SDLV120 - Absorption of one compression wave in an elastic bar

Summary

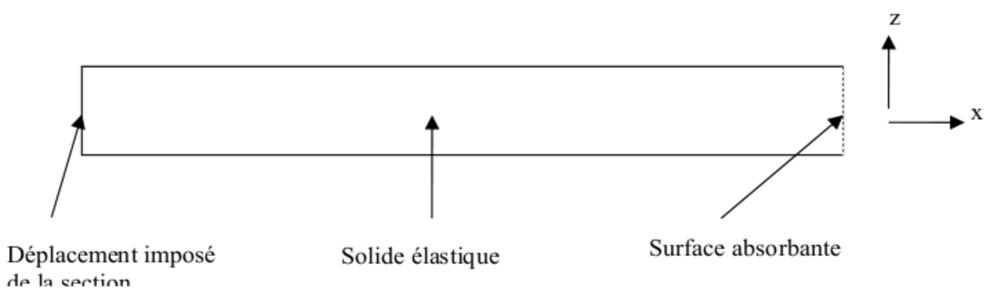
One tests the elastic paraxial elements of order 0 intended to apply conditions absorbing to the border of a grid finite elements to simulate the infinite one in direct transitory calculations.
Are used they to model an infinite elastic bar, in 3D or 2D, in which one creates a wave of pressure by imposing a displacement on the one of the ends. One is interested in nonthe reflection of the wave at the “infinite” end of the bar.

One tests successively the two direct transitory operators of *Code_Aster*, namely `DYNA_VIBRA` and `DYNA_NON_LINE`.

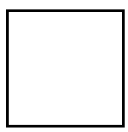
1 Problem of reference

1.1 Geometry

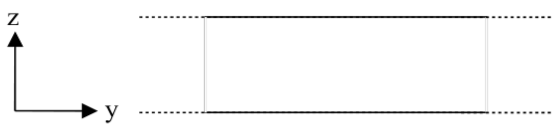
The system considered in the case 3D is that of an elastic bar with square section. One imposes a displacement according to x on one of the vertical faces and one observes the propagation of one compression wave. The side surface of the bar is left free. One places the elements absorbents on the face opposed to the face of excitation to simulate the infinite character of the bar in this direction. In the case 2D, the principle is identical with a very broad supposed bar which one models only one vertical section (see diagram).



Section case 3D:



Section case 2D:



1.2 Properties of materials

Bar: concrete

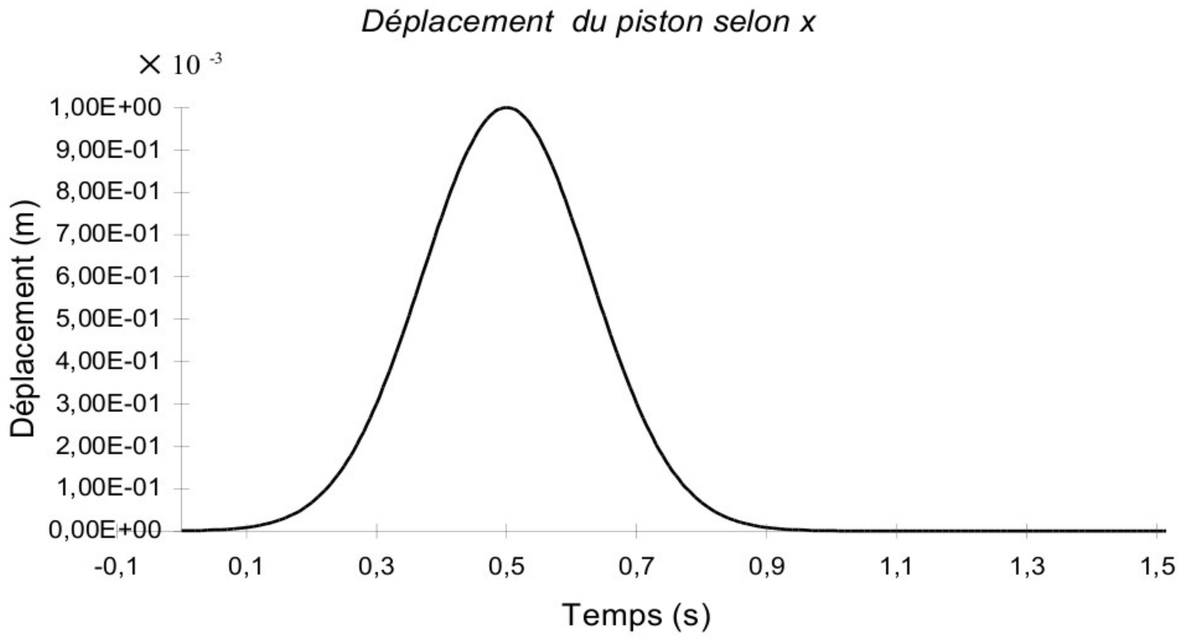
Density:	$2400\ kg.m^{-3}$
Young modulus:	$3{,}6.10^{10}\ Pa$
Poisson's ratio:	$0{,}48$

Notice

This test is also used to check the dependence of material of the elements absorbents according to the coordinates. One thus uses the following formula for the Young modulus: $3.6\cdot 10^{10}\times x/200$ *with* $x=200$ *on these elements.*

1.3 Boundary conditions and loadings

One imposes on all the nodes of the face of the piston in contact with the fluid a displacement according to x with the function of following temporal excitation:



1.4 Initial conditions

Displacement is null in all the bar at the initial moment.

2 Reference solution

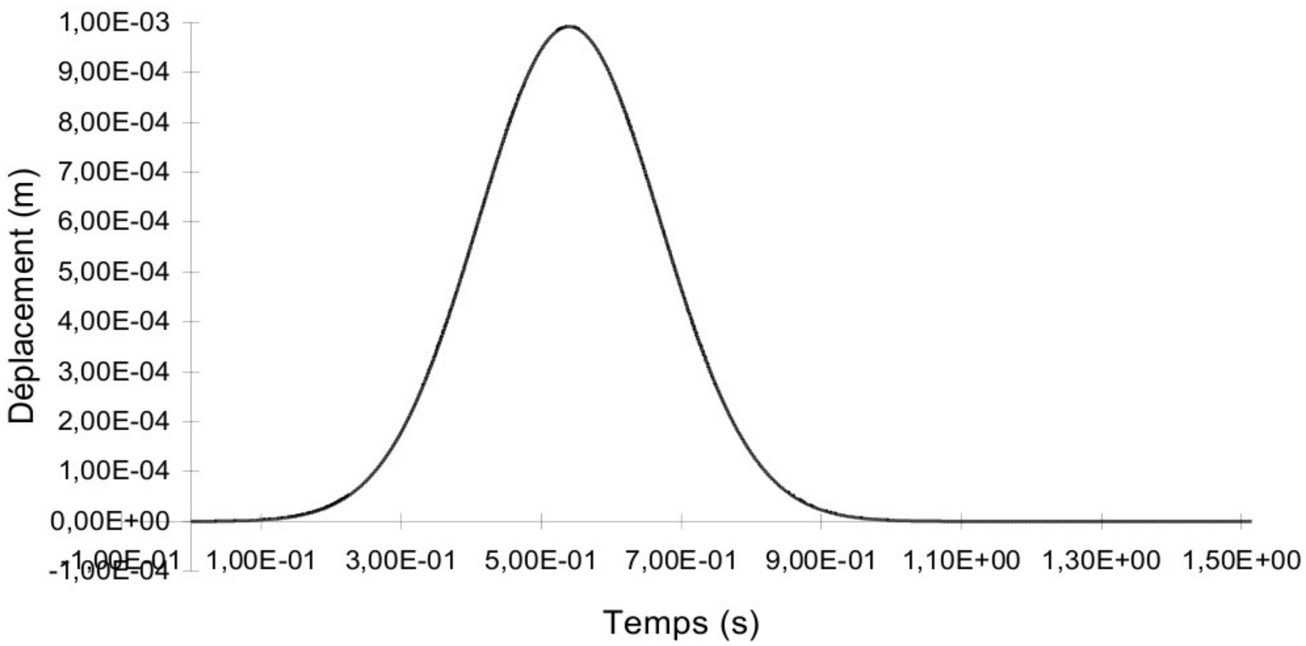
The solution must show the absorption of one compression wave by absorbing surface. Imposed displacement is a uniform translation according to the axis of x . One must obtain an identical field of displacement according to this direction in all the plans $x=Cte$. Moreover, the absorbing border is orthogonal with this axis. One thus studies the absorption of plane compression waves under normal incidence. The theory [bib1] known as that with a solid paraxial border of order 0, this absorption is perfect. It is what one must check with this reference solution.

One thus goes, by observing the evolution of displacement in a given point of the grid, to endeavour to find in the signal obtained the duration of excitation and the return at rest after the passage of the wave, characteristic of his absorption.

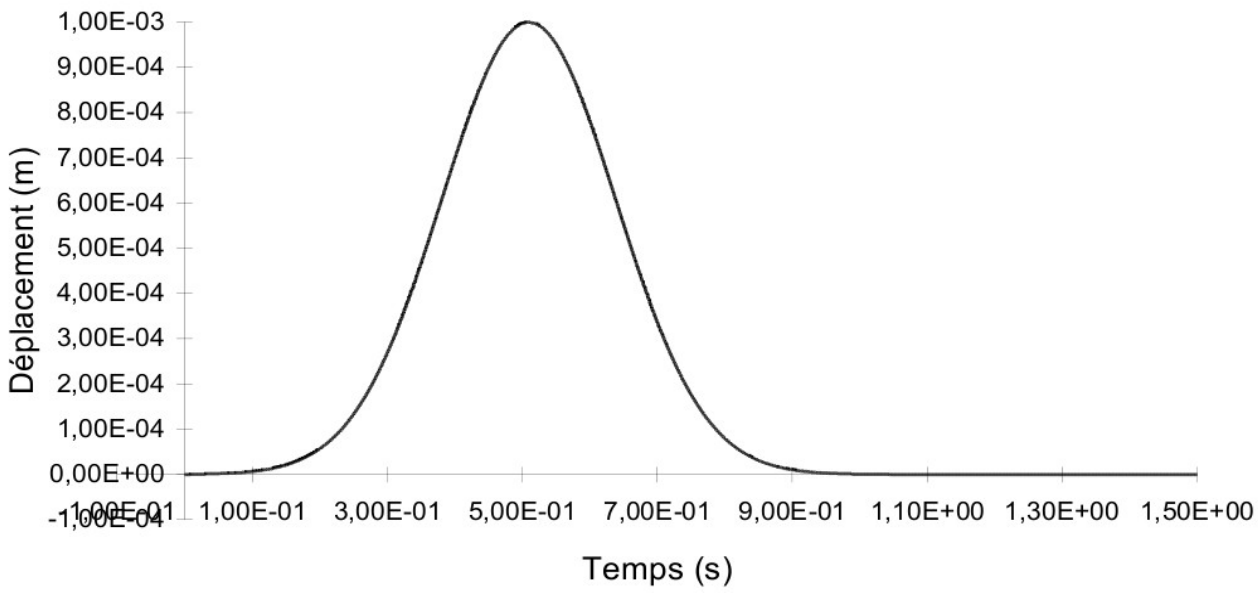
2.1 Results of reference

One gives in this paragraph the results got with *Code_Aster* in this configuration. It is checked that they are satisfactory and one takes them as reference for the future.
They concern, for the case 3D, the bar having $200\,m$ of length, evolution of displacement in x in a point of the bar located at $150\,m$ face excited in the direction x and in the center of the section in the plan yz . For the case 2D, the bar having $50\,m$ of length, the point is located at $40\,m$ face according to x and in the middle of the section in the direction y (in 2D, one takes a shorter and refined grid).

Déplacement en x dans le barreau - cas 3D



Déplacement dans le barreau - cas 2D



As envisaged, the width of the signal measured in both cases is identical to that of the function of excitation. Physically, the compression wave propagation well is observed. The signal is modified little in its propagation and one thus finds well the maximum amplitude of 1 mm. One also clearly notes the return at rest immediately after the passage of the wave and the absence of signal thought of the end of the grid.

2.2 Uncertainties

It is about a digital result of the study. The qualitative forecasts are found. The digital values are related to the precision of calculation. Only the return at rest is precisely given by the analysis.

2.3 Bibliographical references

1) H. MODARESSI "digital Modeling of the wave propagation in the elastic porous environments." Thesis doctor-engineer, Central School of Paris (1987).

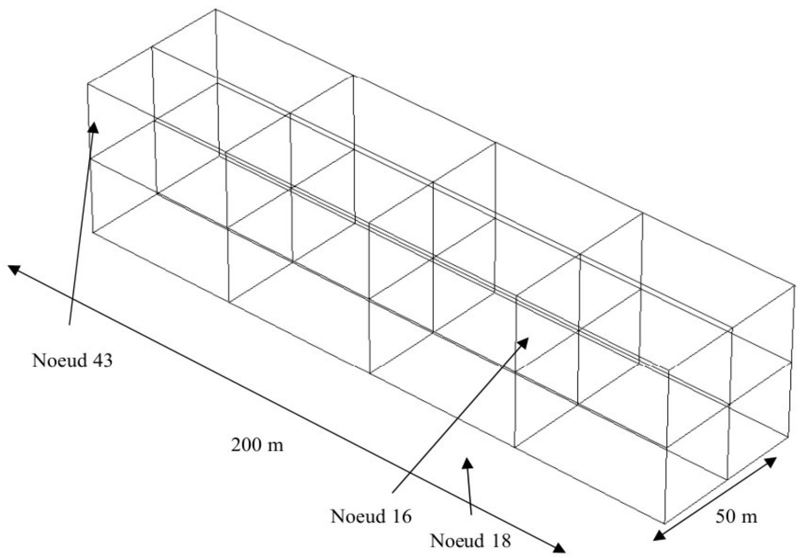
3 Modeling A

3.1 Characteristics of modeling

Bar: `PHENOMENON: 'MECHANICAL'`
`MODELING: '3D'`

3.2 Characteristics of the grid

Many nodes: 45
Many meshs and types: 16 HEXA8
8 QUA4 (faces of HEXA8)



3.3 Values tested

One tests the values of displacement in x with nodes 16.18 and 43 (see grid). For node 16, one tests the maximum and the return at rest. For nodes 18 and 43, one tests the maximum.

- `DYNA_VIBRA` :

Node	**Moment** (s)	**Results of reference (displacement in** m **)**
N16	5.39500E-01	1.00000E-03
	1.20000E+00	0.
N18	5.40000E-01	1.00000E-03
N43	5.00000E-01	1.00000E-03

- `DYNA_NON_LINE` :

Node	**Moment** (s)	**Results of reference (displacement in** m **)**

N16	5.40000E-01	9.92640E-04
	1.20000E+00	0.
N18	5.40000E-01	9.92182E-04
N43	5.00000E-01	1.00000E-03

Identification	Value of reference	Type of reference	Tolerance
Field MATE_ELGA, Mesh M21, Point 1, comp. E	3.6E+10	'ANALYTICAL'	0.1 %
Field MATE_ELEM, Mesh M21, Comp. NAKED	0.2	'ANALYTICAL'	0.1 %

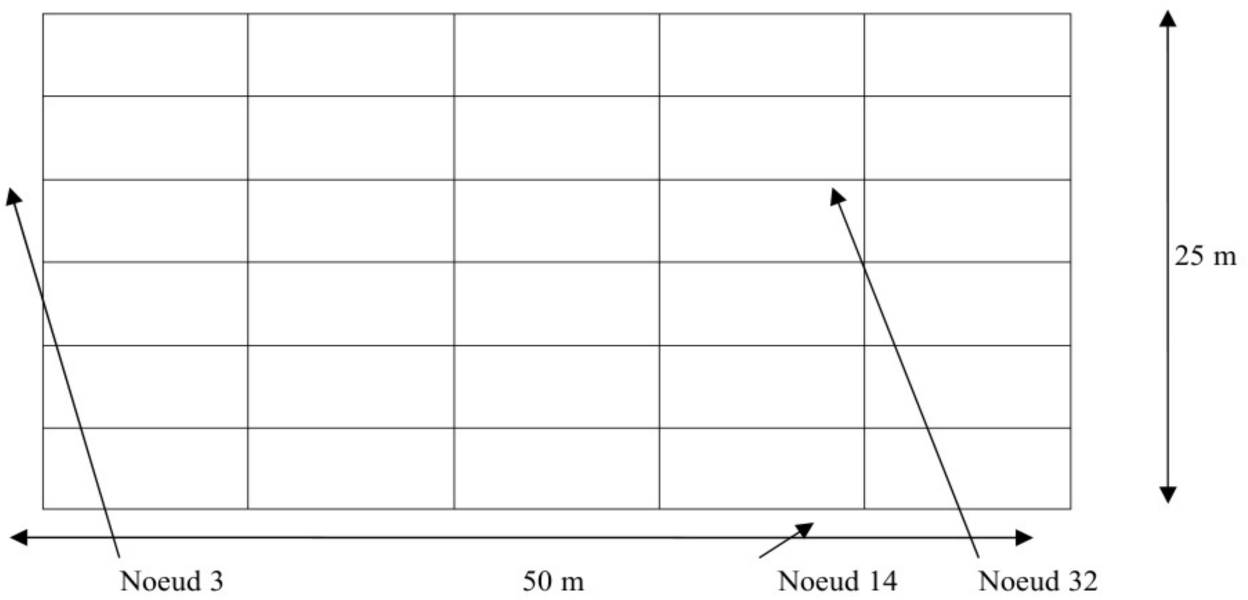
4 Modeling B

4.1 Characteristics of modeling

Bar: `PHENOMENON: 'MECHANICAL'`
`MODELING: 'D_PLAN'`

4.2 Characteristics of the grid

Many nodes: 36
Many meshs and types: 30 QUA4
12 SEG2 (faces of QUA4)



4.3 Values tested

One tests the values of displacement in x with nodes 32.14 and 3 (see grid). For node 32, one tests the maximum and the return at rest. For nodes 14 and 3, one tests the maximum.

Note:

Node 3 is on vis-a-vis imposed displacement. One thus has exactly the values of excitation in this point.

- DYNA_VIBRA :

Node	Moment (s)	Results of reference (displacement in m)
N32	5.09500E-01	1.00000E-03
	1.20000E+00	0.
N14	5.09500E-01	1.00000E-03
N3	5.00000E-01	1.00000E-03

- DYNA_NON_LINE :

Node	Moment (s)	Results of reference (displacement in m)
N32	5.09500E-01	9.99867E-04
	1.20000E+00	0.
N14	5.09500E-01	9.99867E-04
N3	5.00000E-01	1.00000E-03

Identification	Value of reference	Type of reference	Tolerance
Field MATE_ELGA, Mesh M16, Point 1, comp. E	3.6E+10	'ANALYTICAL'	0.1 %
Field MATE_ELEM, Mesh M21, Comp. NAKED	0.2	'ANALYTICAL'	0.1 %
Field MATE_ELGA, Mesh M46, Point 1, comp. E	3.6E+10	'ANALYTICAL'	0.1 %
Field MATE_ELEM, Mesh M46, Comp. NAKED	0.2	'ANALYTICAL'	0.1 %

5 Summary of the results

One finds by calculation with two modelings quantitatively, the maximum of displacement equal to the maximum amplitude of the signal and qualitatively, the return at rest after the passage of the wave.
Results got with the operators DYNA_VIBRA and DYNA_NON_LINE are very close. The difference comes from obtaining to each step in time from the state from balance from the efforts from the second member with the operator DYNA_NON_LINE, which explains why its results are a little bit better even with a step of larger time. This difference remains however tiny because the step of time used with DYNA_VIBRA is sufficiently small.