SSNL101 - Behavior nonlinear of an element of arrangement conductor

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

The element has a behavior governed by a nonlinear relation expressed in force 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 behavior model: elastic, plastic and ultimate.

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

1 Problem of reference

1.1 Geometry

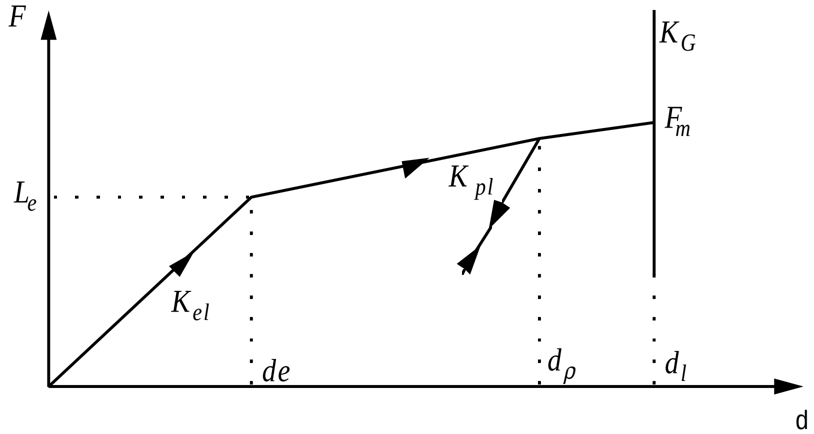
a discrete element of size null to 2 nodes.
Local coordinate system = total reference.
A stiffness matrix K_TR_D_L affected by default:
$1.6 N/m$ in translation, $1.9 N/m$ rotation.
The characteristics of stiffness according to the local direction y (here equalizes with the total axis Y) are modified by a behavior model of the type ARMS in force-displacement introduced by a characteristic material.

1.2 Material properties

Related to an incremental behavior ARMS with 5 parameters: d_e (key word DLE) = $0.048 m$, d_l (key word DLP) = $0.7 m$, K_{el} (key word KYE) = $1.67 E4 N/m$, K_{pl} (key word KYP) = $2.9 E3 N/m$, K_G (key word KYG) = $1 \text{E6} N/m$.

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

Behavior of an arm of armament in longitudinal request



$d_e = 0.048 m$ $d_l = 0.7 m$ $L_e = 800\ N$, $F_m = 2800\ N$
Behavior one-way in force-displacement with 1 local 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

Fixed support 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 $500\ N$.

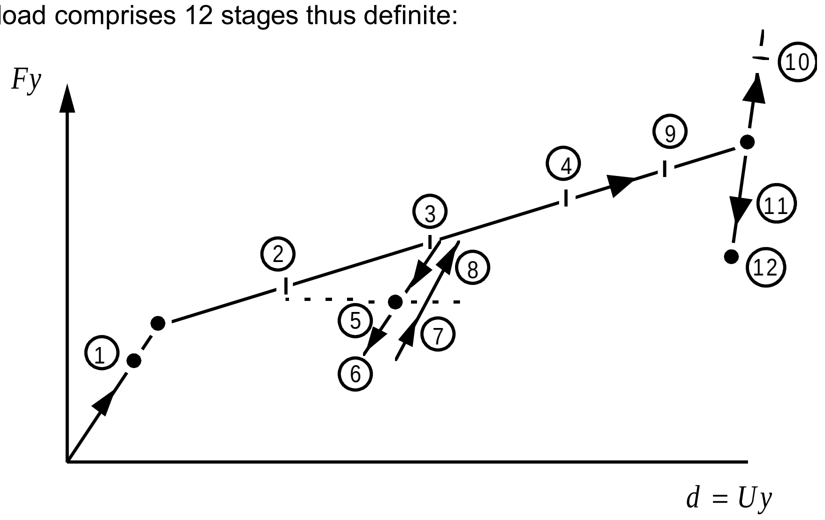
1.4 Initial conditions

Displacements, forces and local variables null.

2 Reference solution

2.1 Method of calculating used for the reference solution

One reproduces on an element a path of loading in each of the 3 fields (elastic, plastic, limit) of an one-way behavior model (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 Computations on the curve limits behavior model:

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

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

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

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

2.3 Uncertainty on the solution

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

2.4 Bibliographical references

Notes HM-77/94/368, G. DEVESA. “Dynamic Study of fracture of driver and discharge of white frost on line experimental with Medium Average”.

3 Modelization A

3.1 Characteristic of the modelization

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

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

3.2 Characteristics of mesh

1 SEG2.
2 nodes.

3.3 Quantities tested and results

Identification	Reference	*Aster*	% difference
Uy Displacement: N3 node, Order 2 $(F_y=1000\text{N})$	1.16E-001	idem	0
Uy Displacement: N3 node, Order 8 $(F_y=2000\text{N})$	4.61E-001	idem	0
Uy Displacement: N3 node, Order 10 $(F_y=3000\text{N})$	7.00E-001	idem	0
Local variable 1: Order 2 $(F_y=1000\text{N})$	6.84E-002	idem	0
Local variable 1: Order 8 $(F_y=2000\text{N})$	4.13E-001	idem	0
Local variable 1: Order 10 $(F_y=3000\text{N})$	5.20E-002	idem	0

3.4 Remarks

General:

The behavior WEAPON is usable also in linear Dynamic analysis not - but is not tested.

4 Summary of the results

the reduced dimension of the problem makes it possible to have only one unknown, transverse displacement U_y related to the local variable, exact solution computable by an algebraical expression and found by *Aster* with the identical one.