

Code_Aster

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Titre : SSND102 – Loi de comportement cinématique non-linéé[...]
Responsable : VOLDOIRE François

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Clé : V6.08.102 Révision :
054678e2a3c0

SSND102 – Law of kinematic behavior non-linear for discrete elements

Summary:

The problem is quasi-static non-linear in mechanics of the structures. It is about a law with non-linear kinematic work hardening. One analyzes the answer of discrete elements supporting a law of kinematic behavior non-linear under a cyclic loading.

The discrete elements tested are:

[1] 3D (K_T_D_L, K_TR_D_L, K_T_D_N, K_TR_D_N);

[2] 2D (K_T_D_L, K_TR_D_L, K_T_D_N, K_TR_D_N).

All the degrees of freedom are tested, the parameters of the loading in displacements and those of the kinematic law are different for all the degrees of freedom in order to cover various situations.

The reference solutions are obtained in an analytical way or by comparison with an external application.

1 Problem of reference

1.1 Geometry

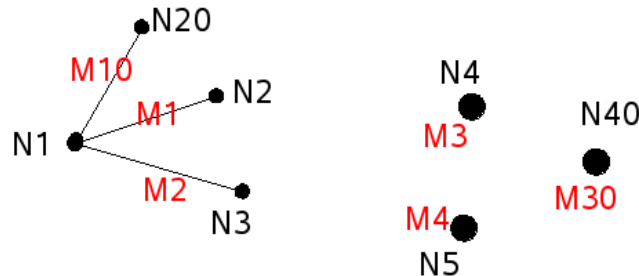


Figure 1.1.a : geometry.

	Model in 3D	Model in 2D	GROUP_MA
Mesh <i>M1</i> : Node <i>N1</i> with <i>N2</i>	DIS_T	2D_DIS_T	DL_T
Mesh <i>M2</i> : Node <i>N1</i> with <i>N3</i>	DIS_TR	2D_DIS_TR	DL_TR
Mesh <i>M3</i> : Node <i>N4</i>	DIS_T	2D_DIS_T	DN_T
Mesh <i>M4</i> : Node <i>N5</i>	DIS_TR	2D_DIS_TR	DN_TR
Mesh <i>M10</i> : Node <i>N1</i> with <i>N20</i>	DIS_T		DL_T0
Mesh <i>M30</i> : Node <i>N40</i>	DIS_T		DN_T0

1.2 Properties of material

The law of behavior is written in the following generic form (for each degree of freedom):

the elastoplastic relation: $F = K_e (U - U^{an})$

limiting surface: $f = |F - X| - F_y$

the kinematic work hardening part:

$$X = \frac{k_x \cdot \alpha}{\left[1 + \left[\frac{k_x \cdot \alpha}{F_u} \right]^n \right]^{1/n}}$$

It thus requires 5 characteristics. Their units must be in agreement with those of the study.

K_e : elastic stiffness

F_y : yield stress

k_x : kinematic stiffness

F_u : effort limits kinematic

n : power

1.3 Boundary conditions and loadings

Node *N1* : embedding

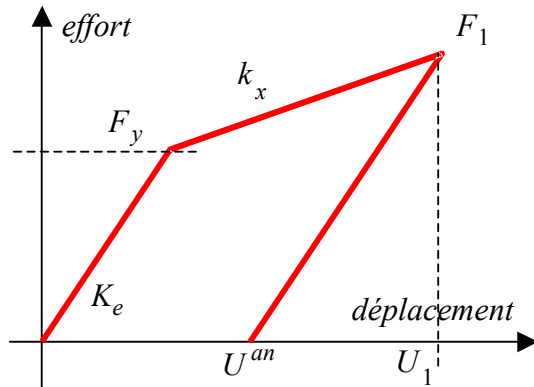
Nodes *N2*, *N3*, *N4*, *N5*, *N20*, *N40* : for all the degrees of freedom the signal is cyclic with imposed displacement.

2 Reference solution

2.1 Method of calculating used for the reference solution

In the case general, the complex form of the law does not make it possible to calculate a reference solution.

To validate the law, a linear kinematic work hardening in the case of is placed (the power and the effort limit kinematic are not given). The efforts as well as dissipated energy can be calculated analytically.



The data are: F_y , K_e , k_x and the amplitude of displacement: $U_1 = 5 \cdot \frac{F_y}{K_e}$

What gives:

$$F_1 = F_y + 4 \cdot k_x \cdot \frac{F_y}{K_e}$$

$$U_{an} = 4 \cdot \frac{F_y}{K_e^2} (K_e - k_x)$$

$$\text{Dissipated energy is: } W_1 = U_{an} \cdot \frac{(F_y + F_1)}{2}$$

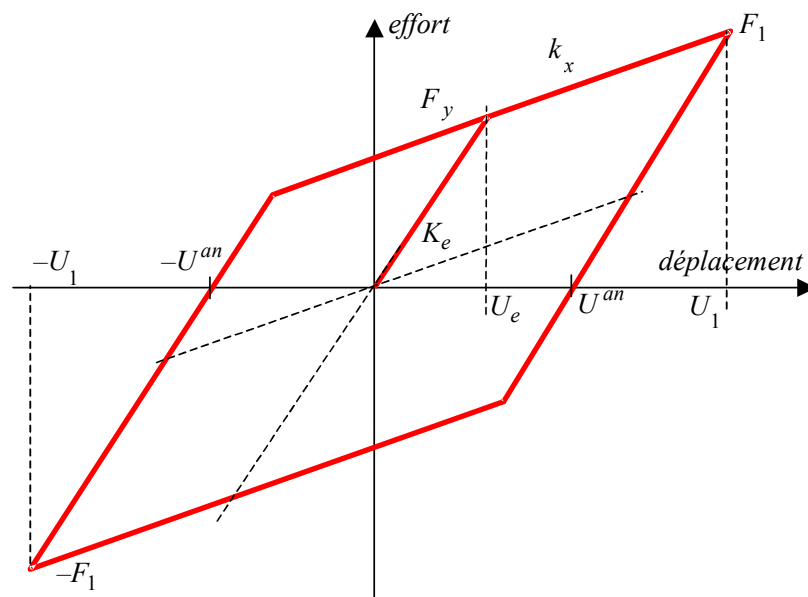


Figure 2.1.a: cycle of loading.

For a cycle stabilized (going displacement of 0 with U_1 with $-U_1$ with U_e) dissipated energy is

$$W_d = 4 \cdot U_{an} \cdot F_y$$

In the case general of the law power, an external program made it possible to validate the answers in efforts.

2.2 Results of reference

The tests are carried out on:

- 1) effort with each inversion of loading;
- 2) the energy dissipated at the end of the loading.

For two modelings a table presents the parameters of the law as well as the values of the efforts and the energy dissipated at the end of the cycle.

2.3 Uncertainty on the solution

In the case of linear kinematic work hardening there is no uncertainty, the solution is analytical, as well for the efforts as for energy.

In the case of nonlinear work hardening the reference solution is given by an external program.

3 Modeling A

3.1 Characteristics of modeling

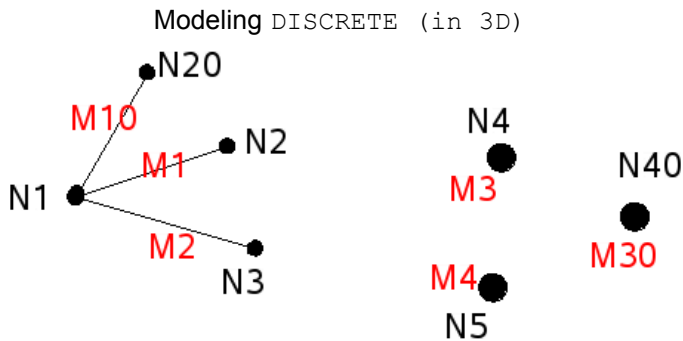


Figure 3.1.a: geometry.

Characteristics of the discrete elements

Mesh *M1* : Node *N1* with *N2*
 Mesh *M2* : Node *N1* with *N3*
 Mesh *M3* : Node *N4*
 Mesh *M4* : Node *N5*
 Mesh *M10* : Node *N1* with *N20*
 Mesh *M30* : Node *N40*

Modeling in 3D

Modeling in 3D	GROUP_MA
DIS_T	DL_T
DIS_TR	DL_TR
DIS_T	DN_T
DIS_TR	DN_TR
DIS_T	DL_T0
DIS_T	DN_T0

The discrete one DL_T0 with the same characteristics as DL_T, on the other hand its orientation is different.

CARA = 'ANGL_NAUT' , VALE = (90 . 0 , - 90.0 , 0.0)

Effort *N* is thus along the axis *Z*, effort *VY* along the axis *Z* and effort *VZ* according to *X*.

3.2 Characteristics of the grid

Many nodes: 7, Many meshes: 6, Elements SEG2 : 3, Elements POI1: 3

3.3 Definition of the function of loading

moments	values
0.0	0,000
30.0	1,000
90.0	-1,000
145.0	0,800
180.0	-0,450
230.0	1,150
250.0	0,500
280.0	1,450

The selected step is of 1. s .

3.4 Properties of the discrete ones

The table below gives for all the requested directions the characteristics of the discrete ones.

		F_y LIMY_*	K_e K_T*	F_u LIMU_*	k_x KCIN_*	n PUIS_*
DL_T	dx	1000.0	3400000.0	1000.0	700000.0	2.00
DL_T0	Dy	1500.0	2000000.0	800.0	900000.0	1.50
	dz	2000.0	2500000.0	800.0	700000.0	2.25
DN_T	dx	1000.0	3400000.0	1000.0	700000.0	2.00
	Dy	1500.0	2000000.0	800.0	900000.0	1.50
	dz	2000.0	2500000.0	800.0	700000.0	2.25
DL_TR	dx	1000.0	3400000.0	1000.0	700000.0	2.00
	Dy	1500.0	2000000.0	800.0	900000.0	1.50
	dz	2000.0	2500000.0	800.0	700000.0	2.25
	X-ray	3000.0	3000000.0	1000.0	600000.0	2.00
	ry	3500.0	2700000.0	1800.0	800000.0	1.50
	rz	2500.0	3200000.0	1400.0	850000.0	2.25
DN_TR	dx	1000.0	3400000.0	1000.0	700000.0	2.00
	Dy	1500.0	2000000.0	800.0	900000.0	1.50
	dz	2000.0	2500000.0	800.0	700000.0	2.25
	X-ray	3000.0	3000000.0	1000.0	600000.0	2.00
	ry	3500.0	2700000.0	1800.0	800000.0	1.50
	rz	2500.0	3200000.0	1400.0	850000.0	2.25
DN_T0	dx	1000.0	3400000.0		700000.0	
	Dy	1500.0	2000000.0		900000.0	
	dz	2000.0	2500000.0		700000.0	

3.5 Sizes tested and results

GROUP_MA	Effort	Moment	Effort Reference	Effort Code_Aster	Error
DN_TR	NR	30,000	1635.707253	1635.707253	-8.4900e-11
DN_TR	NR	90,000	-1635.707253	-1635.707253	-8.4900e-11
DN_TR	NR	145,000	1525.492881	1525.492881	-1.8200e-10
DN_TR	NR	180,000	-1249.231871	-1249.231871	1.4500e-11
DN_TR	NR	230,000	1699.177353	1699.177353	-1.6000e-10
DN_TR	NR	250,000	-415.381013	-415.381013	-1.1200e-10
DN_TR	NR	280,000	1789.595108	1789.595108	-4.9600e-11
DN_TR	VY	30,000	2224.098875	2224.098875	-4.9400e-12
DN_TR	VY	90,000	-2224.098875	-2224.098875	-4.9400e-12
DN_TR	VY	145,000	2190.040518	2190.040518	-1.0900e-10
DN_TR	VY	180,000	-2017.290415	-2017.290415	-1.5500e-10
DN_TR	VY	230,000	2239.745512	2239.745512	-6.2600e-12
DN_TR	VY	250,000	-790.397664	-790.397663	-3.5800e-11
DN_TR	VY	280,000	2258.782745	2258.782745	1.0400e-10
DN_TR	VZ	30,000	2767.252580	2767.252580	-7.5200e-11
DN_TR	VZ	90,000	-2767.252580	-2767.252580	-7.5200e-11
DN_TR	VZ	145,000	2740.932239	2740.932239	1.8200e-10
DN_TR	VZ	180,000	-2547.183658	-2547.183658	2.5800e-11
DN_TR	VZ	230,000	2777.276300	2777.276300	-1.5700e-10
DN_TR	VZ	250,000	-1243.236082	-1243.236082	-9.2100e-11
DN_TR	VZ	280,000	2787.481342	2787.481342	7.7000e-11
DN_TR	MFY	30,000	5022.231028	5022.231028	9.6800e-11
DN_TR	MFY	90,000	-5022.231028	-5022.231028	9.6800e-11
DN_TR	MFY	145,000	4911.499221	4911.499221	8.9600e-11
DN_TR	MFY	180,000	-4443.221450	-4443.221450	-4.3200e-12
DN_TR	MFY	230,000	5075.752629	5075.752629	3.5200e-12
DN_TR	MFY	250,000	-2025.828992	-2025.828992	-8.7200e-11
DN_TR	MFY	280,000	5143.339483	5143.339483	-4.7600e-11
DN_TR	MFZ	30,000	3773.863680	3773.863680	4.0200e-11
DN_TR	MFZ	90,000	-3773.863680	-3773.863680	4.0200e-11
DN_TR	MFZ	145,000	3686.099695	3686.099695	-2.8500e-11
DN_TR	MFZ	180,000	-3236.583886	-3236.583886	1.3700e-10
DN_TR	MFZ	230,000	3810.233618	3810.233618	6.2600e-11
DN_TR	MFZ	250,000	-1262.367026	-1262.367026	5.6200e-11
DN_TR	MFZ	280,000	3849.201624	3849.201624	-1.8600e-12

GROUP_MA	Effort	Moment	Effort Reference	Effort Code_Aster	Error
DN_T	NR	30,000	1635.707253	1635.707253	-8.4900e-11
DN_T	NR	90,000	-1635.707253	-1635.707253	-8.4900e-11
DN_T	NR	145,000	1525.492881	1525.492881	-1.8200e-10
DN_T	NR	180,000	-1249.231871	-1249.231871	1.4500e-11
DN_T	NR	230,000	1699.177353	1699.177353	-1.6000e-10
DN_T	NR	250,000	-415.381013	-415.381013	-1.1200e-10
DN_T	NR	280,000	1789.595108	1789.595108	-4.9600e-11
DN_T	VY	30,000	2224.098875	2224.098875	-4.9400e-12
DN_T	VY	90,000	-2224.098875	-2224.098875	-4.9400e-12
DN_T	VY	145,000	2190.040518	2190.040518	-1.0900e-10
DN_T	VY	180,000	-2017.290415	-2017.290415	-1.5500e-10
DN_T	VY	230,000	2239.745512	2239.745512	-6.2600e-12
DN_T	VY	250,000	-790.397664	-790.397663	-3.5800e-11

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DN_T	VZ	30,000	2767.252580	2767.252580	-7.5200e-11
DN_T	VZ	90,000	-2767.252580	-2767.252580	-7.5200e-11
DN_T	VZ	145,000	2740.932239	2740.932239	1.8200e-10
DN_T	VZ	180,000	-2547.183658	-2547.183658	2.5800e-11
DN_T	VZ	230,000	2777.276300	2777.276300	-1.5700e-10
DN_T	VZ	250,000	-1243.236082	-1243.236082	-9.2100e-11
DN_T	VZ	280,000	2787.481342	2787.481342	7.7000e-11

GROUP_MA	Effort	Moment	Effort Reference	Effort Code_Aster	Error
DL_TR	NR	30,000	1635.707253	1635.707253	-8.4900e-11
DL_TR	NR	90,000	-1635.707253	-1635.707253	-8.4900e-11
DL_TR	NR	145,000	1525.492881	1525.492881	-1.8200e-10
DL_TR	NR	180,000	-1249.231871	-1249.231871	1.4500e-11
DL_TR	NR	230,000	1699.177353	1699.177353	-1.6000e-10
DL_TR	NR	250,000	-415.381013	-415.381013	-1.1200e-10
DL_TR	NR	280,000	1789.595108	1789.595108	-4.9600e-11
DL_TR	VY	30,000	2224.098875	2224.098875	-4.9400e-12
DL_TR	VY	90,000	-2224.098875	-2224.098875	-4.9400e-12
DL_TR	VY	145,000	2190.040518	2190.040518	-1.0900e-10
DL_TR	VY	180,000	-2017.290415	-2017.290415	-1.5500e-10
DL_TR	VY	230,000	2239.745512	2239.745512	-6.2600e-12
DL_TR	VY	250,000	-790.397664	-790.397663	-3.5800e-11
DL_TR	VY	280,000	2258.782745	2258.782745	1.0400e-10
DL_TR	VZ	30,000	2767.252580	2767.252580	-7.5200e-11
DL_TR	VZ	90,000	-2767.252580	-2767.252580	-7.5200e-11
DL_TR	VZ	145,000	2740.932239	2740.932239	1.8200e-10
DL_TR	VZ	180,000	-2547.183658	-2547.183658	2.5800e-11
DL_TR	VZ	230,000	2777.276300	2777.276300	-1.5700e-10
DL_TR	VZ	250,000	-1243.236082	-1243.236082	-9.2100e-11
DL_TR	VZ	280,000	2787.481342	2787.481342	7.7000e-11
DL_TR	MFY	30,000	5022.231028	5022.231028	9.6800e-11
DL_TR	MFY	90,000	-5022.231028	-5022.231028	9.6800e-11
DL_TR	MFY	145,000	4911.499221	4911.499221	8.9600e-11
DL_TR	MFY	180,000	-4443.221450	-4443.221450	-4.3200e-12
DL_TR	MFY	230,000	5075.752629	5075.752629	3.5200e-12
DL_TR	MFY	250,000	-2025.828992	-2025.828992	-8.7200e-11
DL_TR	MFY	280,000	5143.339483	5143.339483	-4.7600e-11
DL_TR	MFZ	30,000	3773.863680	3773.863680	4.0200e-11
DL_TR	MFZ	90,000	-3773.863680	-3773.863680	4.0200e-11
DL_TR	MFZ	145,000	3686.099695	3686.099695	-2.8500e-11
DL_TR	MFZ	180,000	-3236.583886	-3236.583886	1.3700e-10
DL_TR	MFZ	230,000	3810.233618	3810.233618	6.2600e-11
DL_TR	MFZ	250,000	-1262.367026	-1262.367026	5.6200e-11
DL_TR	MFZ	280,000	3849.201624	3849.201624	-1.8600e-12

GROUP_MA	Effort	Moment	Effort Reference	Effort Code_Aster	Error
DL_T	NR	30,000	1635.707253	1635.707253	-8.4900e-11
DL_T	NR	90,000	-1635.707253	-1635.707253	-8.4900e-11
DL_T	NR	145,000	1525.492881	1525.492881	-1.8200e-10
DL_T	NR	180,000	-1249.231871	-1249.231871	1.4500e-11
DL_T	NR	230,000	1699.177353	1699.177353	-1.6000e-10

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DL_T	NR	250,000	-415.381013	-415.381013	-1.1200e-10
DL_T	NR	280,000	1789.595108	1789.595108	-4.9600e-11
DL_T	VY	30,000	2224.098875	2224.098875	-4.9400e-12
DL_T	VY	90,000	-2224.098875	-2224.098875	-4.9400e-12
DL_T	VY	145,000	2190.040518	2190.040518	-1.0900e-10
DL_T	VY	180,000	-2017.290415	-2017.290415	-1.5500e-10
DL_T	VY	230,000	2239.745512	2239.745512	-6.2600e-12
DL_T	VY	250,000	-790.397664	-790.397663	-3.5800e-11
DL_T	VY	280,000	2258.782745	2258.782745	1.0400e-10
DL_T	VZ	30,000	2767.252580	2767.252580	-7.5200e-11
DL_T	VZ	90,000	-2767.252580	-2767.252580	-7.5200e-11
DL_T	VZ	145,000	2740.932239	2740.932239	1.8200e-10
DL_T	VZ	180,000	-2547.183658	-2547.183658	2.5800e-11
DL_T	VZ	230,000	2777.276300	2777.276300	-1.5700e-10
DL_T	VZ	250,000	-1243.236082	-1243.236082	-9.2100e-11
DL_T	VZ	280,000	2787.481342	2787.481342	7.7000e-11

GROUP_MA	Effort	Moment	Effort Reference	Effort Code_Aster	Error
DL_T0	NR	30,000	1635.707253	1635.707253	-8.4900e-11
DL_T0	NR	90,000	-1635.707253	-1635.707253	-8.4900e-11
DL_T0	NR	145,000	1525.492881	1525.492881	-1.8200e-10
DL_T0	NR	180,000	-1249.231871	-1249.231871	1.4500e-11
DL_T0	NR	230,000	1699.177353	1699.177353	-1.6000e-10
DL_T0	NR	250,000	-415.381013	-415.381013	-1.1200e-10
DL_T0	NR	280,000	1789.595108	1789.595108	-4.9600e-11
DL_T0	VY	30,000	2224.098875	2224.098875	-4.9400e-12
DL_T0	VY	90,000	-2224.098875	-2224.098875	-4.9400e-12
DL_T0	VY	145,000	2190.040518	2190.040518	-1.0900e-10
DL_T0	VY	180,000	-2017.290415	-2017.290415	-1.5500e-10
DL_T0	VY	230,000	2239.745512	2239.745512	-6.2600e-12
DL_T0	VY	250,000	-790.397664	-790.397663	-3.5800e-11
DL_T0	VY	280,000	2258.782745	2258.782745	1.0400e-10
DL_T0	VZ	30,000	2767.252580	2767.252580	-7.5200e-11
DL_T0	VZ	90,000	-2767.252580	-2767.252580	-7.5200e-11
DL_T0	VZ	145,000	2740.932239	2740.932239	1.8200e-10
DL_T0	VZ	180,000	-2547.183658	-2547.183658	2.5800e-11
DL_T0	VZ	230,000	2777.276300	2777.276300	-1.5700e-10
DL_T0	VZ	250,000	-1243.236082	-1243.236082	-9.2100e-11
DL_T0	VZ	280,000	2787.481342	2787.481342	7.7000e-11

GROUP_MA	Effort	Moment	Effort Reference	Effort Code_Aster	Error
DN_T0	NR	30,000	1823.529412	1823.529412	3.5500e-11
DN_T0	NR	90,000	-1823.529412	-1823.529412	3.5500e-11
DN_T0	NR	145,000	1823.529412	1823.529412	3.5500e-11
DN_T0	VY	30,000	4200.000000	4200.000000	2.1700e-16
DN_T0	VY	90,000	-4200.000000	-4200.000000	-4.3300e-16
DN_T0	VY	145,000	4200.000000	4200.000000	-2.1700e-16
DN_T0	VZ	30,000	4240.000000	4240.000000	0.0000e+00
DN_T0	VZ	90,000	-4240.000000	-4240.000000	-2.1500e-16
DN_T0	VZ	145,000	4240.000000	4240.000000	2.1500e-16

GROUP_MA	Direction	Energy Reference	Energy Code_Aster	Error
DN TR	DX	9.083900	9.083899	-1.1600e-07
DN TR	DY	35.563390	35.563387	-9.4500 10 ⁻⁸
DN TR	DZ	51.155440	51.155445	9.2600 10 ⁻⁸
DN TR	X-ray	96.706530	96.706529	-1.5000 10 ⁻⁸
DN TR	RY	144.155340	144.155339	-4.8400 10 ⁻⁹
DN TR	RZ	61.549450	61.549446	-5.8100 10 ⁻⁸
DN T	DX	9.083900	9.083899	-1.1600e-07
DN T	DY	35.563390	35.563387	-9.4500 10 ⁻⁸
DN T	DZ	51.155440	51.155445	9.2600 10 ⁻⁸
DL TR	DX	9.083900	9.083899	-1.1600e-07
DL TR	DY	35.563390	35.563387	-9.4500 10 ⁻⁸
DL TR	DZ	51.155440	51.155445	9.2600 10 ⁻⁸
DL TR	X-ray	96.706530	96.706529	-1.5000 10 ⁻⁸
DL TR	RY	144.155340	144.155339	-4.8400e-09
DL TR	RZ	61.549450	61.549446	-5.8100 10 ⁻⁸
DL T	DX	9.083900	9.083899	-1.1600e-07
DL T	DY	35.563390	35.563387	-9.4500 10 ⁻⁸
DL T	DZ	51.155440	51.155445	9.2600 10 ⁻⁸
DL T0	DX	9.083900	9.083899	-1.1600e-07
DL T0	DY	35.563390	35.563387	-9.4500 10 ⁻⁸
DL T0	DZ	51.155440	51.155445	9.2600 10 ⁻⁸
DN T0	DX	5.055974	5.055974	-5.5200e-12
DN T0	DY	14.602500	14.602500	0.0000
DN T0	DZ	25.620480	25.620480	1.3900e-16

4 Modeling B

4.1 Characteristics of modeling

Modeling 2D_DISCRET

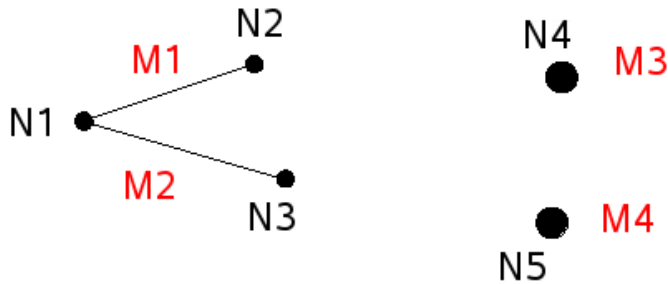


Figure 5.1.a: geometry.

Characteristics of the discrete elements

Mesh $M1$: Node $N1$ with $N2$
 Mesh $M2$: Node $N1$ with $N3$
 Mesh $M3$: Node $N4$
 Mesh $M4$: Node $N5$

Modeling 2D	GROUP_MA
2D_DIS_T	DL_T
2D_DIS_TR	DL_TR
2D_DIS_T	DN_T
2D_DIS_TR	DN_TR

4.2 Characteristics of the grid

Many nodes: 5, Many meshes: 4, Element SEG2 : 2, Element POI1 : 2

4.3 Properties of the discrete ones

The table below gives for all the requested directions the characteristics of the discrete ones.

		F_y	K_e	F_u	k_x	n
DL_T	dx	1000.0	3400000.0	1000.0	700000.0	2.00
	Dy	1500.0	2000000.0	800.0	900000.0	1.50
DN_T	dx	1000.0	3400000.0	1000.0	700000.0	2.00
	Dy	1500.0	2000000.0	800.0	900000.0	1.50
DL_TR	dx	1000.0	3400000.0	1000.0	700000.0	2.00
	Dy	1500.0	2000000.0	800.0	900000.0	1.50
	rz	2500.0	3200000.0	1400.0	850000.0	2.25
DN_TR	dx	1000.0	3400000.0	1000.0	700000.0	2.00
	Dy	1500.0	2000000.0	800.0	900000.0	1.50
	rz	2500.0	3200000.0	1400.0	850000.0	2.25

4.4 Sizes tested and results

GROUP_MA	Effort	Moment	Effort Reference	Effort Code_Aster	Error
DN_TR	NR	30,000	1635.707253	1635.707253	-8.4900e-11
DN_TR	NR	90,000	-1635.707253	-1635.707253	-8.4900e-11
DN_TR	NR	145,000	1525.492881	1525.492881	-1.8200e-10
DN_TR	NR	180,000	-1249.231871	-1249.231871	1.4500e-11
DN_TR	NR	230,000	1699.177353	1699.177353	-1.6000e-10
DN_TR	NR	250,000	-415.381013	-415.381013	-1.1200e-10
DN_TR	NR	280,000	1789.595108	1789.595108	-4.9600e-11
DN_TR	VY	30,000	2224.098875	2224.098875	-4.9400e-12
DN_TR	VY	90,000	-2224.098875	-2224.098875	-4.9400e-12
DN_TR	VY	145,000	2190.040518	2190.040518	-1.0900e-10
DN_TR	VY	180,000	-2017.290415	-2017.290415	-1.5500e-10
DN_TR	VY	230,000	2239.745512	2239.745512	-6.2600e-12
DN_TR	VY	250,000	-790.397664	-790.397663	-3.5800e-11
DN_TR	VY	280,000	2258.782745	2258.782745	1.0400e-10
DN_TR	MFZ	30,000	3773.863680	3773.863680	4.0200e-11
DN_TR	MFZ	90,000	-3773.863680	-3773.863680	4.0200e-11
DN_TR	MFZ	145,000	3686.099695	3686.099695	-2.8500e-11
DN_TR	MFZ	180,000	-3236.583886	-3236.583886	1.3700e-10
DN_TR	MFZ	230,000	3810.233618	3810.233618	6.2600e-11
DN_TR	MFZ	250,000	-1262.367026	-1262.367026	5.6200e-11
DN_TR	MFZ	280,000	3849.201624	3849.201624	-1.8600e-12

GROUP_MA	Effort	Moment	Effort Reference	Effort Code_Aster	Error
DN_T	NR	30,000	1635.707253	1635.707253	-8.4900e-11
DN_T	NR	90,000	-1635.707253	-1635.707253	-8.4900e-11
DN_T	NR	145,000	1525.492881	1525.492881	-1.8200e-10
DN_T	NR	180,000	-1249.231871	-1249.231871	1.4500e-11
DN_T	NR	230,000	1699.177353	1699.177353	-1.6000e-10
DN_T	NR	250,000	-415.381013	-415.381013	-1.1200e-10
DN_T	NR	280,000	1789.595108	1789.595108	-4.9600e-11
DN_T	VY	30,000	2224.098875	2224.098875	-4.9400e-12
DN_T	VY	90,000	-2224.098875	-2224.098875	-4.9400e-12
DN_T	VY	145,000	2190.040518	2190.040518	-1.0900e-10
DN_T	VY	180,000	-2017.290415	-2017.290415	-1.5500e-10
DN_T	VY	230,000	2239.745512	2239.745512	-6.2600e-12
DN_T	VY	250,000	-790.397664	-790.397663	-3.5800e-11
DN_T	VY	280,000	2258.782745	2258.782745	1.0400e-10

GROUP_MA	Effort	Moment	Effort Reference	Effort Code_Aster	Error
DL_TR	NR	30,000	1635.707253	1635.707253	-8.4900e-11
DL_TR	NR	90,000	-1635.707253	-1635.707253	-8.4900e-11
DL_TR	NR	145,000	1525.492881	1525.492881	-1.8200e-10
DL_TR	NR	180,000	-1249.231871	-1249.231871	1.4500e-11
DL_TR	NR	230,000	1699.177353	1699.177353	-1.6000e-10
DL_TR	NR	250,000	-415.381013	-415.381013	-1.1200e-10
DL_TR	NR	280,000	1789.595108	1789.595108	-4.9600e-11
DL_TR	VY	30,000	2224.098875	2224.098875	-4.9400e-12
DL_TR	VY	90,000	-2224.098875	-2224.098875	-4.9400e-12

Warning : The translation process used on this website is a "Machine Translation". It may be imprecise and inaccurate in whole or in part and is provided as a convenience.

DL_TR	VY	145,000	2190.040518	2190.040518	-1.0900e-10
DL_TR	VY	180,000	-2017.290415	-2017.290415	-1.5500e-10
DL_TR	VY	230,000	2239.745512	2239.745512	-6.2600e-12
DL_TR	VY	250,000	-790.397664	-790.397663	-3.5800e-11
DL_TR	VY	280,000	2258.782745	2258.782745	1.0400e-10
DL_TR	MFZ	30,000	3773.863680	3773.863680	4.0200e-11
DL_TR	MFZ	90,000	-3773.863680	-3773.863680	4.0200e-11
DL_TR	MFZ	145,000	3686.099695	3686.099695	-2.8500e-11
DL_TR	MFZ	180,000	-3236.583886	-3236.583886	1.3700e-10
DL_TR	MFZ	230,000	3810.233618	3810.233618	6.2600e-11
DL_TR	MFZ	250,000	-1262.367026	-1262.367026	5.6200e-11
DL_TR	MFZ	280,000	3849.201624	3849.201624	-1.8600e-12

GROUP_MA	Effort	Moment	Effort Reference	Effort Code_Aster	Error
DL_T	NR	30,000	1635.707253	1635.707253	-8.4900e-11
DL_T	NR	90,000	-1635.707253	-1635.707253	-8.4900e-11
DL_T	NR	145,000	1525.492881	1525.492881	-1.8200e-10
DL_T	NR	180,000	-1249.231871	-1249.231871	1.4500e-11
DL_T	NR	230,000	1699.177353	1699.177353	-1.6000e-10
DL_T	NR	250,000	-415.381013	-415.381013	-1.1200e-10
DL_T	NR	280,000	1789.595108	1789.595108	-4.9600e-11
DL_T	VY	30,000	2224.098875	2224.098875	-4.9400e-12
DL_T	VY	90,000	-2224.098875	-2224.098875	-4.9400e-12
DL_T	VY	145,000	2190.040518	2190.040518	-1.0900e-10
DL_T	VY	180,000	-2017.290415	-2017.290415	-1.5500e-10
DL_T	VY	230,000	2239.745512	2239.745512	-6.2600e-12
DL_T	VY	250,000	-790.397664	-790.397663	-3.5800e-11
DL_T	VY	280,000	2258.782745	2258.782745	1.0400e-10

GROUP_MA	Direction	Energy Reference	Energy Code_Aster	Error
DN_TR	DX	12.862800	12.862836	2.8000 10 ⁻⁶
DN_TR	DY	49.538500	49.538536	7.3200e-07
DN_TR	RZ	84.921900	84.921949	5.8100e-07
DN_T	DX	12.862800	12.862836	2.8000 10 ⁻⁶
DN_T	DY	49.538500	49.538536	7.3200e-07
DL_TR	DX	12.862800	12.862836	2.8000 10 ⁻⁶
DL_TR	DY	49.538500	49.538536	7.3200e-07
DL_TR	RZ	84.921900	84.921949	5.8100e-07
DL_T	DX	12.862800	12.862836	2.8000 10 ⁻⁶
DL_T	DY	49.538500	49.538536	7.3200e-07

5 Summary of the results

These tests make it possible to check the good performance of the discrete elements 2D and 3D with the behavior DIS_ECRO_CINE and the use of STAT_NON_LINE.