SSNL101 - Non-linear behavior of an element of conductor arrangement

Summary:
One considers in this test, 1 discrete element with 2 nodes subjected to a transverse effort in nonlinear static analysis.

The element has a behavior governed by a nonlinear relation expressed in effort and one-way displacement in the transverse and local direction y .

The interest of the test is to simulate in an exhaustive way the ways of possible loading, in load and discharge, in each field of the relation of behavior: rubber band, plastic and ultimate.

The reduced dimension of the problem to an unknown factor (the transverse displacement of the end) makes it possible to have as solution the result of an algebraical expression found exactly by *Aster*.

1 Problem of reference

1.1 Geometry

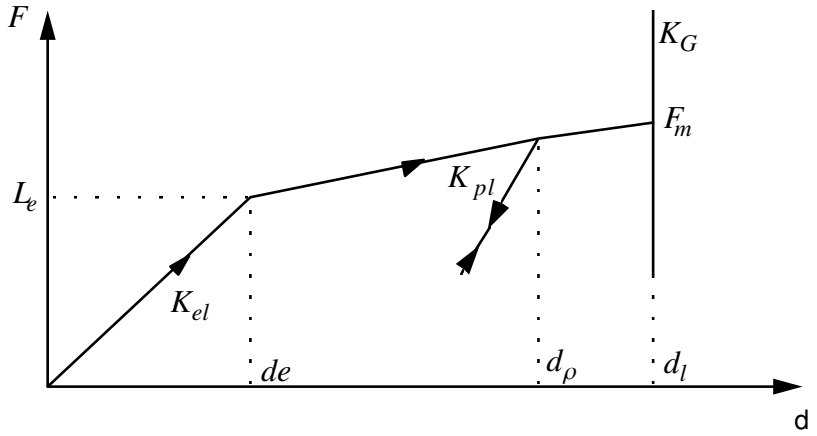
A discrete element of worthless size to 2 nodes.
Local reference mark = total reference mark.
A matrix of rigidity K_TR_D_L affected by default:
$1.6\,N/m$ in translation, $1.9\,N/m$ in rotation.
Characteristics of rigidity according to the local direction y (here equalizes with the total axis Y) are modified by a relation of behavior of the type WEAPON in effort-displacement introduced by a characteristic material.

1.2 Material properties

Dependent on an incremental behavior WEAPON with 5 parameters: d_e (keyword DLE) = $0.048\,m$, d_l (keyword DLP) = $0.7\,m$, K_{el} (keyword KYE) = $1.67\,E4\,N/m$, K_{pl} (keyword KYP) = $2.9\,E3\,N/m$, K_G (keyword KYG) = $1\ \mathrm{E6}\ N/m$.

- d_e displacement limits elastic range,
- d_l displacement limits plastic range,
- K_{el} slope of the elastic range,
- K_{pl} slope of the plastic range,
- K_G ultimate slope,

Behavior of an arm of armament in longitudinal request



$d_e = 0.048\,m$, $d_l = 0.7\,m$, $L_e = 800\ N$, $F_m = 2800\ N$

One-way behavior in force-displacement with 1 internal variable: $d_p - d_e$ defined by 5 parameters: d_e, d_l, K_{el}, K_{pl} and K_G, affected with a discrete element with 2 nodes.

1.3 Boundary conditions and loadings

Embedding in one of the 2 nodes.
Force imposed in the local direction y (identical to Y total) on the second node, by increments of load. A unit increment being worth $500\ N$.

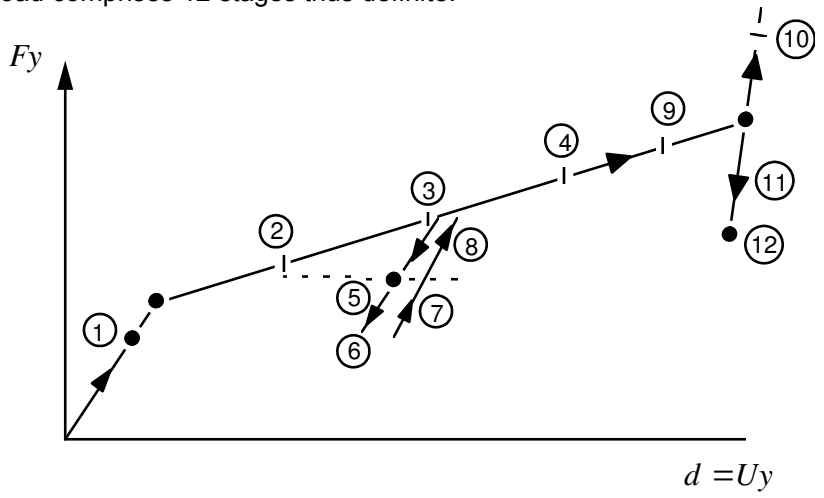
1.4 Initial conditions

Internal displacements, efforts and variables worthless.

2 Reference solution

2.1 Method of calculating used for the reference solution

One reproduces on an element a course of loading in each of the 3 fields (rubber band, plastic, limit) of an one-way relation of behavior (local direction y). The parameters are described on united figure 1.
The way of load comprises 12 stages thus definite:



2.2 Results of reference

Direct calculations on the curve limits relation of behavior:

$F_y = k_{el} \cdot U_y$ if $U_y < d_e$

$F_y = k_{el} \cdot d_e + k_{pl}\left(U_y - d_e\right)$ if $U_y \in \left[d_e, d_l\right]$

$Vari = U_y - d_e$
$Varimax = d_l - d_e$

$F_y = k_{el} \cdot d_e + k_{pl}\left(d_l - d_e\right) + k_G\left(U_y - d_l\right)$ if $Vari = Varimax$

2.3 Uncertainty on the solution

Exact solution: Fy imposed and Uy deduced directly from the relations in [§2.2].

2.4 Bibliographical references

Note HM-77/94/368, G. DEVESA. “Dynamic study of rupture of driver and discharge of white frost on an experimental line with Medium Average”.

3 Modeling A

3.1 Characteristics of modeling

An element DIS_TR_L with 2 nodes of worthless size (idem [§1.1]).
A node N2: all is blocked.
A N3 node: one imposes Fy by step of $500\ N$ with the map of time:

t	0.	4.	6.	10.	12.
$F(t)$	0.	4.	2.	6.	4.

3.2 Characteristics of the grid

1 SEG2.
2 nodes.

3.3 Sizes tested and results

Identification	Reference	*Aster*	% difference
Uy displacement: N3 node, Order 2 $\left(F_y=1000\mathrm{N}\right)$	1,16E-001	idem	0
Uy displacement: N3 node, Order 8 $\left(F_y=2000\mathrm{N}\right)$	4,61E-001	idem	0
Uy displacement: N3 node, Order 10 $\left(F_y=3000\mathrm{N}\right)$	7,00E-001	idem	0
Variable interns 1: Order 2 $\left(F_y=1000\mathrm{N}\right)$	6,84E-002	idem	0
Variable interns 1: Order 8 $\left(F_y=2000\mathrm{N}\right)$	4,13E-001	idem	0
Variable interns 1: Order 10 $\left(F_y=3000\mathrm{N}\right)$	5,20E-002	idem	0

3.4 Remarks

General:

The behavior WEAPON also in dynamic Analysis not - is usable linear but is not tested.

4 Summary of the results

The reduced dimension of the problem makes it possible to have only one unknown factor, transverse displacement U_y dependent on the internal variable, calculable exact solution by an algebraical expression and found by *Aster* with the identical one.