SDLV120 - Absorption of one compression wave in a Summarized elastic

bar

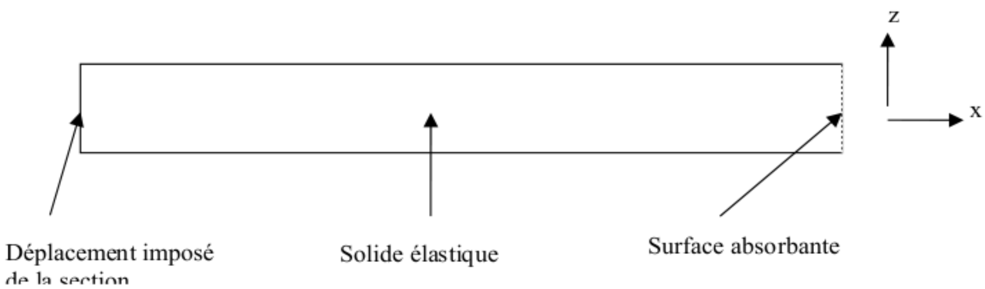
One tests the elastic paraxial elements of order 0 intended to apply conditions absorbing to the border of a mesh finite elements to simulate the infinite one in direct transient computations.
Are used they to model an infinite elastic bar, in 3D or 2D, in which one creates one wave of pressure by imposing 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.

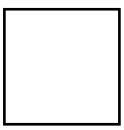
1 Problem of reference

1.1 Geometry

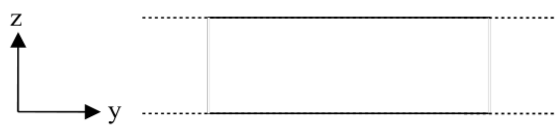
the system considered in 3D case is that of an elastic bar with square section. One imposes a displacement according to x on one of the vertical sides and one observes the propagation of one compression wave. The side surface of the bar is left free. One places the elements absorbents on the face opposed 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 3D case:



Section case 2D:



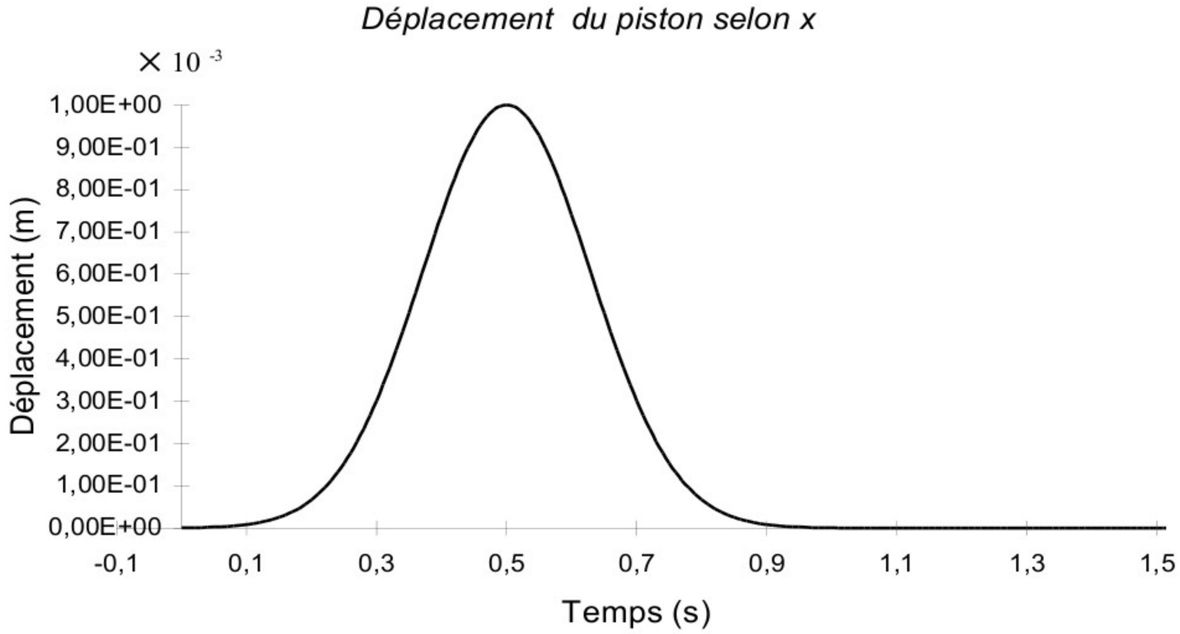
1.2 Properties of the materials

Bar: concrete

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

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 following temporal forcing function:



1.4 Initial conditions

displacement is null in all the bar at initial time.

2 Reference solution

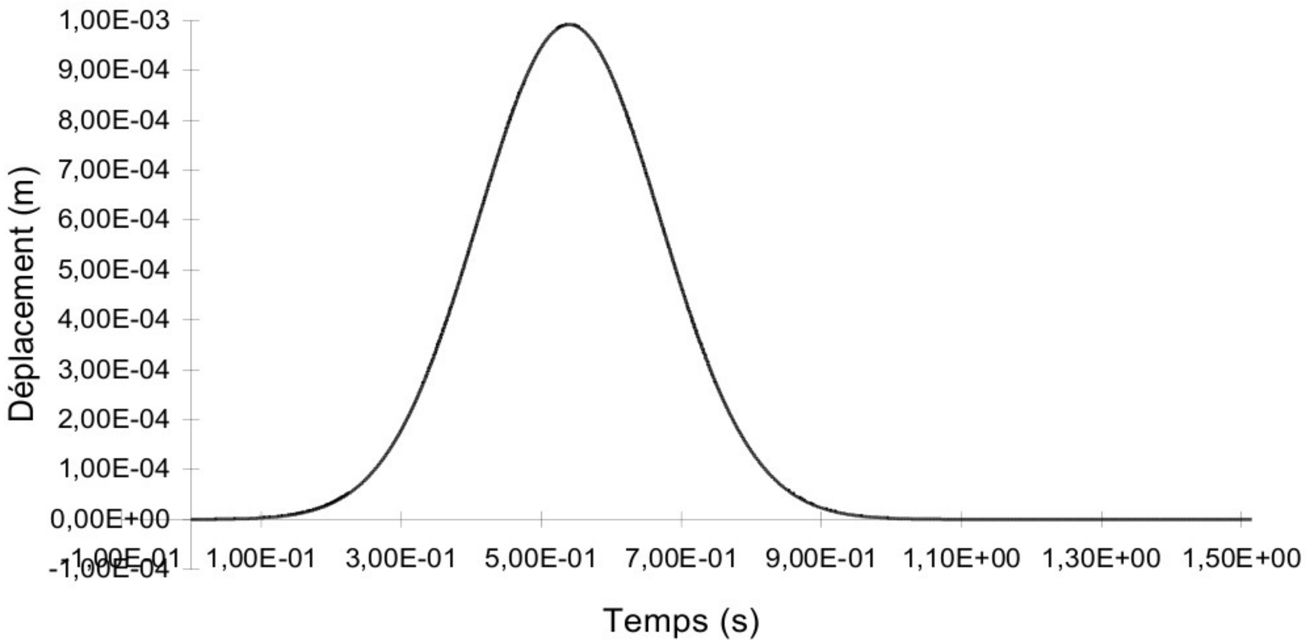
the solution must show the absorption of one compression wave by absorbing surface. Imposed displacement is a uniform translation according to the axis Des. x One must obtain an identical field of displacement according to this direction in all the planes $x=Cte$. Moreover, the absorbing border is orthogonal 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 mesh, to endeavor to find in the signal obtained the period of excitation and the return at rest after the transition of the wave, characteristic of his absorption.

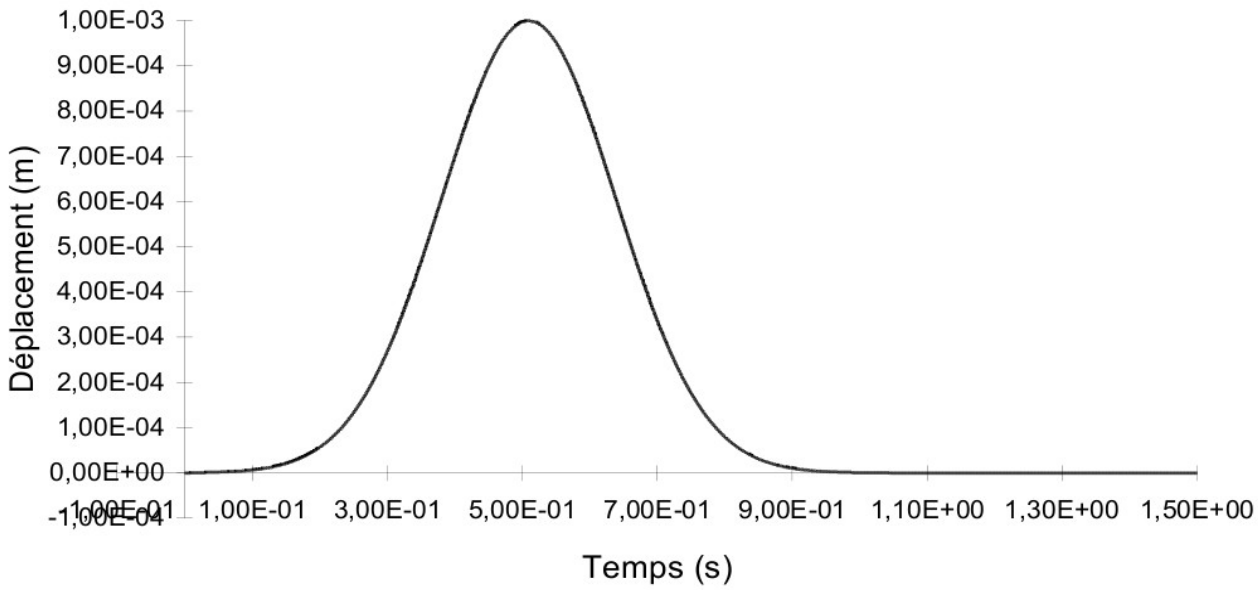
2.1 Results of reference

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 relate to, for 3D case, the bar having $200\,m$ length, the evolution of displacement in x of a point of the bar located at $150\,m$ face excited in the direction x and at the center of the section in the plane yz . For the case 2D, the bar having $50\,m$ 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 mesh).

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 forcing function. 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 transition of the wave and the absence of signal thought of the end of the mesh.

2.2 Uncertainties

It is about result of the numerical study. The qualitative forecasts are found. The numerical values are related to the accuracy of computation. Only the return at rest is precisely given by the analysis.

2.3 Bibliographical references

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

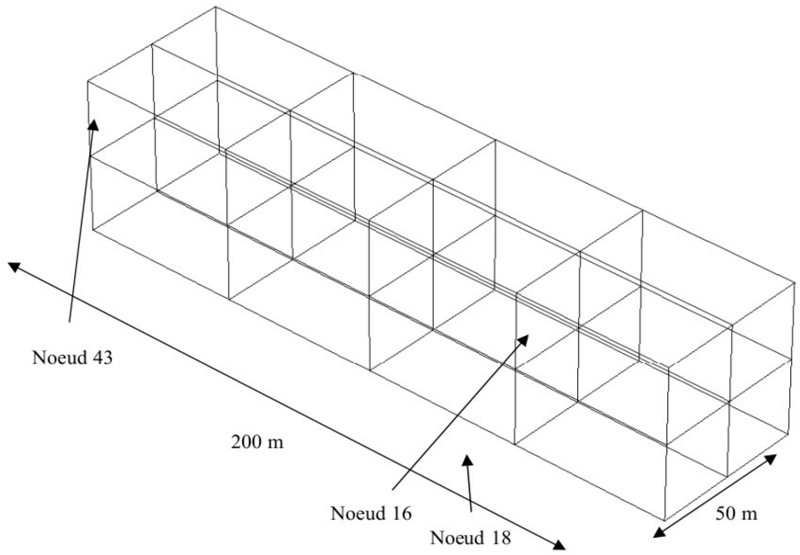
3 Modelization A

3.1 Characteristic of the modelization

Bar: `PHENOMENE: "MECHANICAL"`
`MODELISATION: "3D"`

3.2 Characteristic of the mesh

Many nodes: 45
Number of meshes and types: 16 HEXA8
8 QUA4 (sides of HEXA8)



3.3 Values tested

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

`DYNA_VIBRA`:

Urgent	node (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`:

Urgent	node (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

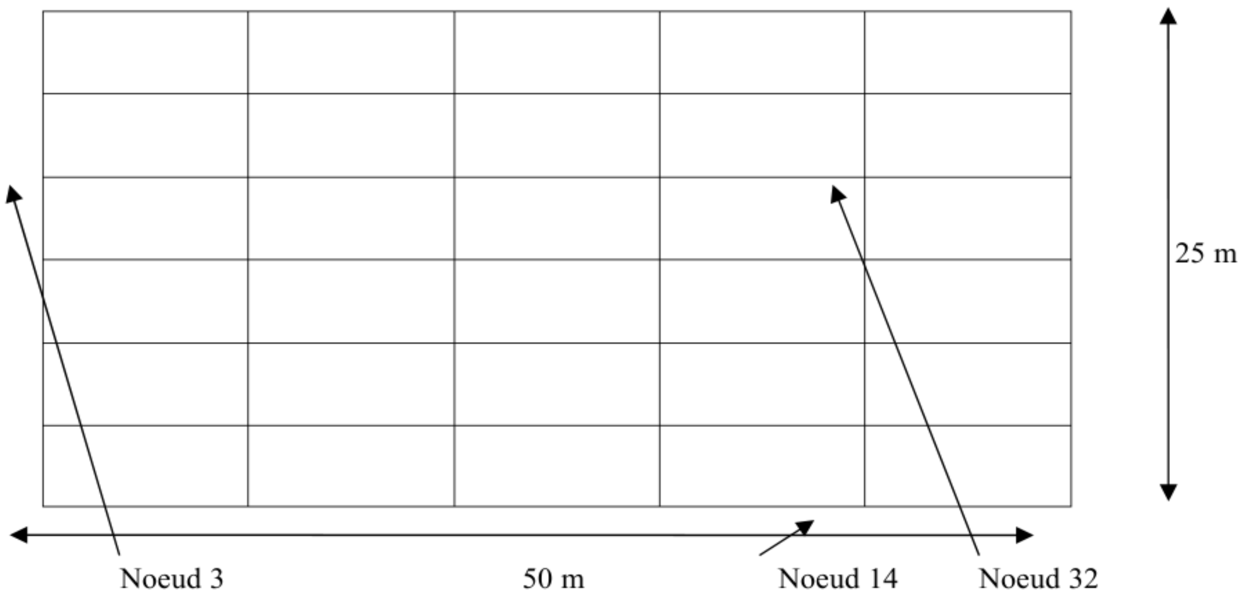
4 Modelization B

4.1 Characteristic of the modelization

Bar: PHENOMENE: "MECHANICAL"
MODELISATION: "D_PLAN"

4.2 Characteristics of the mesh

Many nodes: 36
Number of meshes and types: 30 QUA4
12 SEG2 (sides of QUA4)



4.3 Values tested

One test the values of displacement in x to nodes 32,14 and 3 (see mesh). 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:

Urgent	**node** (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:

Urgent	**node** (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

5 Summary of the results

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