



POLYTECH[°]
NICE SOPHIA



UNIVERSITÉ
CÔTE D'AZUR

Mécanique des solides

2. Poutre appuyée et poutre encastree

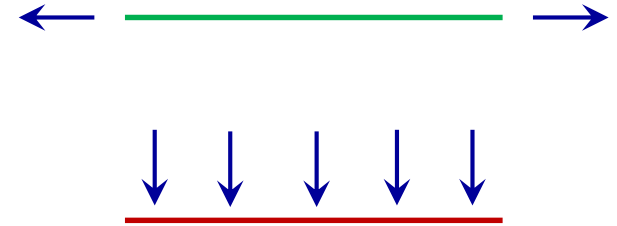
Reine Fares

reine.fares@cea.fr

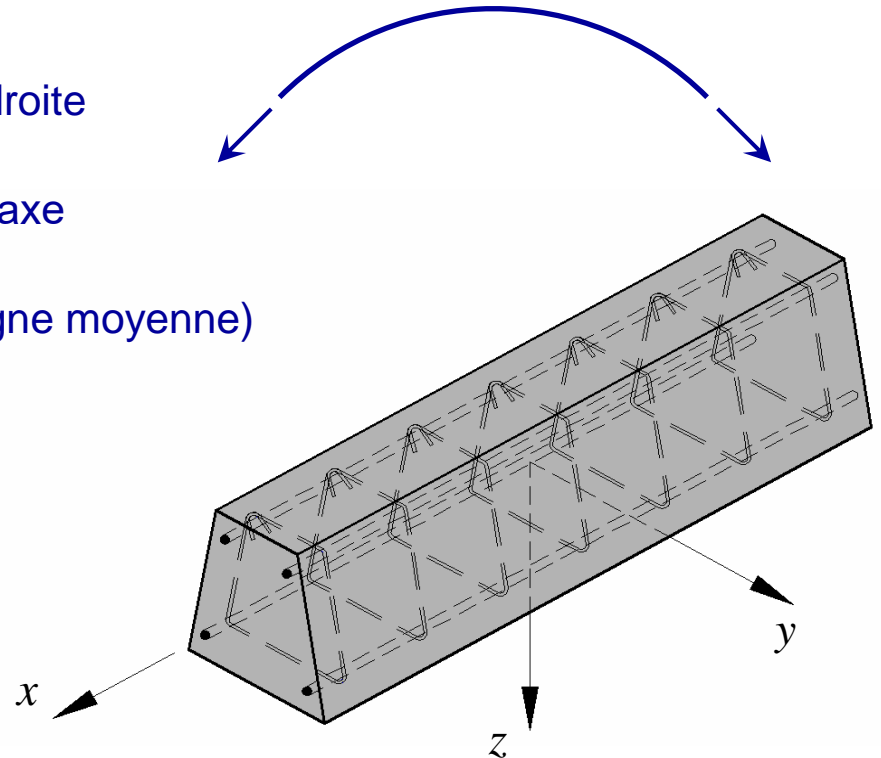
Théorie de la poutre 1/3

- Solide 1D : 1 dimension beaucoup plus grande par rapport aux 2 autres

- **Barre** : actions dans l'axe
- **Poutre** : actions transversales à l'axe
- **Arc** : courbe moyenne non linéaire

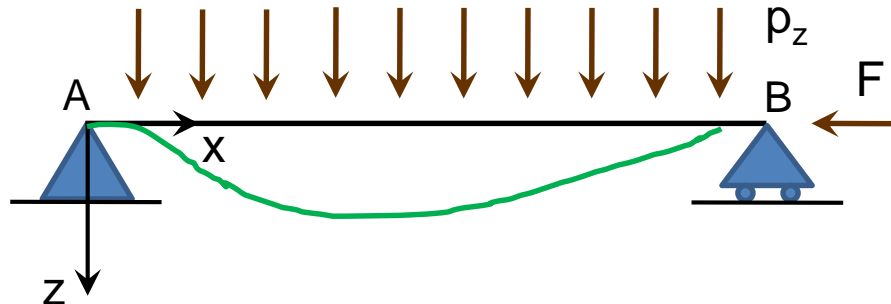


- Poutre : élément 1D ayant ligne moyenne droite
- Hypothèse : section constante au long de l'axe
- Une poutre est représentée par son axe (ligne moyenne)



Théorie de la poutre 2/3

- Hypothèse de petits déplacements et petites déformations :
 - Représentation de la géométrie de la poutre dans sa configuration initiale
 - **Déformée de la poutre** très proche de la **configuration initiale**
- Actions : analyse dans le plan
 - Forces concentrées en direction x et z
 - Charge distribuées (force par unité de longueur)
 - Moments selon l'axe y



Théorie de la poutre 3/3

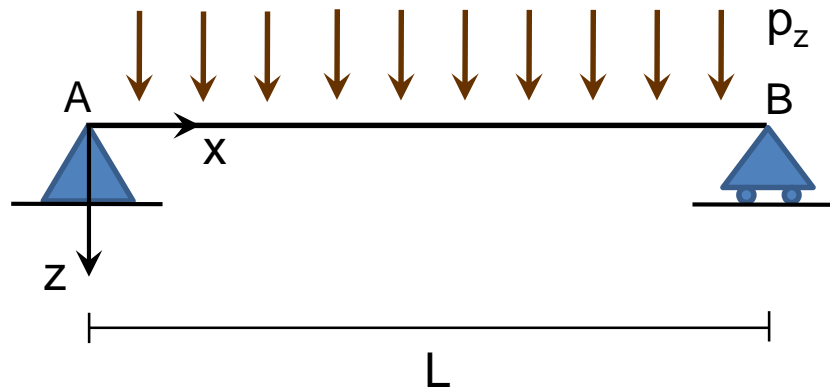
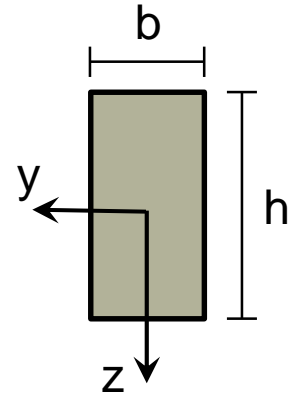
- Hypothèses sur le matériau :
 - Homogène : même propriétés dans tous les points
 - Isotrope : même comportement dans toutes les directions
 - Élastique : à la décharge le matériau revient à l'état initial
 - Linéaire : contraintes proportionnelles aux déformations, loi de Hooke

- Problème élastique :
 - Données : Actions, géométrie de la structure, propriétés des matériaux
 - Inconnues : Réactions des liaisons, déformations et déplacements
 - Équations : d'équilibre, de compatibilité, constitutives

Poutre appuyée 1/2

Données :

- Charges : uniforme p_z [N/m] = 25000 N/m
- Géométrie **1D** : section rectangulaire 30 x 60 cm, $L = 3$ m
- Matériau : béton, $E = 31220$ N/mm², $\nu = 0.2$, $\rho = 2500$ kg/m³
- Loi de comportement : élastique linéaire
- Conditions aux limites : A) $u_x = u_z = 0$, B) $u_z = 0$



Poutre appuyée 2/2

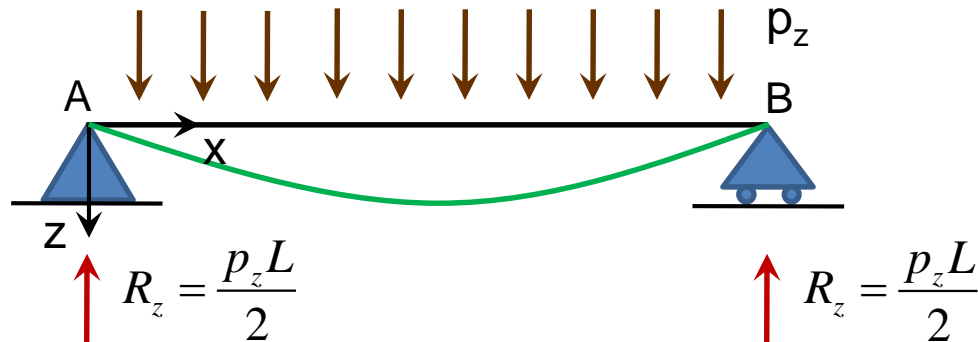
■ Résultats :

- Flèche :
$$u_{z\max} = u_z \left(x = L/2 \right) = \frac{5}{384} \frac{p_z L^4}{EI_y}$$

- Contrainte max :

$$\sigma_x(x, z) = \frac{M_y(x)}{I_y} z \quad M_y \left(x = \frac{L}{2} \right) = \frac{p_z L^2}{8} \quad I_y = \frac{b h^3}{12}$$

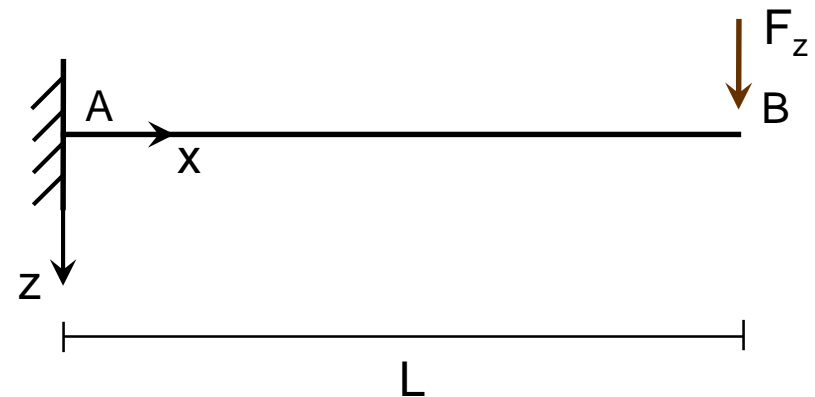
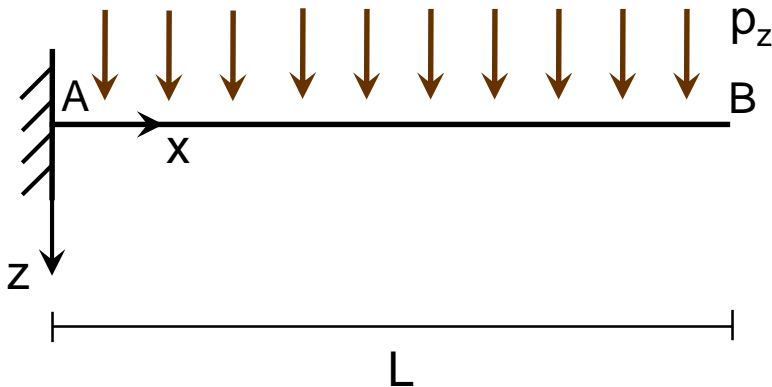
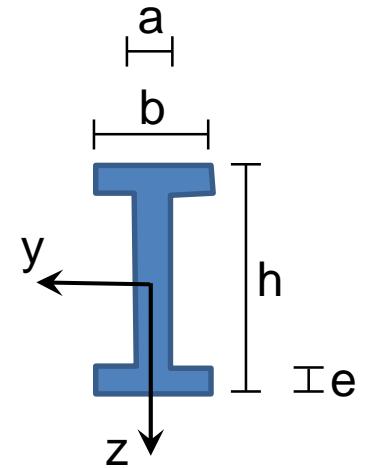
$$\sigma_{x\max} = \sigma_x \left(x = \frac{L}{2}, z = -\frac{h}{2} \right) = -\frac{p_z L^2}{8} \frac{h}{2} \frac{12}{b h^3} = -\frac{3 p_z L^2}{4 b h^2}$$



Poutre encastrée 1/4

Données :

- Charges : 1) uniforme p_z [N/m], 2) concentrée F_z [N]
- Géométrie **1D** : IPE, $L = 1.5\text{m}$
- Matériau : acier, $E = 210000 \text{ N/mm}^2$, $\nu = 0.3$, $\rho = 8000 \text{ kg/m}^3$
- Loi de comportement : élastique linéaire
- Conditions aux limites : A) $u_x = u_z = \varphi_y = 0$



Poutre encastrée 2/4

Profilé IPE

h mm	b mm	a mm	e mm	r mm	Peso kg/m	Sezione cm²	Momenti di inerzia		Moduli di resistenza		Raggi di inerzia	
							Jx cm⁴	Jy cm⁴	Wx cm³	Wy cm³	ix cm	iy cm
80	46	3,8	5,2	5	6,0	7,64	80,14	8,49	20,03	3,69	3,24	1,05
100	55	4,1	5,7	7	8,1	10,32	171,0	15,92	34,20	5,79	4,07	1,24
120	64	4,4	6,3	7	10,4	13,21	317,8	27,67	52,96	8,65	4,90	1,45
140	73	4,7	6,9	7	12,9	16,43	541,2	44,92	77,32	12,31	5,74	1,65
160	82	5,0	7,4	9	15,8	20,09	869,3	68,31	108,7	16,66	6,58	1,84
180	91	5,3	8,0	9	18,8	23,95	1,317	100,9	146,3	22,16	7,42	2,05
200	100	5,6	8,5	12	22,4	28,48	1,943	142,4	194,3	28,47	8,26	2,24
220	110	5,9	9,2	12	26,2	33,37	2,772	204,9	252,0	37,25	9,11	2,48
240	120	6,2	9,8	15	30,7	39,12	3,892	283,6	324,3	47,27	9,97	2,69
270	135	6,6	10,2	15	36,1	45,95	5,790	419,9	428,9	62,20	11,23	3,02
300	150	7,1	10,7	15	42,2	53,81	8,356	603,8	557,1	80,50	12,46	3,35
330	160	7,5	11,5	18	49,1	62,61	11,770	788,1	713,1	98,52	13,71	3,55
360	170	8,0	12,7	18	57,1	72,73	16,270	1,043	903,6	122,8	14,95	3,79
400	180	8,6	13,5	21	66,3	84,46	23,130	1,318	1,156	146,4	16,55	3,95
450	190	9,4	14,6	21	77,6	98,82	33,740	1,676	1,500	176,4	18,48	4,12
500	200	10,2	16,0	21	90,7	115,5	48,200	2,142	1,928	214,2	20,43	4,31
550	210	11,1	17,2	24	106	134,4	67,120	2,668	2.441	254,1	22,35	4,45
600	220	12,0	19,0	24	122	156,0	92,080	3,387	3,069	307,9	24,30	4,66

Poutre encastrée 3/4

■ Résultats :

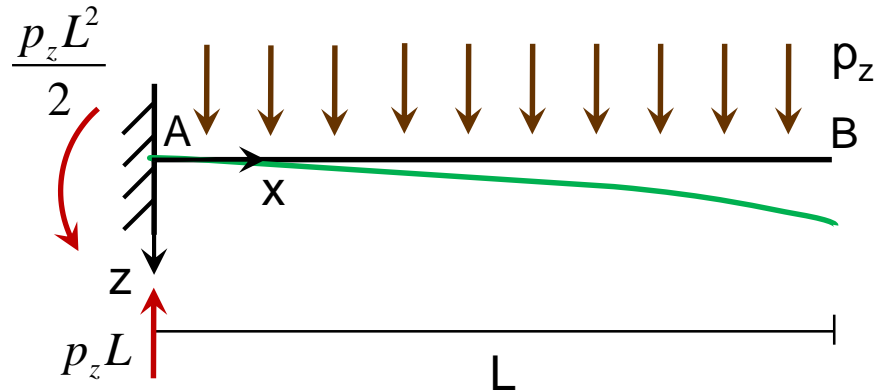
• Flèche :

$$u_{z\max} = u_z(x=L) = \frac{p_z L^4}{8EI_y}$$

• Contrainte max :

$$\sigma_x(x,z) = \frac{M_y(x)}{I_y} z \quad M_y(x=0) = \frac{p_z L^2}{2}$$

$$\sigma_{x\max} = \sigma_x\left(x=0, z = -\frac{h}{2}\right) = -\frac{p_z L^2}{2I_y} \frac{h}{2}$$



Poutre encastrée 4/4

■ Résultats :

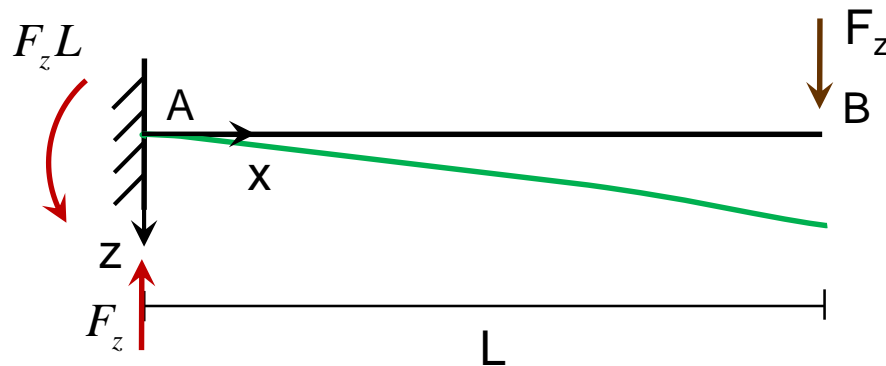
• Flèche :

$$u_{z\max} = u_z(x=L) = \frac{F_z L^3}{3EI_y}$$

• Contrainte max :

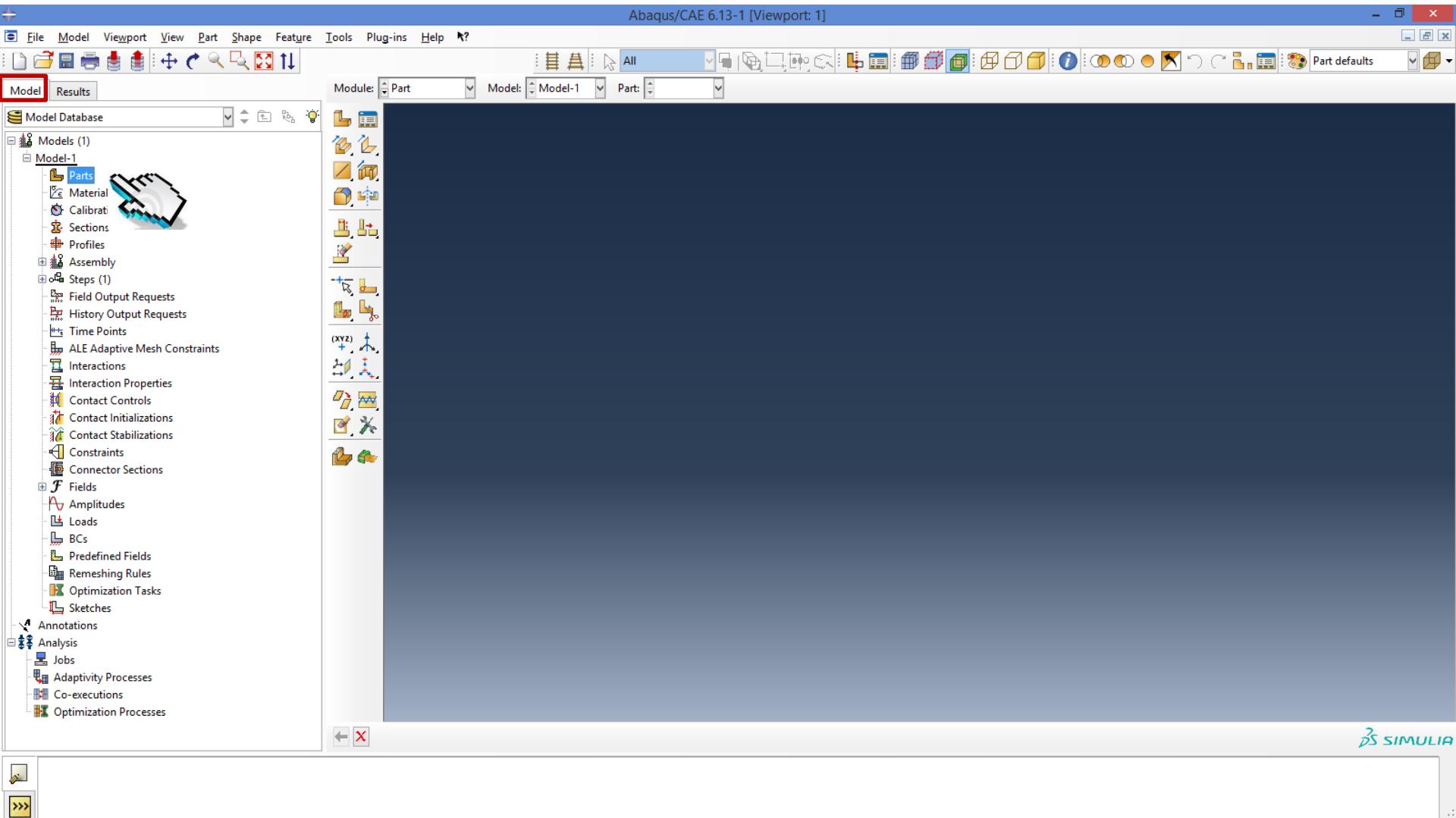
$$\sigma_x(x,z) = \frac{M_y(x)}{I_y} z \quad M_y(x=0) = F_z L$$

$$\sigma_{x\max} = \sigma_x\left(x=0, z = -\frac{h}{2}\right) = -\frac{F_z L}{I_y} \frac{h}{2}$$



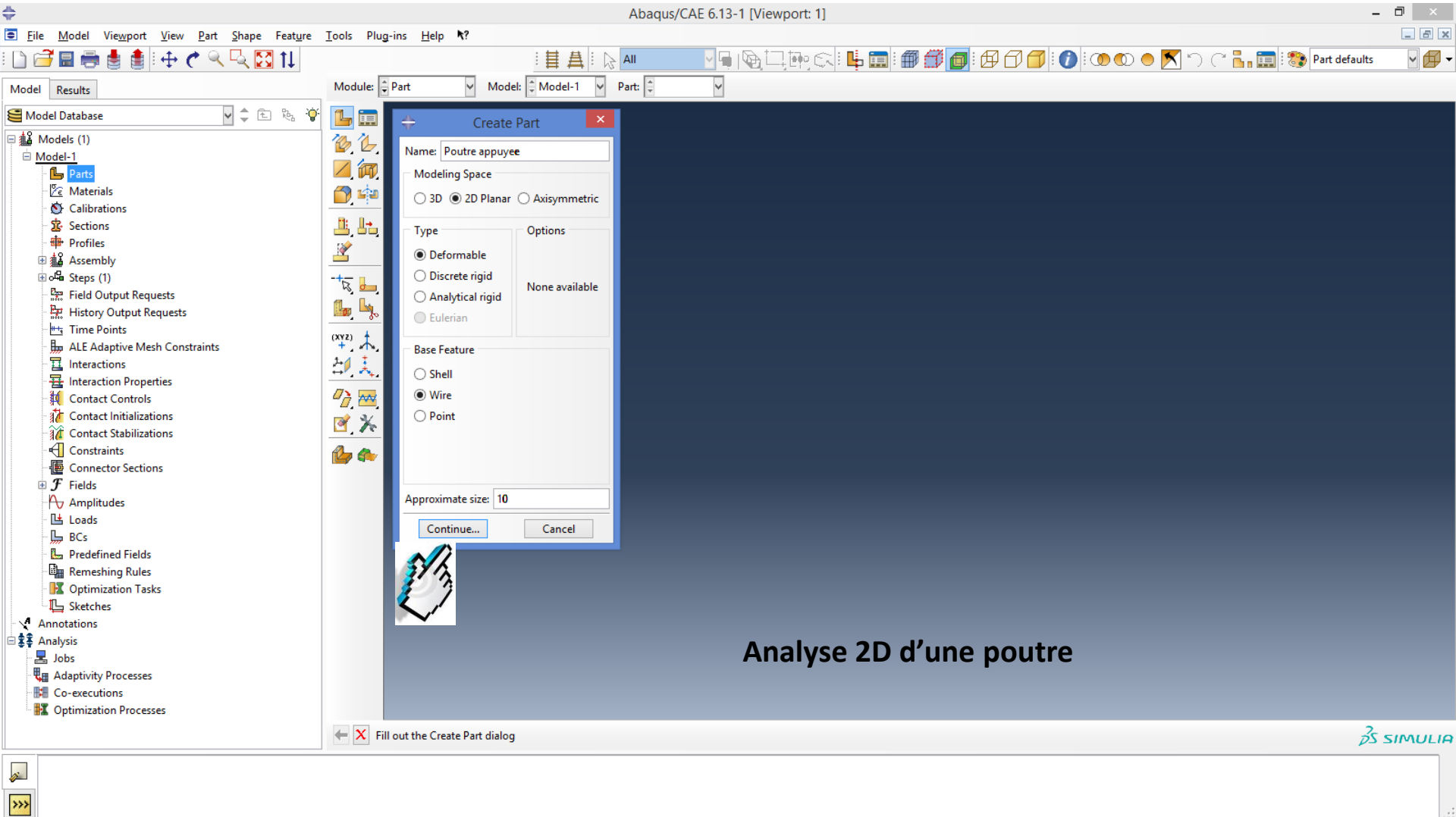
Model - Parts

1. Géométrie



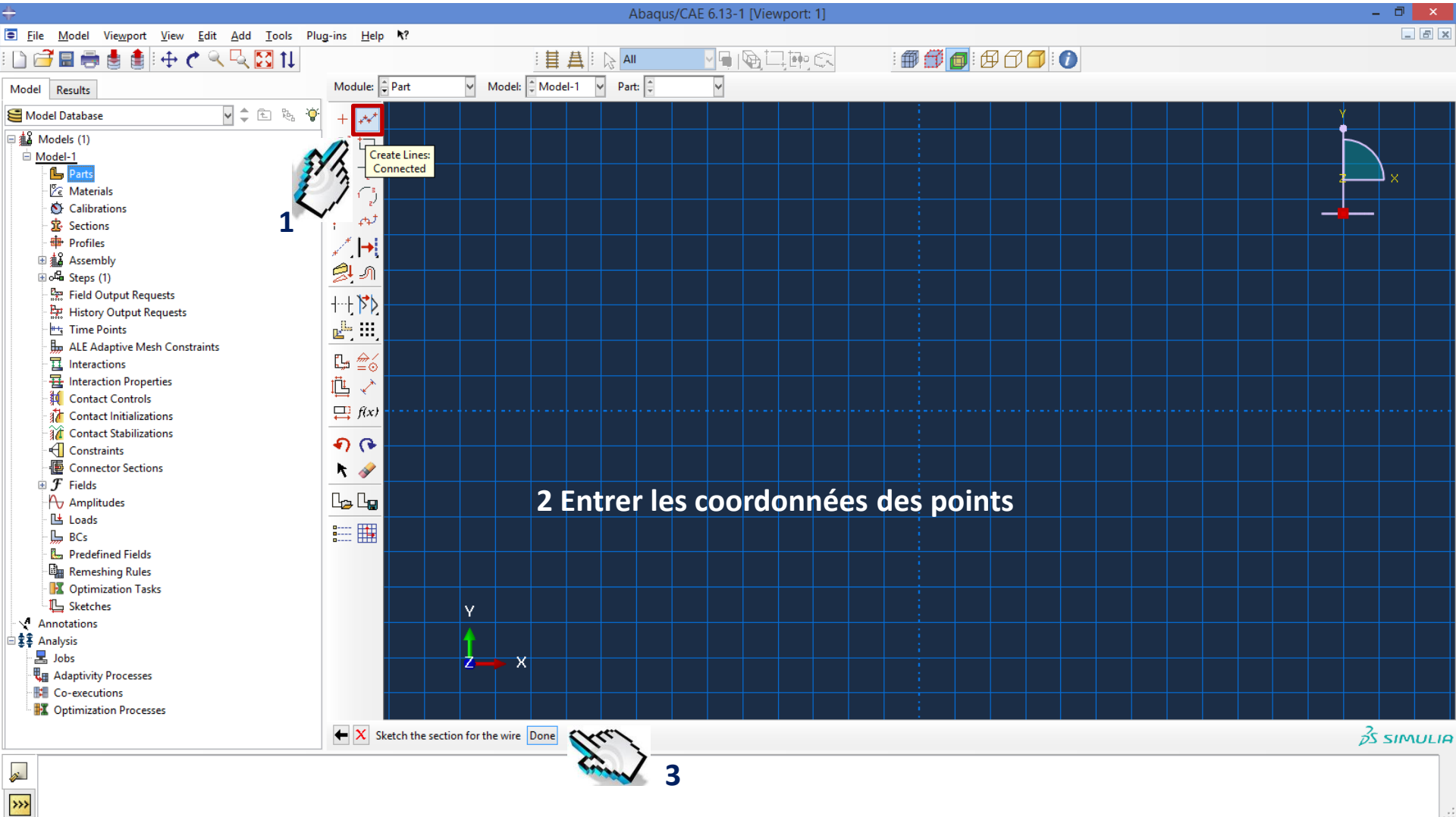
Model - Parts

1. Géométrie : type d'analyse (2D, 3D), type d'élément (poutre, plaque)



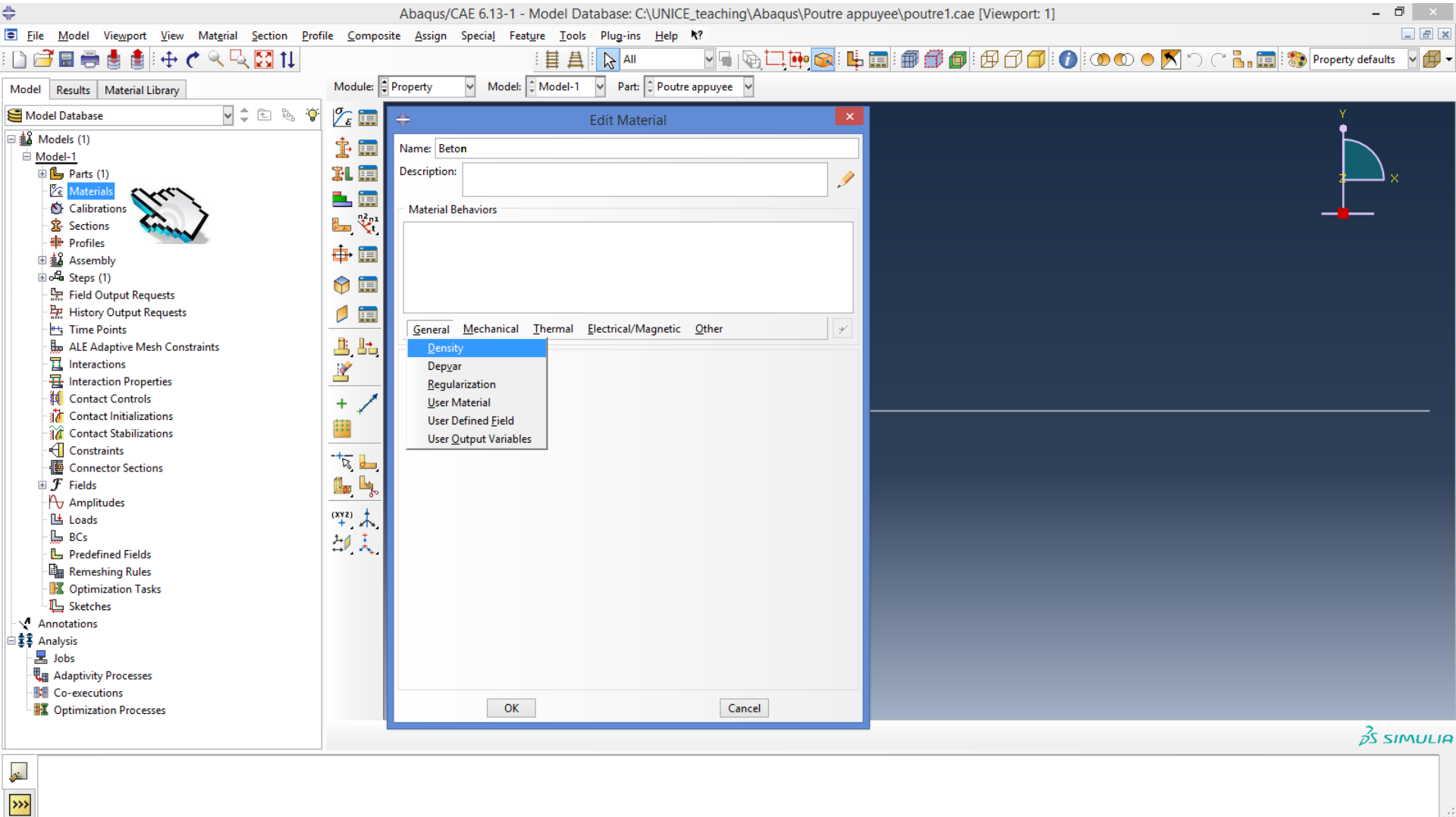
Model - Parts

1. Géométrie : type d'analyse (2D, 3D), type d'élément (poutre, plaque)



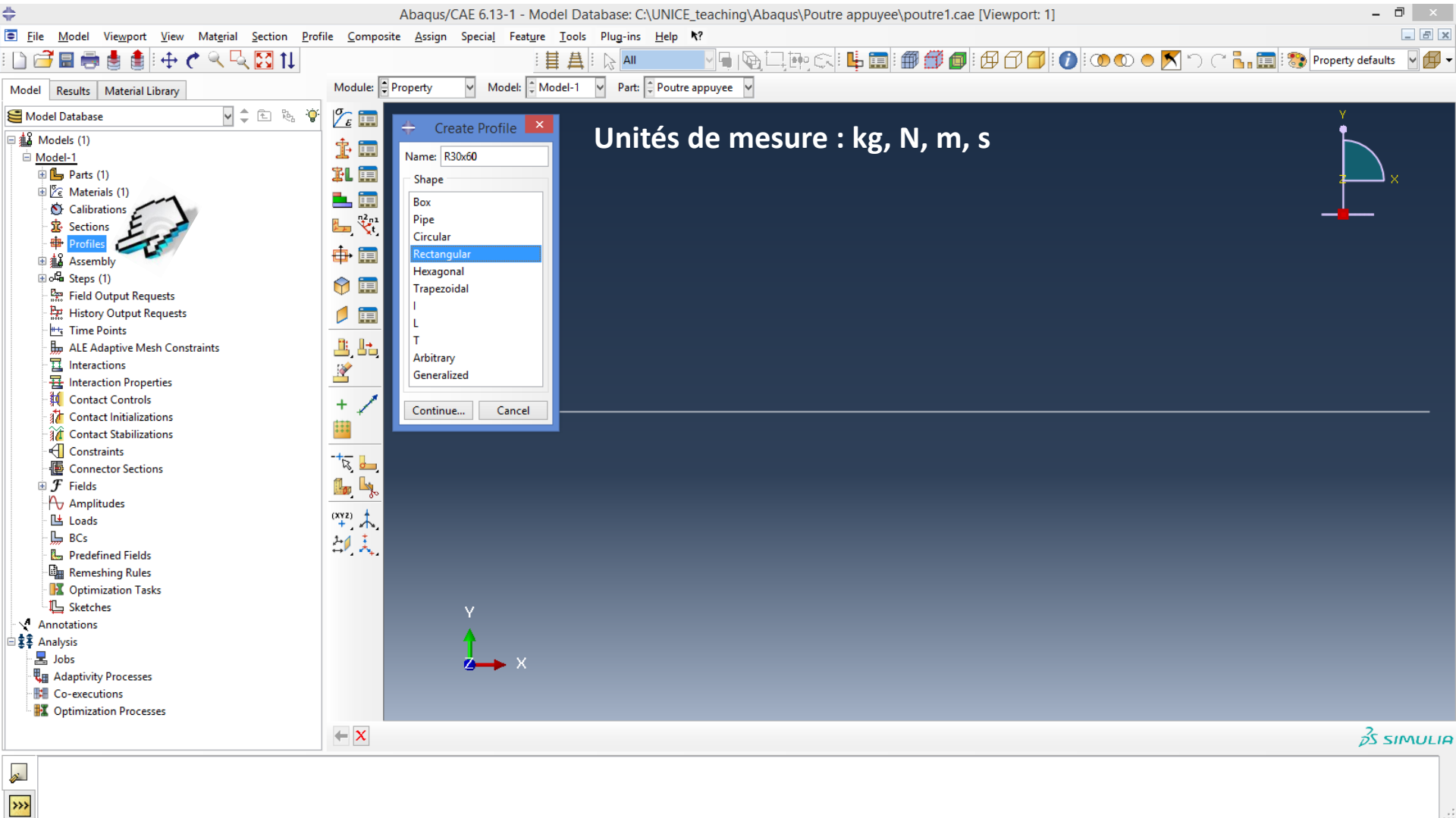
Model - Materials

2. Matériau : densité, élasticité (E, ν)



Model - Profiles

3. Profilé : forme de la section, dimensions de la section



Model - Sections

4. Section : type d'élément

Abaqus/CAE 6.13-1 - Model Database: C:\UNICE_teaching\Abaqus\Poutre appuyee\poutre1.cae [Viewport: 1]

File Model Viewport View Material Section Profile Composite Assign Special Feature Tools Plug-ins Help

Model Results Material Library

Model Database

Models (1)

Model-1

Parts (1)

Materials (1)

Calibrations

Sections

Profiles (1)

Assembly

Steps (1)

Field Output Requests

History Output Requests

Time Points

ALE Adaptive Mesh Constraints

Interactions

Interaction Properties

Contact Controls

Contact Initializations

Contact Stabilizations

Constraints

Connector Sections

Fields

Amplitudes

Loads

BCs

Predefined Fields

Remeshing Rules

Optimization Tasks

Sketches

Annotations

Analysis

Jobs

Adaptivity Processes

Co-executions

Optimization Processes

Module: Property Model: Model-1 Part: Poutre appuyee

Create Section

Name: R30x60

Category Type

☐ Solid

☐ Shell

☒ Beam

☐ Fluid

☐ Other

Continue... Cancel

Edit Beam Section

Name: R30x60

Type: Beam

Section integration: ☒ During analysis ☐ Before analysis

Beam Shape

Profile name: R30x60

Profile shape:

Basic Stiffness Fluid Inertia

Material name: Beton

Section Poisson's ratio: 0.2

Temperature variation:

☒ Linear by gradients

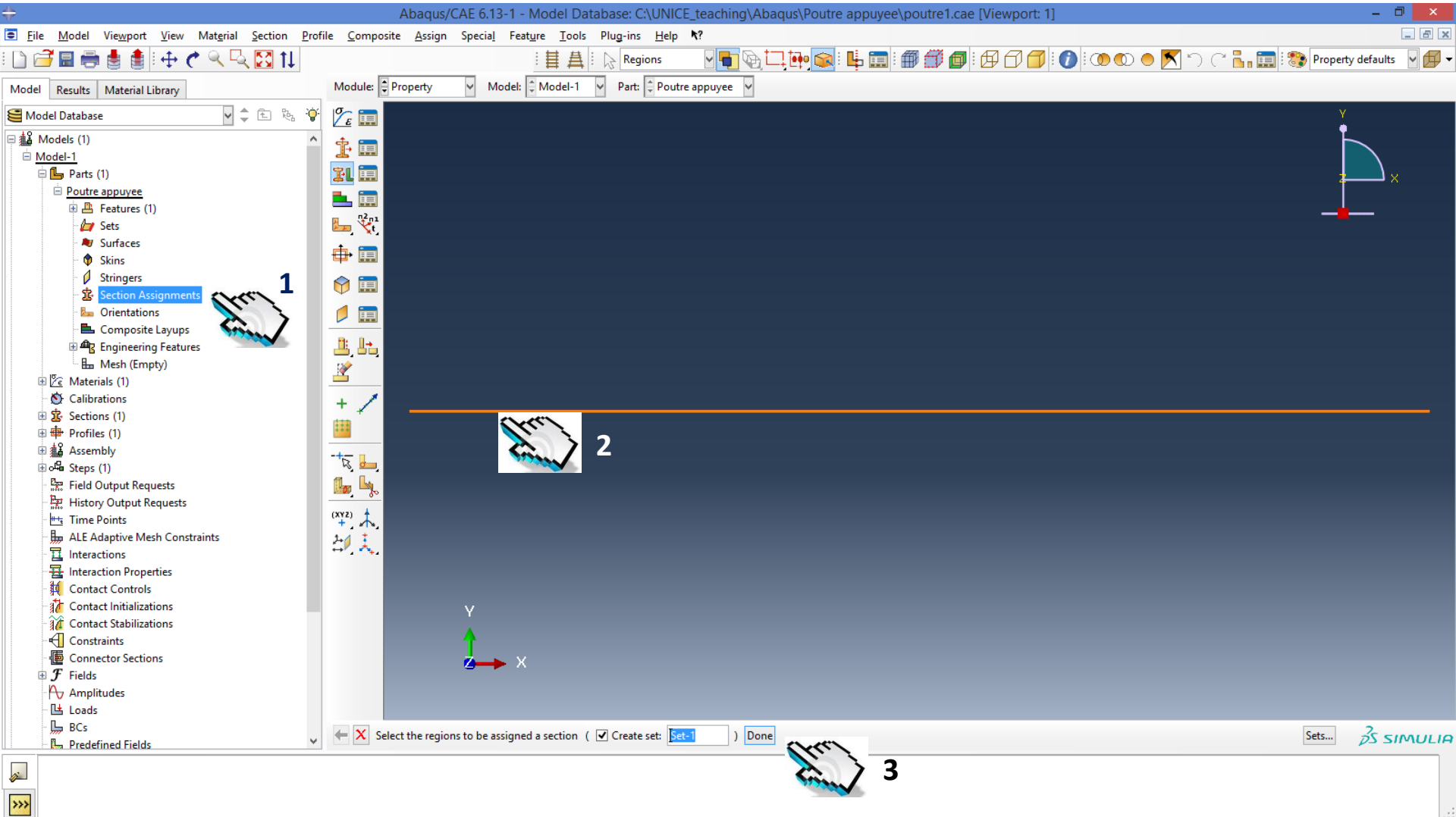
☐ Interpolated from temperature points

Stiffness: Use consistent mass matrix formulation

SIMULIA

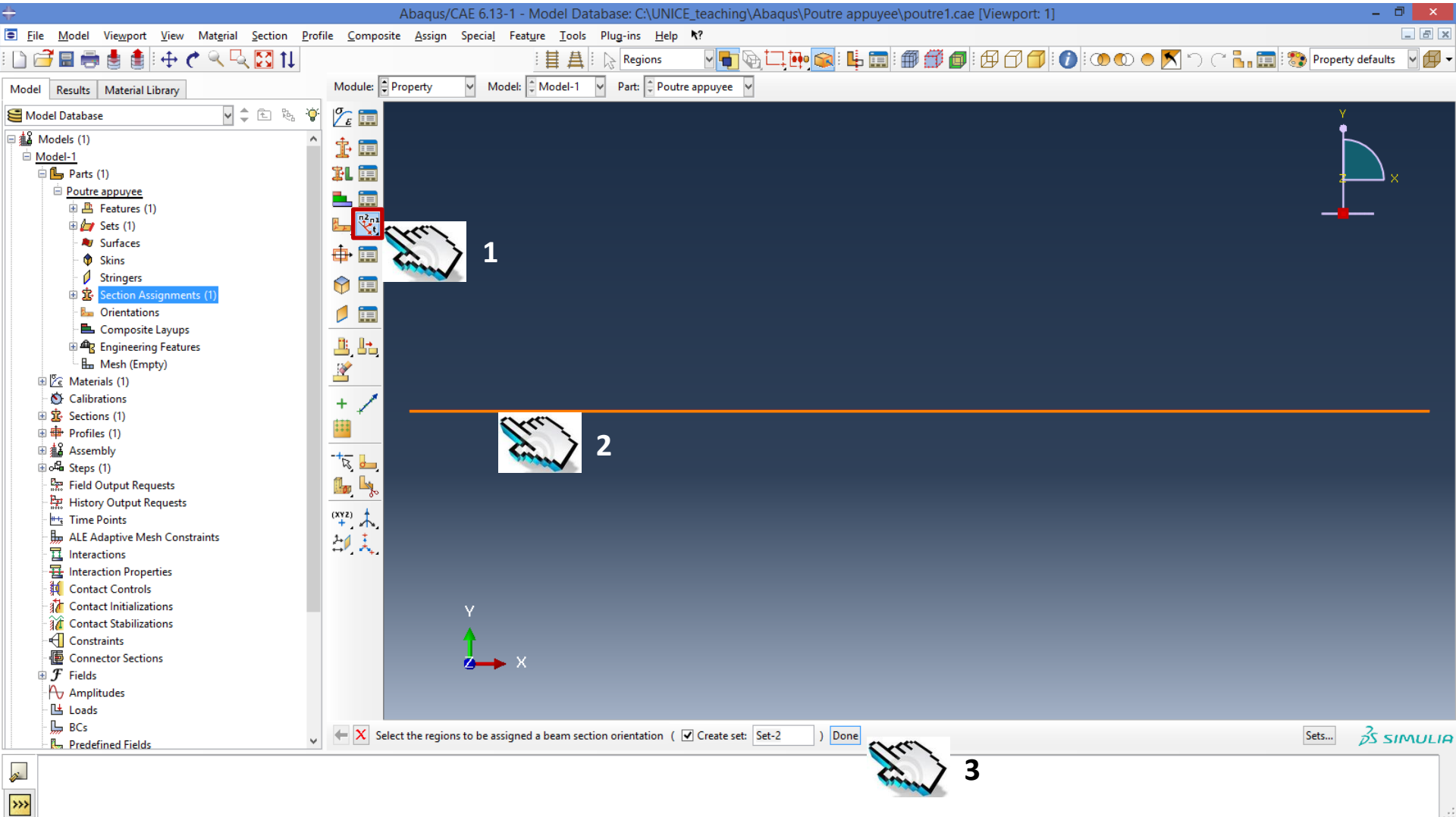
Model - Parts

5. Attribution de la section : type d'élément



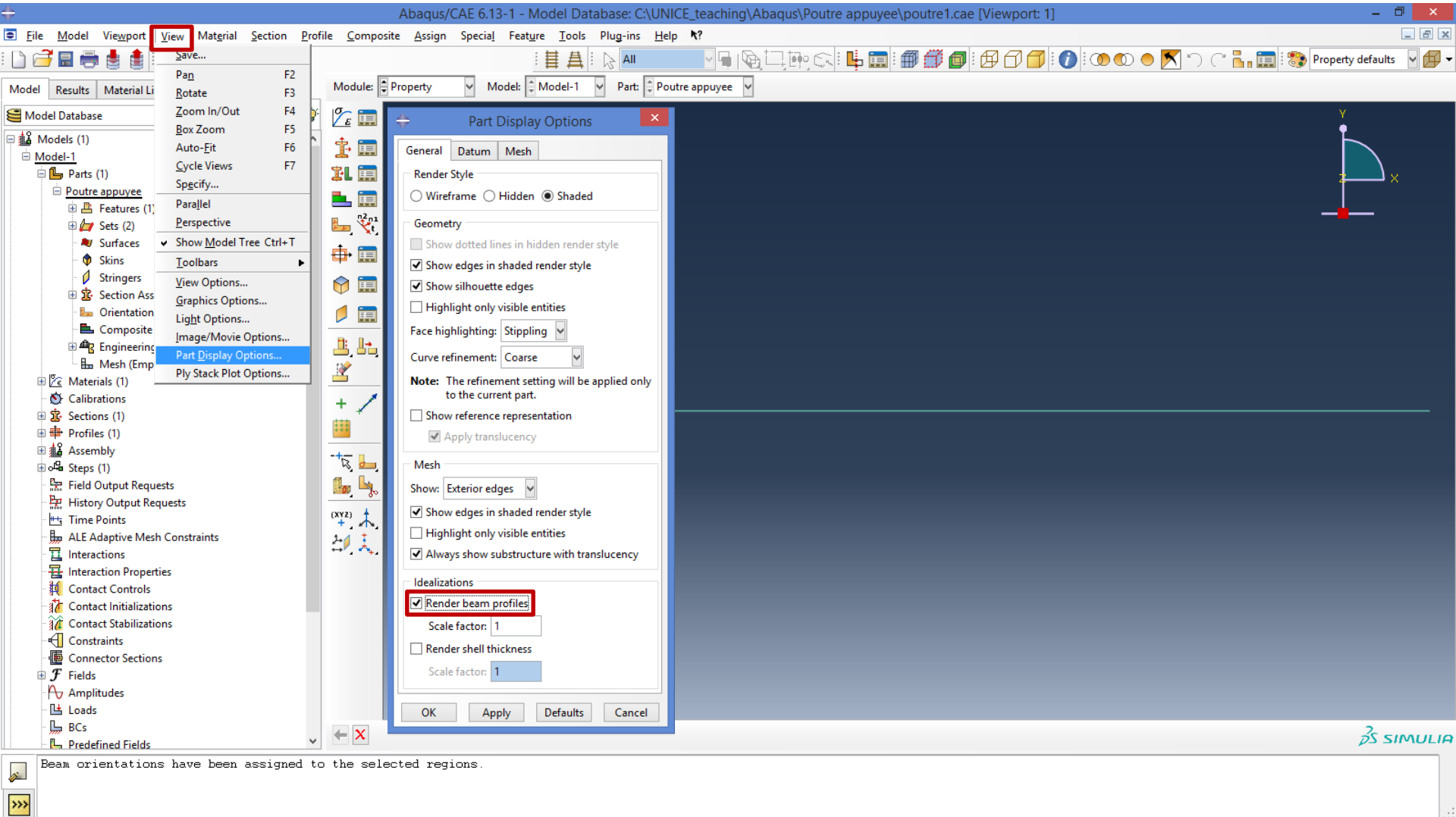
Model - Parts

5. Attribution de la section : type d'élément



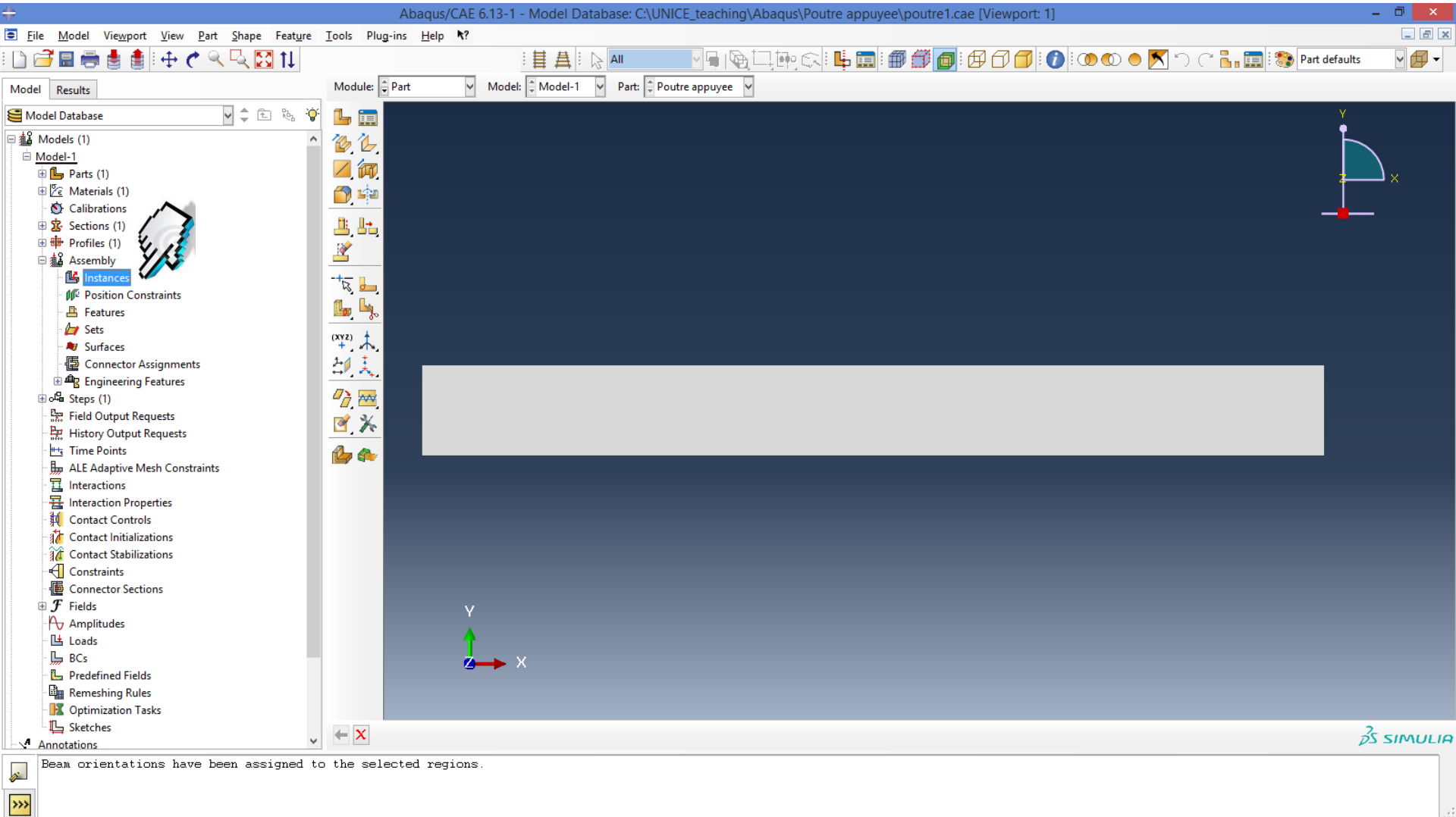
Model - Parts

6. Visualisation



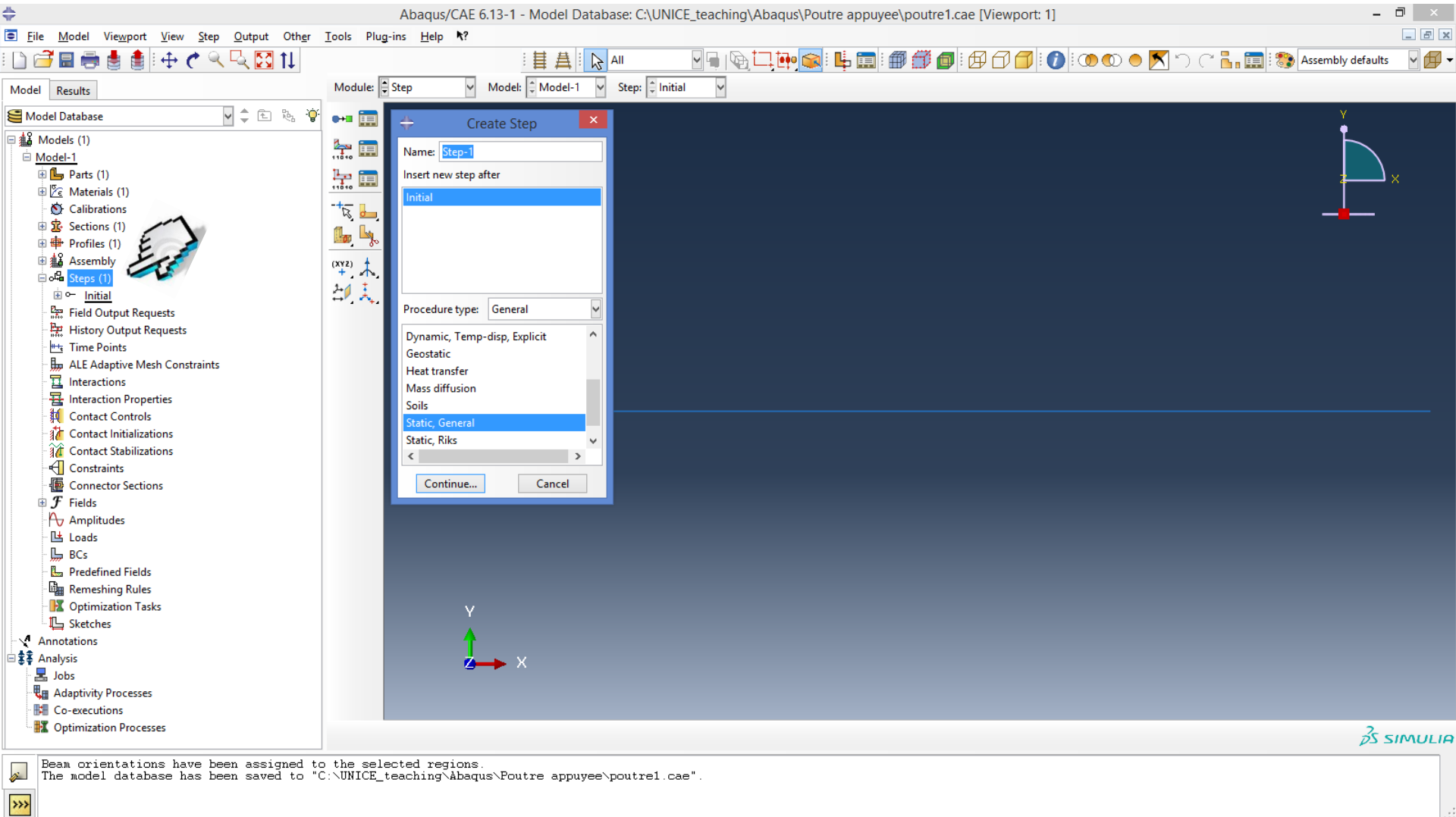
Model - Assembly

7. Assemblage



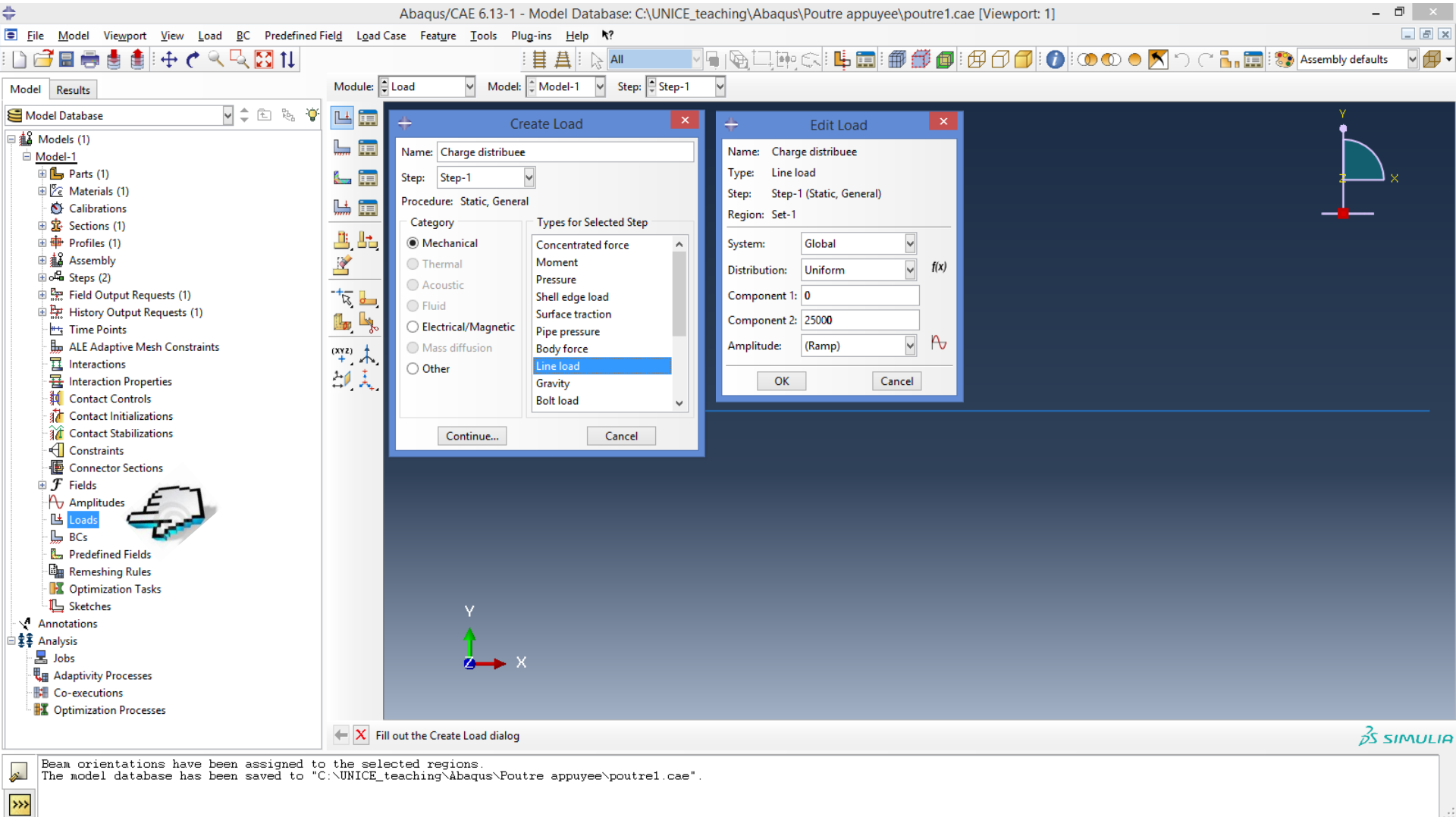
Model - Steps

8. Pas de calcul : Statique, Dynamique implicite, Longueur d'arche/Riks



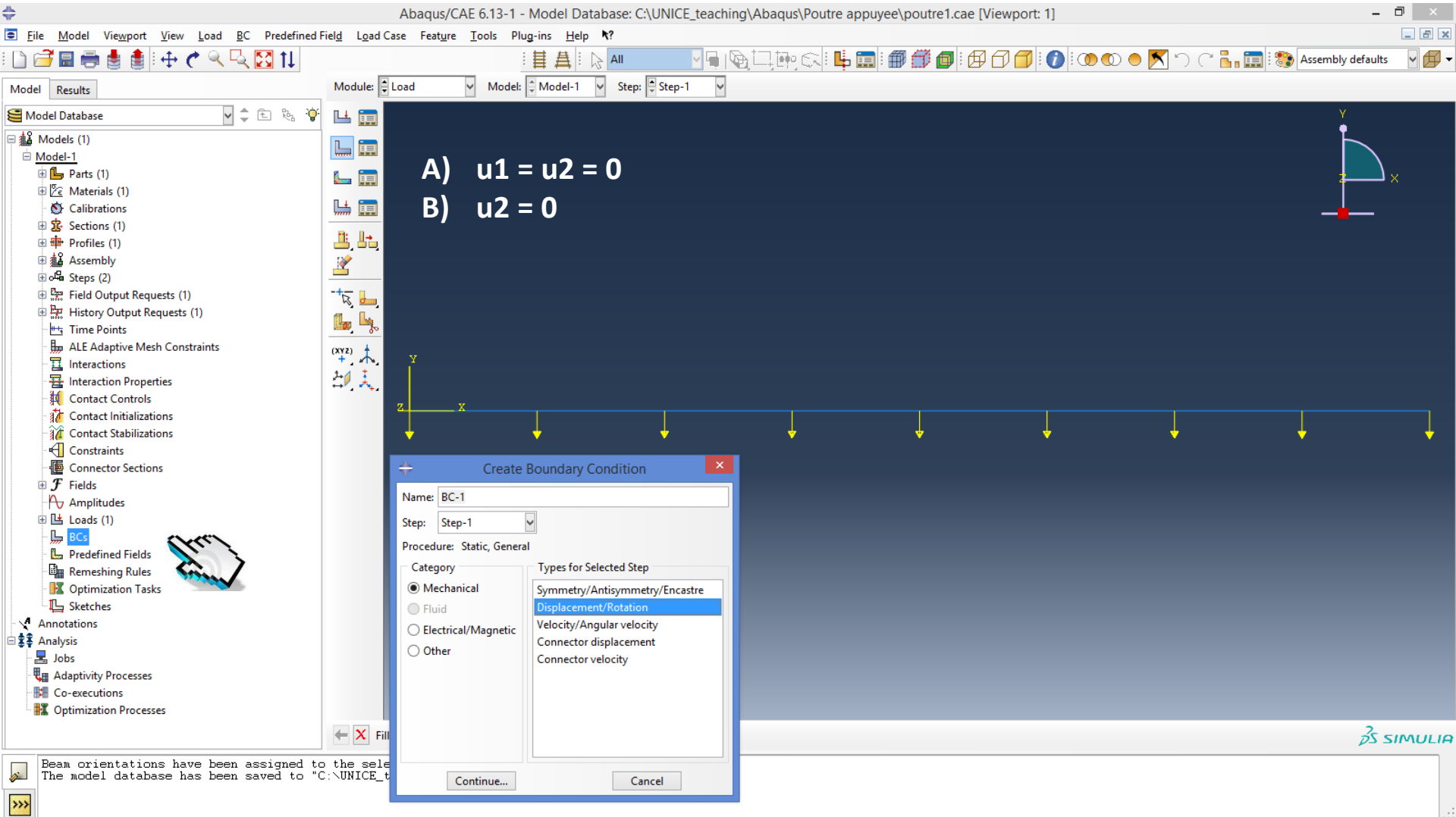
Model - Loads

9. Charges : force concentrée, pression, poids, charge uniforme [N/m]



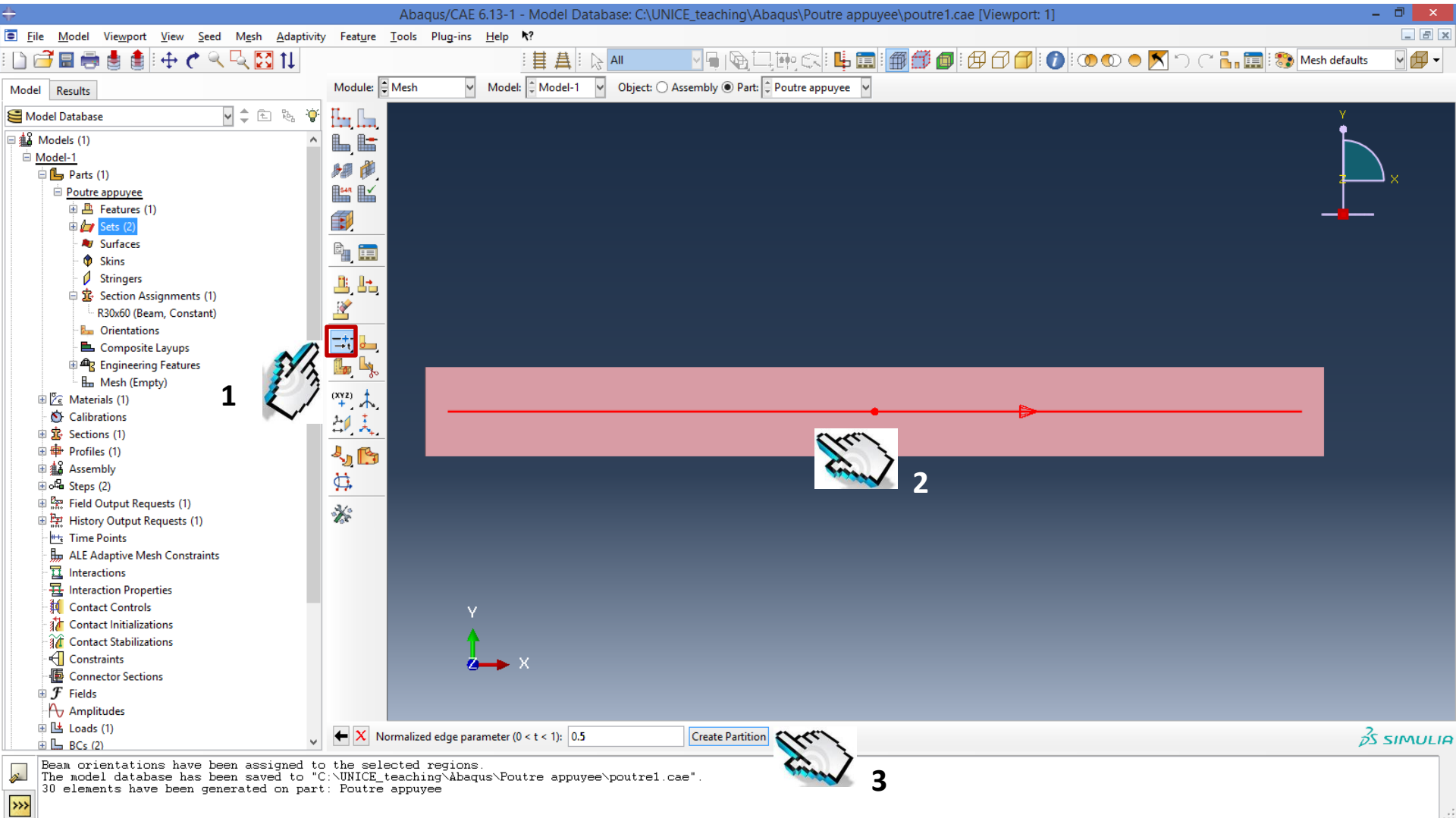
Model - BCs

10. Condition aux limites : déplacement, vitesse, accélération



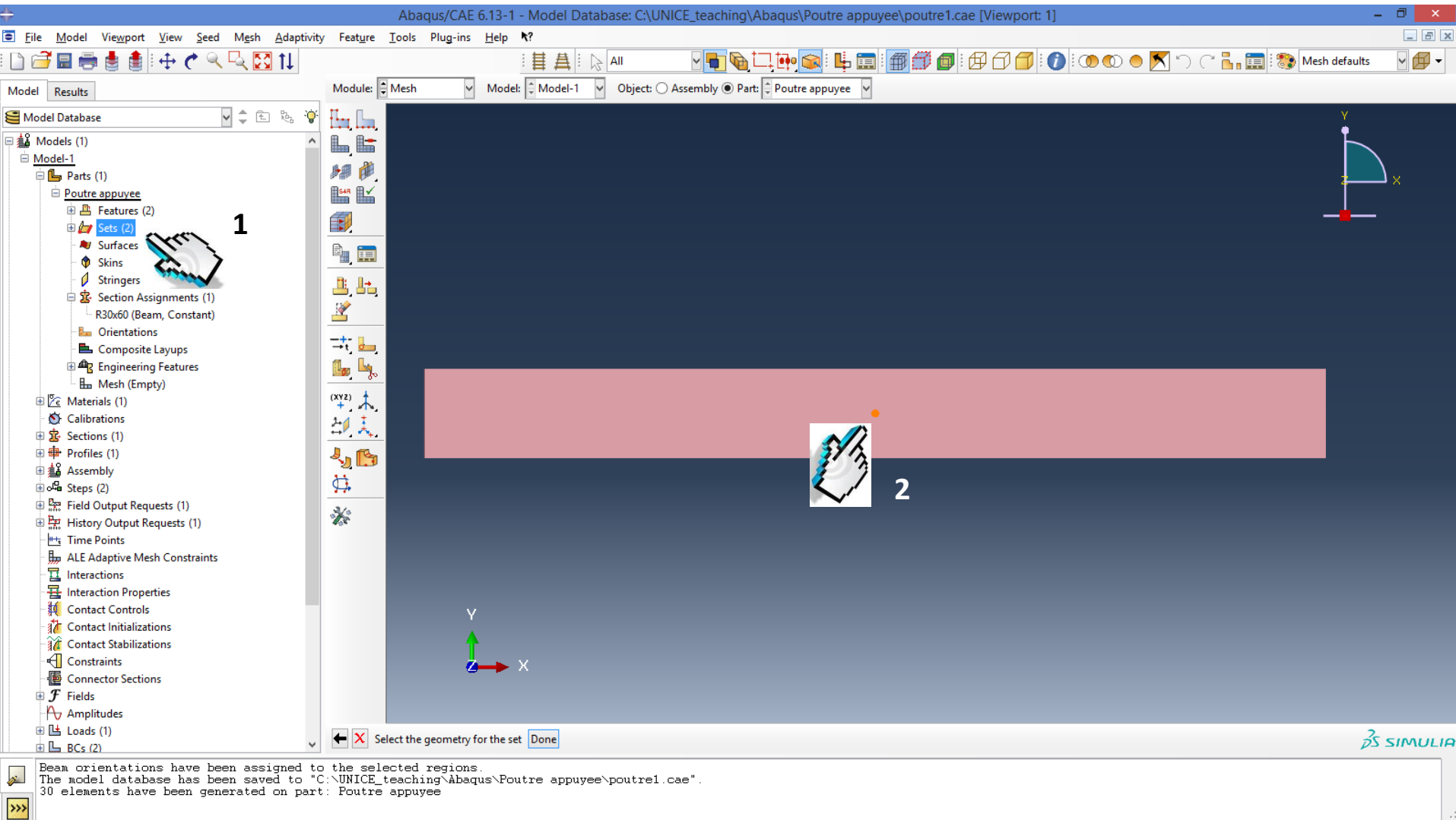
Model - Parts

11. Partition



Model - Parts

12. Point où enregistrer les résultats : point, bord, surface



Model - Field Output Requests

13. Résultats demandés : contraintes, déformations totales, déplacements, réactions

Abaqus/CAE 6.13-1 - Model Database: C:\UNICE_teaching\Abaqus\Poutre appuyee\poutre1.cae [Viewport: 1]

File Model Viewport View Step Output Other Tools Plug-ins Help

Model Results

Model Database

Models (1)

Model-1

Parts (1)

Materials (1)

Calibrations

Sections (1)

Profiles (1)

Assembly

Steps (2)

Field Output Requests (1)

F-Output-1

States (1)

Step-1 (Created)

History Output Requests (1)

Time Points

ALE Adaptive Mesh Constraints

Interactions

Interaction Properties

Contact Controls

Contact Initializations

Contact Stabilizations

Constraints

Connector Sections

Fields

Amplitudes

Loads (1)

BCs (2)

Predefined Fields

Remeshing Rules

Optimization Tasks

Sketches

Annotations

Analysis

Jobs (1)

Adaptivity Processes

Co-executions

Module: Step Model: Model-1 Step: Step-1

Edit Field Output Request

Name: F-Output-1

Step: Step-1

Procedure: Static, General

Domain: Whole model ☐ Exterior only

Frequency: Every n increments n: 1

Timing: Output at exact times

Output Variables

☒ Select from list below ☐ Preselected defaults ☐ All ☐ Edit variables

S,E,U,RF,CF

☒ Stresses

☒ Strains

☒ Displacement/Velocity/Acceleration

☒ Forces/Reactions

☐ Contact

☐ Energy

☐ Failure/Fracture

☐ Thermal

Note: Some error indicators are not available when Domain is Whole Model or Int

☐ Output for rebar

Output at shell, beam, and layered section points:

☒ Use defaults ☐ Specify:

☒ Include local coordinate directions when available

OK Cancel

30 elements have been generated on part: Poutre appuyee
The set 'Point' has been created (1 vertex).
30 elements have been generated on part: Poutre appuyee
The model database has been saved to "C:\UNICE_teaching\Abaqus\Poutre appuyee\poutre1.cae".
The job "Job-1" has been created.

SIMULIA

Model - History Output Requests

14. Résultats demandés : flèche

Abaqus/CAE 6.13-1 - Model Database: C:\UNICE_teaching\Abaqus\Poutre appuyee\poutre1.cae [Viewport: 1]

File Model Viewport View Step Output Other Tools Plug-ins Help

Model Results

Model Database

- Models (1)
 - Model-1
 - Parts (1)
 - Materials (1)
 - Calibrations
 - Sections (1)
 - Profiles (1)
 - Assembly
 - Steps (2)
 - Field Output Requests (1)
 - History Output Requests (1)
 - H-Output-1
 - States (1)
 - Step-1 (Created)
 - Time Points
 - ALE Adaptive Mesh Constraints
 - Interactions
 - Interaction Properties
 - Contact Controls
 - Contact Initializations
 - Contact Stabilizations
 - Constraints
 - Connector Sections
 - Fields
 - Amplitudes
 - Loads (1)
 - BCs (2)
 - Predefined Fields
 - Remeshing Rules
 - Optimization Tasks
 - Sketches
 - Annotations
 - Analysis
 - Jobs (1)
 - Adaptivity Processes
 - Co-executions

Module: Step Model: Model-1 Step: Step-1

Edit History Output Request

Name: H-Output-1
Step: Step-1
Procedure: Static, General

Domain: Set : Poutre appuyee-1.Point

Frequency: Every n increments n: 1

Timing: Output at exact times

Output Variables

☒ Select from list below ☐ Preselected defaults ☐ All ☐ Edit variables

U1,U2,U3,UR1,UR2,UR3

- ☐ Stresses
- ☐ Strains
- ☒ Displacement/Velocity/Acceleration
 - ☒ U, Translations and rotations
 - ☐ UT, Translations
 - ☐ UR, Rotations
 - ☐ V, Translational and rotational velocities
 - ☐ VT, Translational velocities
 - ☐ VR, Rotational velocities
 - ☐ WARP, Warping amplitude for open section beams

☐ Output for rebar

Output at shell, beam, and layered section points:

☒ Use defaults ☐ Specify:

☐ Include sensor when available

☒ Use global directions for vector-valued output

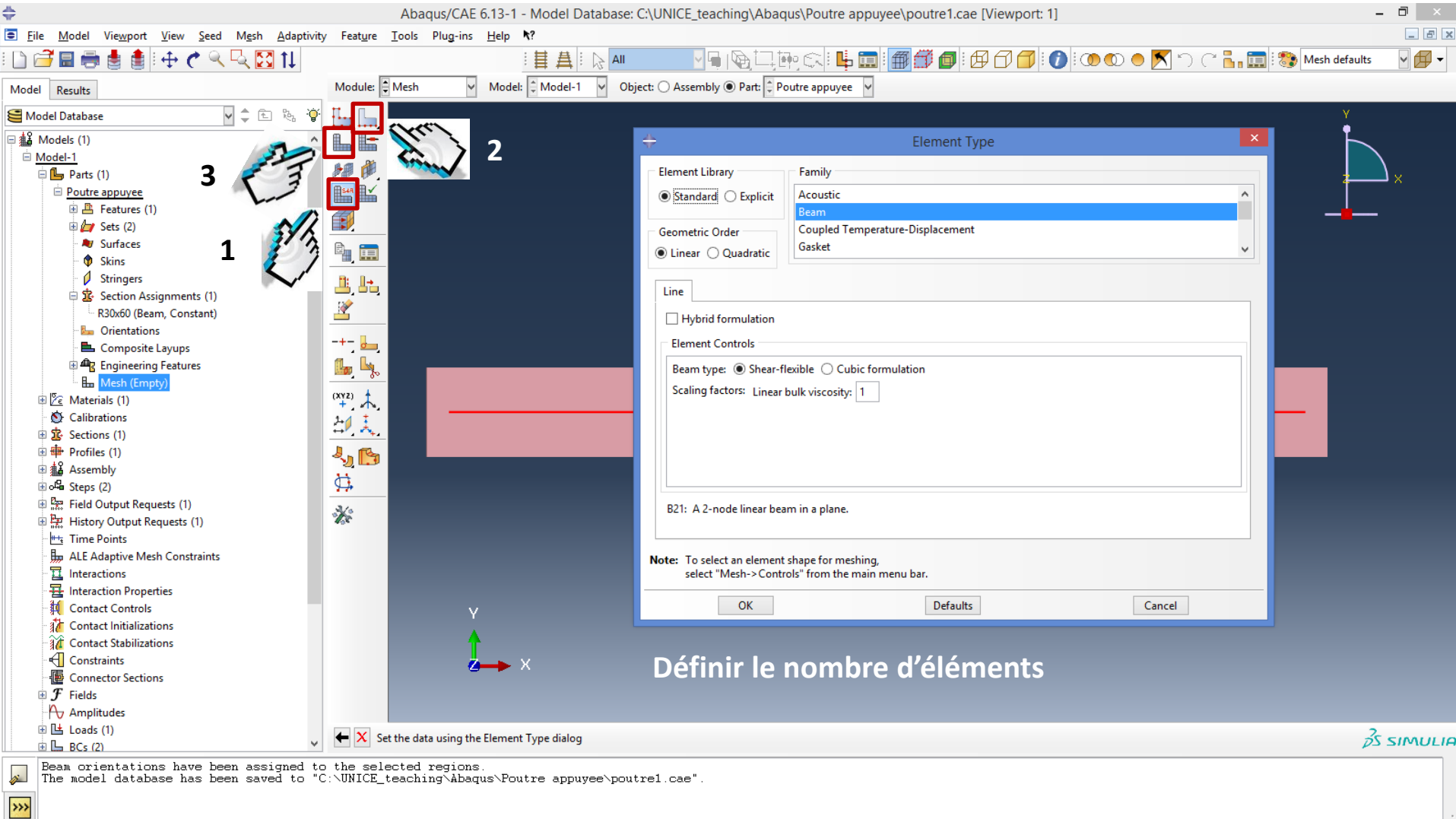
OK Cancel

30 elements have been generated on part: Poutre appuyee
The set 'Point' has been created (1 vertex).
30 elements have been generated on part: Poutre appuyee
The model database has been saved to "C:\UNICE_teaching\Abaqus\Poutre appuyee\poutre1.cae".
The job "Job-1" has been created.

3D SIMULIA

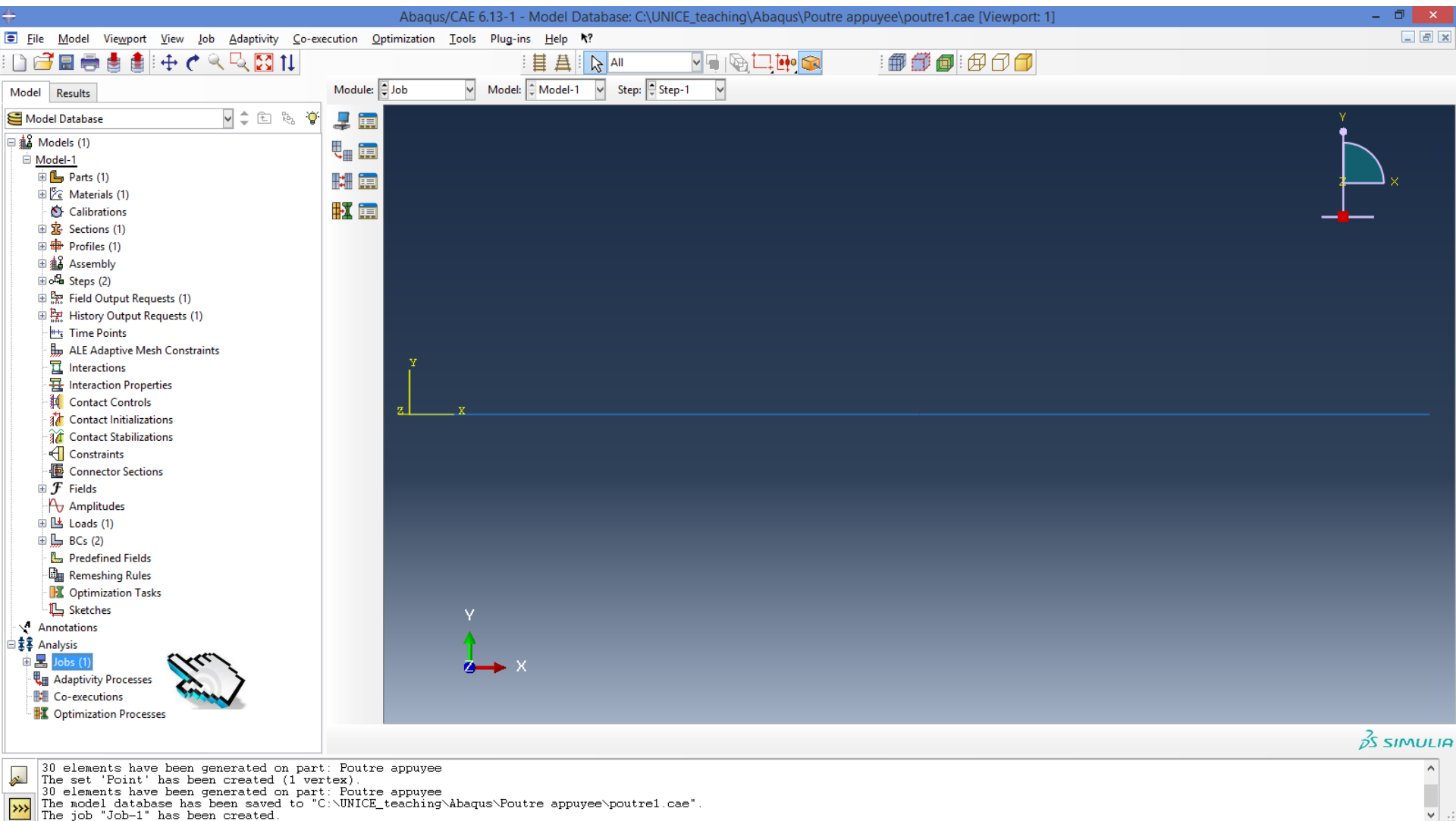
Model - Parts

15. Maillage : type d'élément (2 ou 3 nœuds), nombre d'éléments

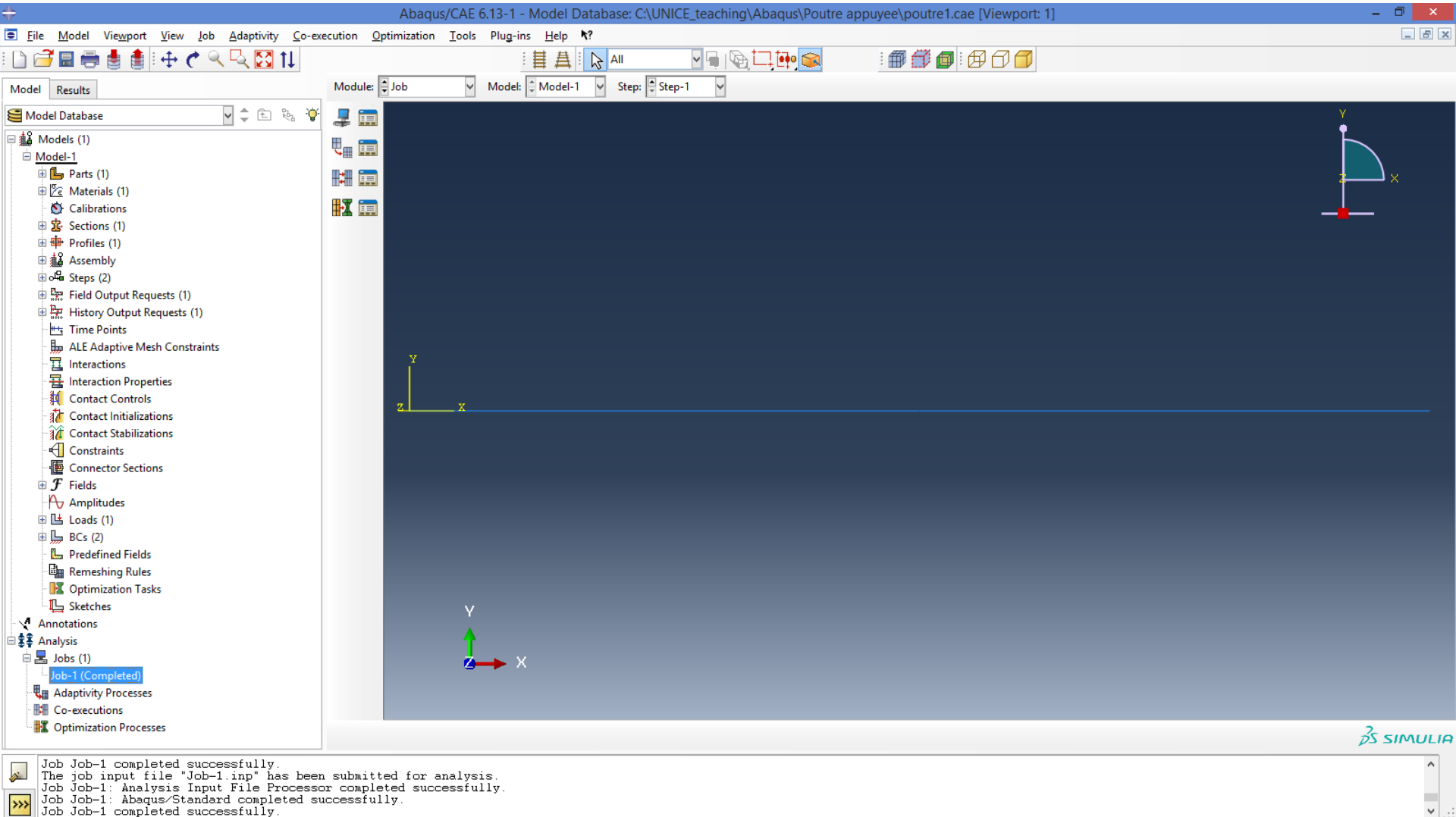


Model - Analysis

16. Création du projet, vérification des données et calcul

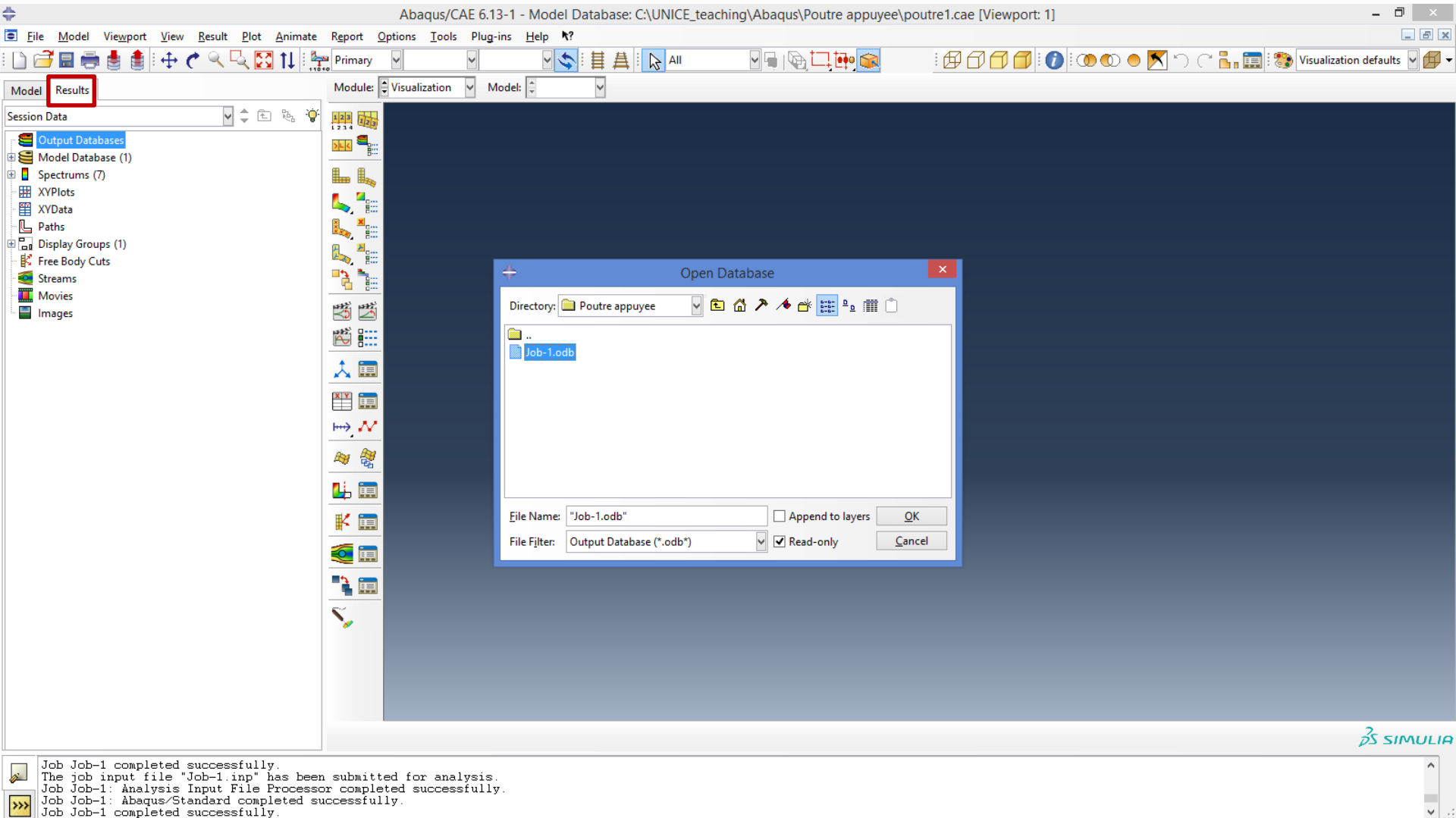


Calcul complet



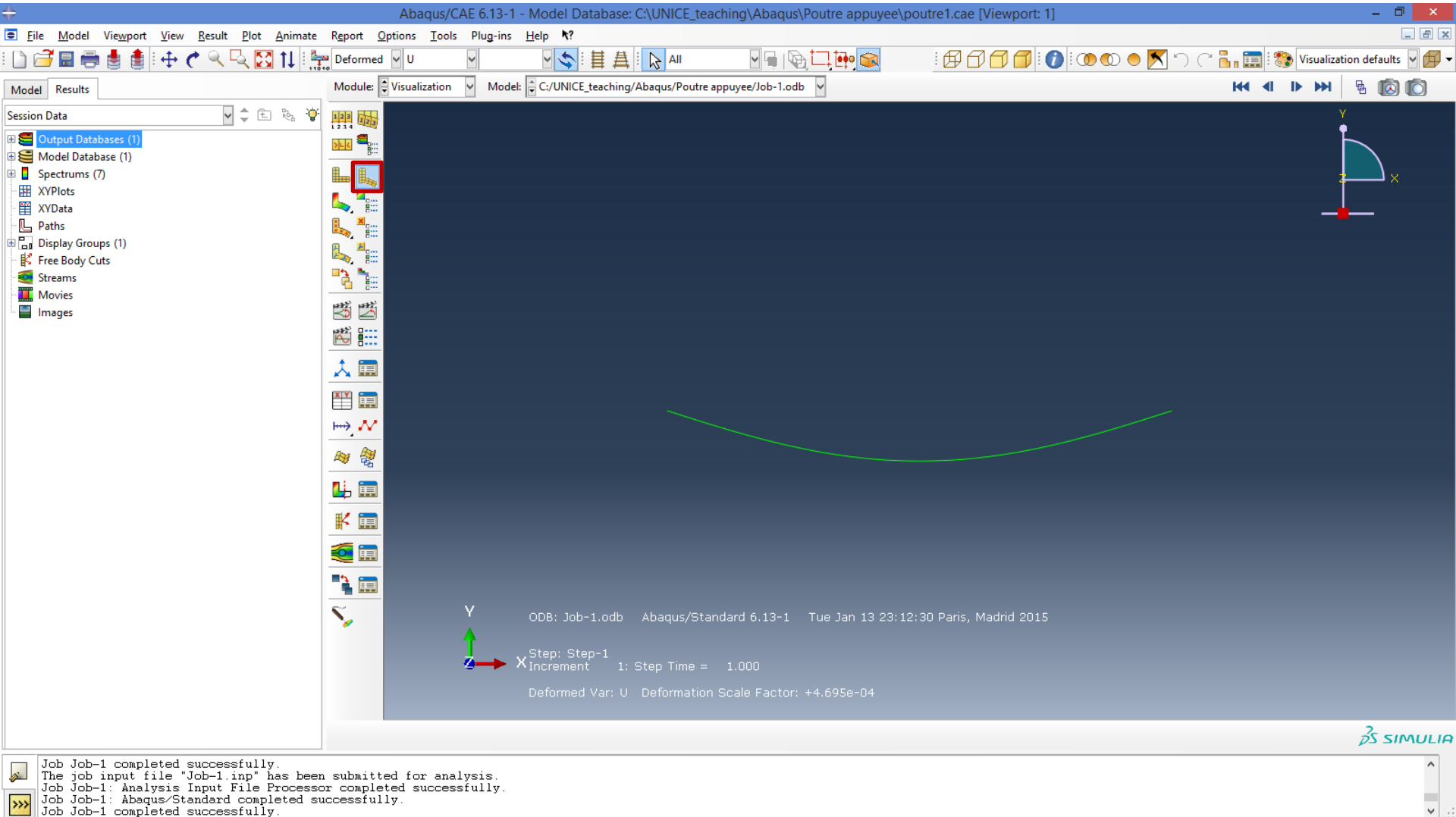
Résultats

1. Fichier de résultats : *.odb



Résultats

2. Déformée



Résultats

3. Cartographie : déplacement, contrainte

Abaqus/CAE 6.13-1 - Model Database: C:\UNICE_teaching\Abaqus\Poutre appuyee\poutre1.cae [Viewport: 1]

File Model Viewport View Result Plot Animate Report Options Tools Plug-ins Help

Primary S Mises All Visualization Model: C:\UNICE_teaching\Abaqus\Poutre appuyee\Job-1.odb

Session Data

- Output Databases (1)
 - Job-1.odb
 - History Output (2)
 - Steps (1)
 - Step-1
 - Frames (2)
 - Frame: 0
 - Frame: 1
- Instances (1)
- Materials (1)
- Sections (1)
- Element Sets (4)
- Node Sets (7)
- Surface Sets
- Session Coordinate Systems
- ODB Coordinate Systems
- User Data
 - Annotations
 - XYData

- Model Database (1)
- Spectrums (7)
- XYPlots (1)
- XYData (1)
- Paths
- Display Groups (1)
- Free Body Cuts
- Streams
- Movies
- Images

S, Mises
Bottom, (fraction = -1.0)
(Avg: 75%)

- +3.118e+06
- +2.875e+06
- +2.632e+06
- +2.389e+06
- +2.146e+06
- +1.903e+06
- +1.660e+06
- +1.417e+06
- +1.174e+06
- +9.306e+05
- +6.875e+05
- +4.444e+05
- +2.014e+05

Field Output

Step/Frame
Step: 1, Step-1
Frame: 1

Primary Variable Deformed Variable Symbol Variable Status Variable Stream Variable

Output Variable

☐ List only variables with results:

Name	Description (* indicates complex)
CF	Point loads at nodes
CM3	Point moments at nodes
E	Strain components at integration points
RF	Reaction force at nodes
RM3	Reaction moment at nodes
S	Stress components at integration points
U	Spatial displacement at nodes
UR3	Rotational displacement at nodes

Invariant
Magnitude

Component
U1
U2

Section Points...

OK Apply Cancel

Y
X
Z

ODB: Job-1.odb

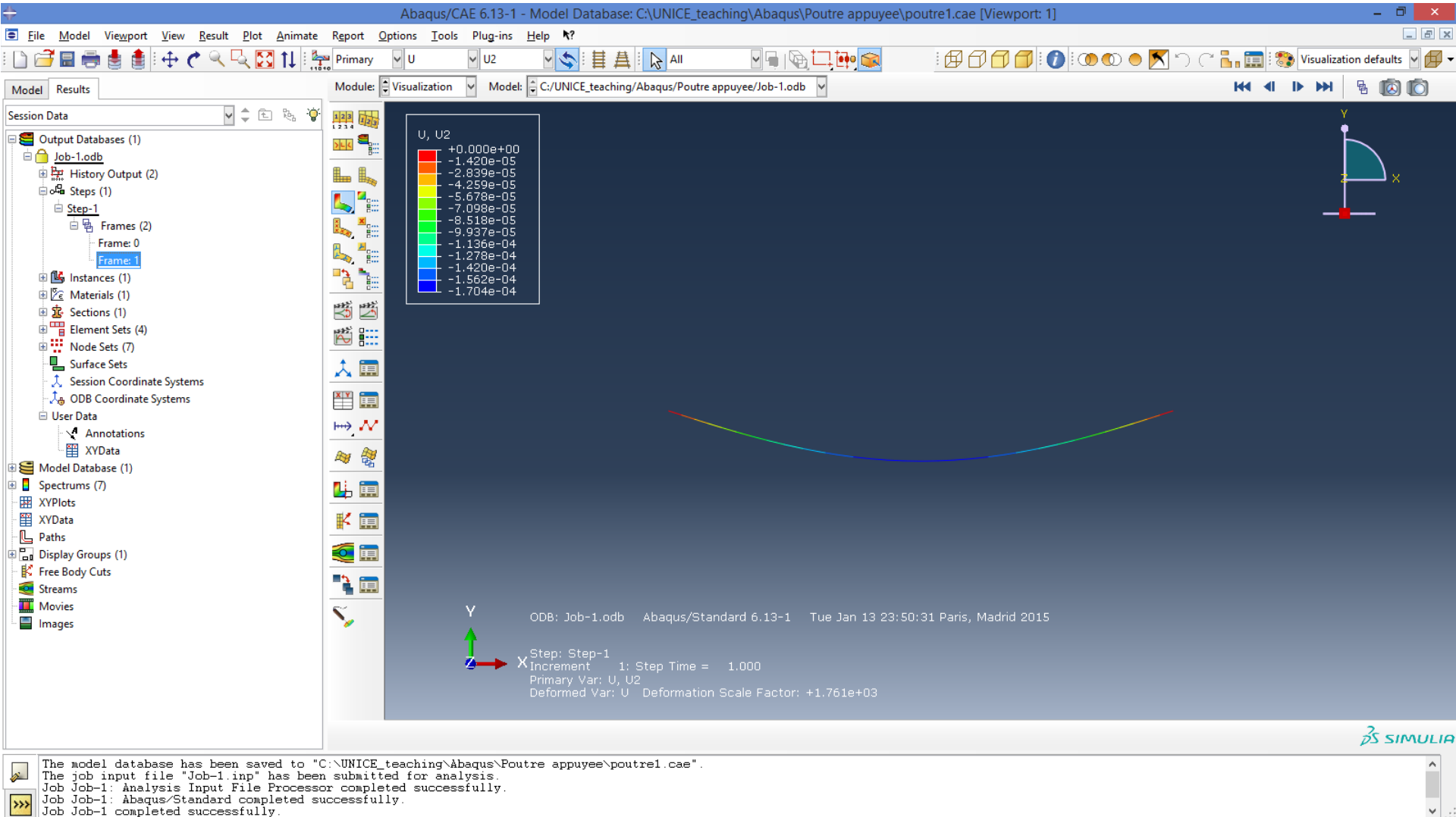
Step: Step-1
Increment: 1
Primary Var: S, M
Deformed Var: U

The job input file "Job-1.inp" has been submitted for analysis.
Job Job-1: Analysis Input File Processor completed successfully.
Job Job-1: Abaqus/Standard completed successfully.
Job Job-1 completed successfully.
A temporary XY data has been created from the History variable "Spatial displacement: U2 at Node 2 in NSET POINT".

SIMULIA

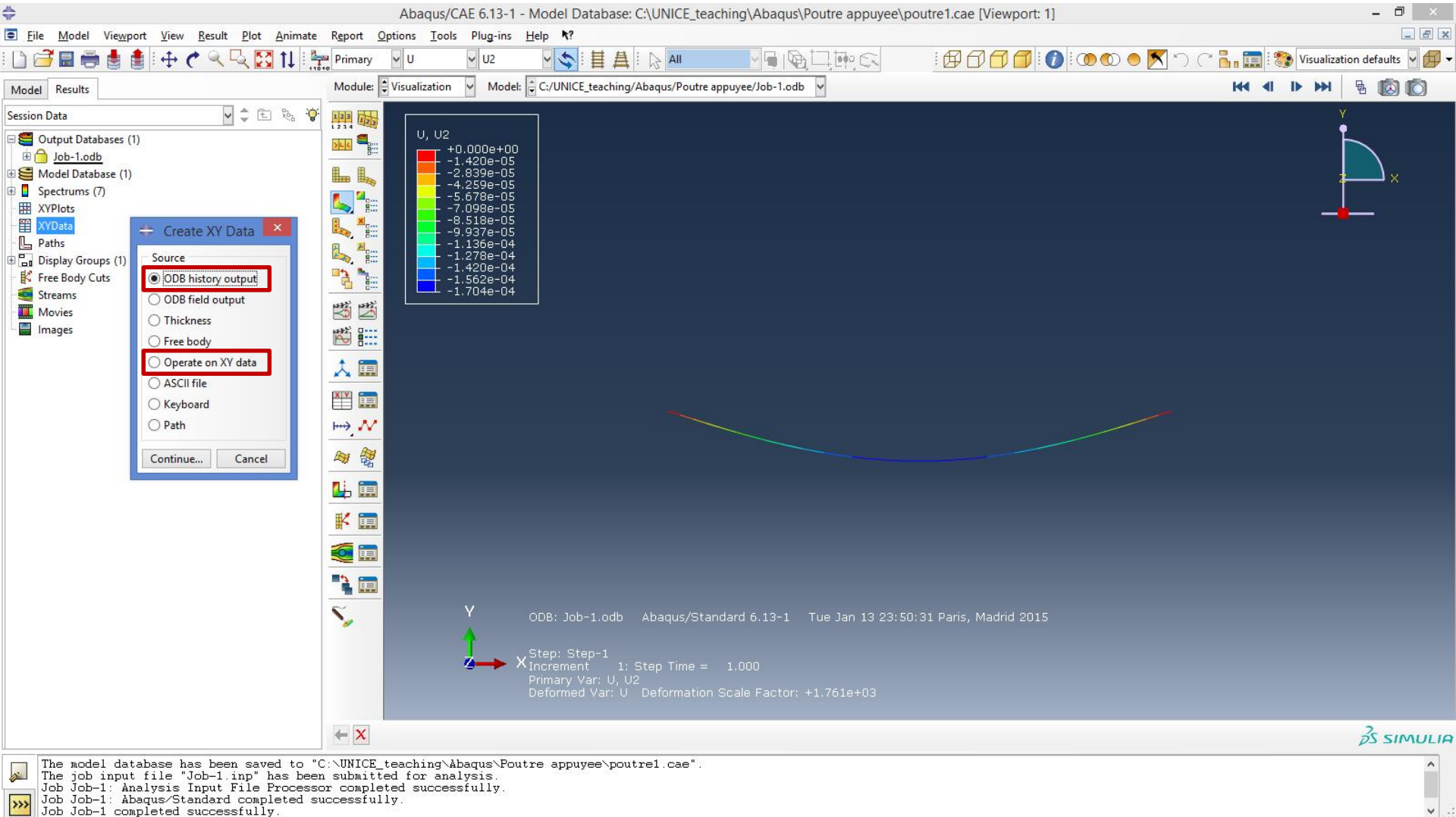
Résultats

3. Cartographie : déplacement



Résultats

4. Courbes : déplacement-temps, force-déplacement



Résultats

5. Courbes : déplacement maximum (flèche)

