 – Test of torsion with the law of Mohr-Coulomb

Summary:

One is carried out test of torsion with the law of Mohr-Coulomb. The objective of the test is to check the good convergence of the model in the presence of rotation of the principal constraints. The calculated tangent matrix is compared with that obtained by disturbance.

1 Problem of reference

1.1 Geometry

One reproduces a test of torsion on a hollow roll subjected to confining pressures interior P_i and external P_e, with a vertical force F and at one torque M. One schematizes this test by a cubic sample (a material point) subjected to the constraints of containment σ_z, σ_r and σ_θ, and with a shearing strain $\varepsilon_{z\theta}=M(t)$ (**Figure 1.1-a**).

If $P_i=P_e=\sigma_0$ and $F=\frac{2\sigma_0}{\pi}$, the following values of containment are obtained:

- $\sigma_\theta=\sigma_r=\sigma_0$
- $\sigma_z=3\sigma_0$

One then has the following values of the principal constraints:

- $\sigma_1=2\sigma_0+|\sigma_{z\theta}|$
- $\sigma_2=\sigma_0$
- $\sigma_3=2\sigma_0-|\sigma_{z\theta}|$

But especially, the main axes turn of an angle α equal to [**1**]:

$$\alpha(t)=\frac{1}{2}\arctan\left(\frac{2\sigma_{z\theta}(t)}{\sigma_z-\sigma_\theta}\right)=\frac{1}{2}\arctan\left(\frac{\sigma_{z\theta}(t)}{\sigma_0}\right)$$

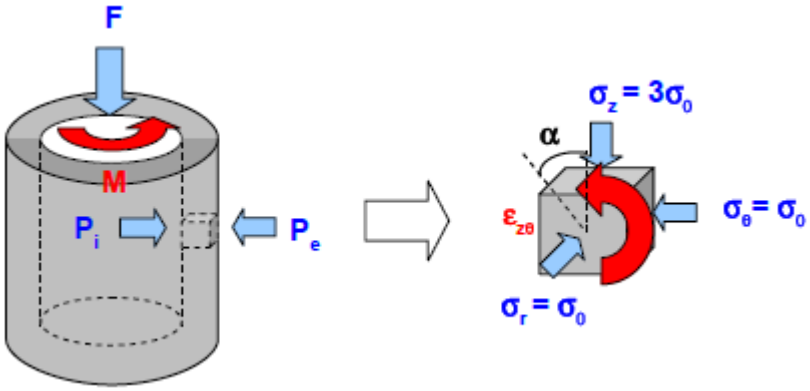

Figure 1.1-a: Schematization of the test of torsion on a hollow roll

1.2 Properties of the sample

The elastic parameters are:

- the isotropic module of compressibility: $K=516{,}2\,MPa$
- the modulus of rigidity: $\mu=238{,}2\,MPa$

Parameters of the law of Mohr-Coulomb are:

- the angle of friction: $\phi=33°$
- the characteristic angle: $\Psi=27°$
- cohesion: $c_0=1\,kPa$

1.3 Boundary conditions and loadings

The test of torsion presented here is carried out on a material point with the order SIMU_POINT_MAT.

One measures a confining pressure $\sigma_0 = -50\,kPa$. The imposed constraints are thus the following ones:

- $\sigma_{xx} = \sigma_{yy} = -50\,kPa$
- $\sigma_{zz} = -150\,kPa$

Shearing strain imposed ε_{yz} vary linearly enters $t = 0$ and $100\,sec$ of 0 with $0{,}01\,\%$ in $N = 10$ pas de time.

2 Reference solution

It is checked that $N^{num} < N^{per}$ with each step of time.

The calculated tangent matrix is thus better than that obtained by disturbance, like one shows it in the paragraph §4, thanks to the best taken into account of the multiple mechanisms of the law of behavior.

3 Modeling A

3.1 Characteristics of modeling

Modeling is carried out on a material point with SIMU_POINT_MAT.

The recutting of the step of time is active.

The convergence criteria are RESI_GLOB_RELA = 10^{-10}.

3.2 Sizes tested and results

One at every moment measures the difference between the iteration count of Newton given by the calculated tangent matrix NB_ITER_1 and that given by the tangent matrix by disturbance NB_ITER_2. The test consists in checking that $NB\_ITER\_1-NB\_ITER\_2\leq 0$ at every moment:

$t[sec]$	$NB\_ITER\_1-NB\_ITER\_2$	Value of reference	Tolerance $[\%]$
10	0	0	0
20	0	0	0
30	0	0	0
40	0	0	0
50	-8	0	0
60	-11	0	0
70	-11	0	0
80	-11	0	0
90	-11	0	0
100	-11	0	0

4 Summary of the results

In the figure below, one presents a comparison of the iterations of Newton between the case of the calculated tangent matrix and that of the tangent matrix by disturbance. One notes that the calculated tangent matrix is much more powerful than that by disturbance, thanks to the best taken into account of the multiple mechanisms of the law of behavior.

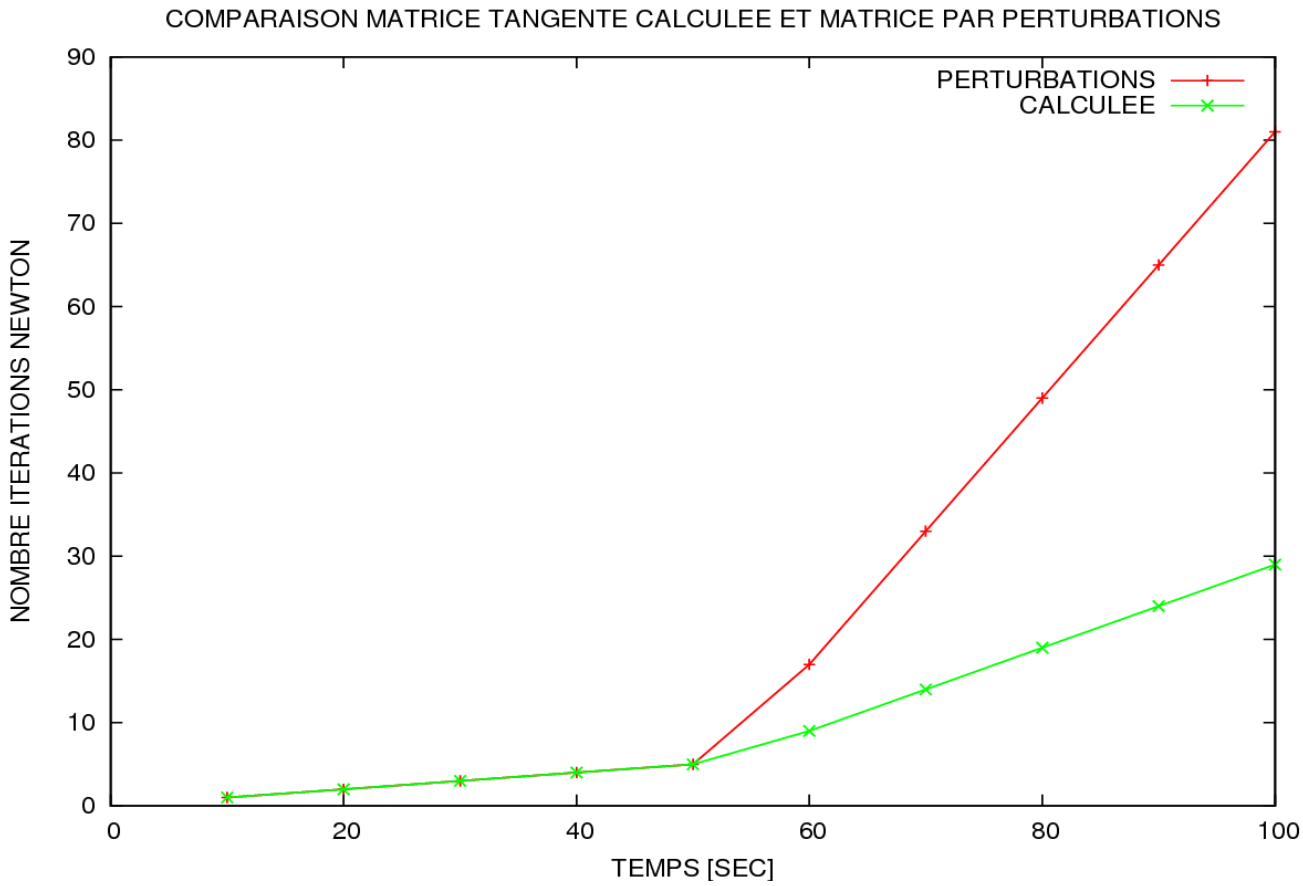

Figure 4-a: Comparison of the cumulated number of iterations of Newton enters the cases “calculated tangent matrix” and “stamps tangent by disturbance”

5 References

[1] P. Reiffsteck. “ *The triaxial press for hollow cylindrical test-tubes of the LCPC adapted under investigation of the original grounds* ”. Bulletin of the Laboratory of the Highways Departments, N°270-271, October-December 2007.