WDNP102 – Reflection and absorption of one compression wave along a poroelastic column

Abstract:

One tests the efficiency of the paraxial elements in hydraulic modelization. The case relates to the propagation of one compression wave in a poroelastic column. The wave is introduced and absorbed by the paraxial element located at the base of the column after being itself considered at its top. One produces two benchmarks, one testing 2D and the other 3D.

1 Problem of reference

1.1 Geometry

The mesh of the poroelastic column is given opposite. The axis of propagation is directed according to (OY). The total height of the column is of $25\,m$, for $0.4\,m$ width. The first 5 meters of bottom are discretized by elements of $1\,m$ thickness while $20\,m$ the following is discretized by elements of $0.2\,m$ thickness. The unit of the column contains 105 elements thus.

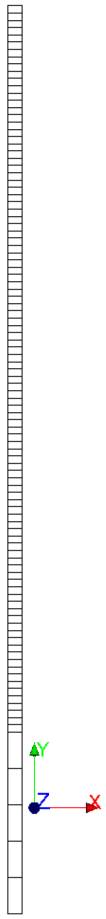


Image 1.1.1 : Mesh of the column

1.2 Properties of the materials

One gives in the table hereafter materials properties of the coupled hydraulic modelization. One supposes the linear elastic porous material and entirely saturated with water.

From materials properties according to, the celerity of the compression waves is given by the relation:

$$C_p=\sqrt{\frac{\lambda+2\mu}{\rho_{homo}}}=534{,}14\,m.s^{-1}$$

where λ and μ are the moduli of Lamé.

Liquid water	Density ρ_l	$1000\,kg.m^{-3}$
	Compressibility K_l	$0{,}1\,MPa$
	Viscosity ν	$0{,}001$
homogenized Parameters	intrinsic Permeability K^{int}	$10^{-12}\,m^2$
	Porosity ϕ	$0{,}23$
	homogenized Density ρ_{homo}	$2105\,kg.m^{-3}$
elastic solid Squelette linear	Modulus of compressibility K	$313{,}1\,MPa$
	Shear modulus G	$215{,}6\,MPa$

Table 1.2-1 : Hydraulic of the column poro-elastic Boundary conditions

1.3 and initial properties

One wishes to propagate upwards a wave compression in the column with a blocking of his upper part so that there is reflection of the wave at this place and propagation reverses from top to bottom. An absorbing border (paraxial element) is placed at the base of the column in order to completely deaden the considered wave.

The column being subjected to gravity, of the conditions geostatics in effective stresses and water pressure preexist initially in this one. The initial balancing of the column is not obvious and requires the following procedure:

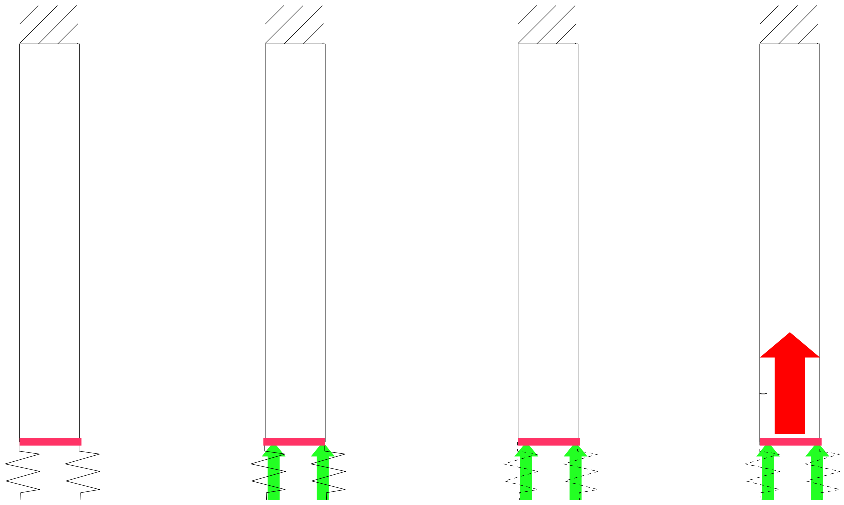
the base of the column, flanked paraxial element (in red), is blocked using very stiff springs. A preliminary static computation (**figure 1**) makes it possible to recover a stress field and of water pressure in equilibrium with the boundary conditions and of loading;

one calculates the nodal forces (resultant of the forces at the same time mechanical and hydraulic, in green) in springs (**figure 2)**;

These nodal forces are reinjected at the base where one disables simultaneously springs in their affecting very low stiffness (**figure 3**). The boundary conditions thus defined make it possible to produce an initial hydraulic state perfectly balanced;

The computation dynamic can take place by injecting the wave from the paraxial element (**figure 4**);

In order to give an account of invariance by horizontal adjustment (problem 1D), one solidarizes side displacements by a connection of the type `LIAISON_DDL`.



STAT_NON_LINE Équilibre geostatiqueRecuperation

of the nodal forces in the ressortsApplication

of the nodal forces in inactivated springs. Activation of

the paraxiauxDYNA_NON_LINEInjection of the wave by paraxial

Image 1.3.1 : Procedure of initial balancing of the column the boundary conditions, initial and of loading are summarized in the following tables:

Boundary conditions		
$HAUT$	`MECA_IMPO`	$DX=DY=DZ=0$
$COTE$	`LIAISON_DDL`	$DX_{gauche}=DX_{droit}$ $DY_{gauche}=DY_{droit}$ $DZ_{face}=DZ_{arrière}$
BAS	`FORC_NODA`	

Table 1.3-1 : boundary conditions

Initial conditions		
$COLONNE$	Geostatics	$SIXX=SIYY=SIZZ=(1-\phi)(\rho_g-\rho_l)gY$ $SIP=-PRE1=\rho_l gY$

Table 1.3-2 : initial conditions

Loadings		
$COLONNE$	`AFFE_CHAR_MECA: PESANTEUR`	$g=-9{,}81\,m.s^{-2}$ according to (OY)
BAS	`AFFE_CHAR_MECA_F: ONDE_PLANE`	

Table 1.3-3 : loadings

1.4 Plane wave

the plane wave of compression is a wavelet of the Ricker type whose profile is given hereafter. It is important to note that the signal must be introduced in the form a velocity according to time.

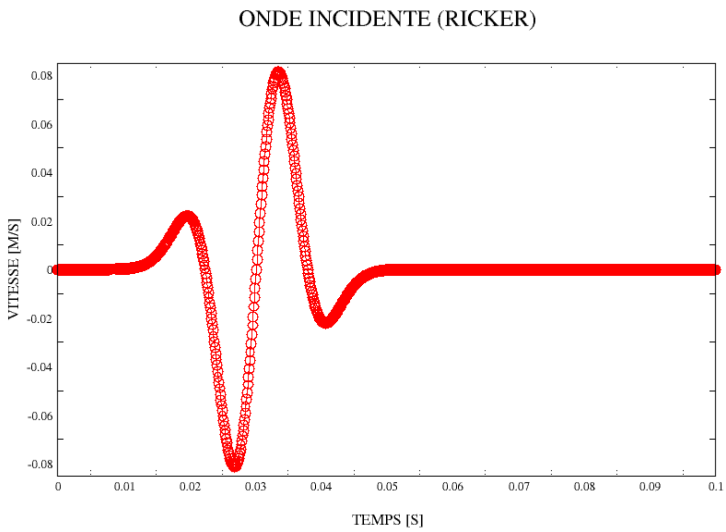


Image 1.4.1 : Incidental Ondelette (Ricker)

2 Modelization A

2.1 Characteristic of the modelization A

two-dimensional Case in modelization HM in plane strains.

The discretization in time is of $10^{-3} s$ until $0,2 s$.

2.2 Results

the figures below present the profiles velocity and water pressure along the column according to time. One observes well a reflection of the wave at the top of the column, followed by a opposite considered wave propagation. This considered wave is then absorbed at the base by the absorbing border.

This benchmark differs from benchmark SDLV121 on the following points:
it shows that the paraxial elements are also functional with modelization HM;
it constitutes a reference closer to the encountered real problems, where it is necessary to start from a state initially balanced by taking account of a field of forces geostatics;

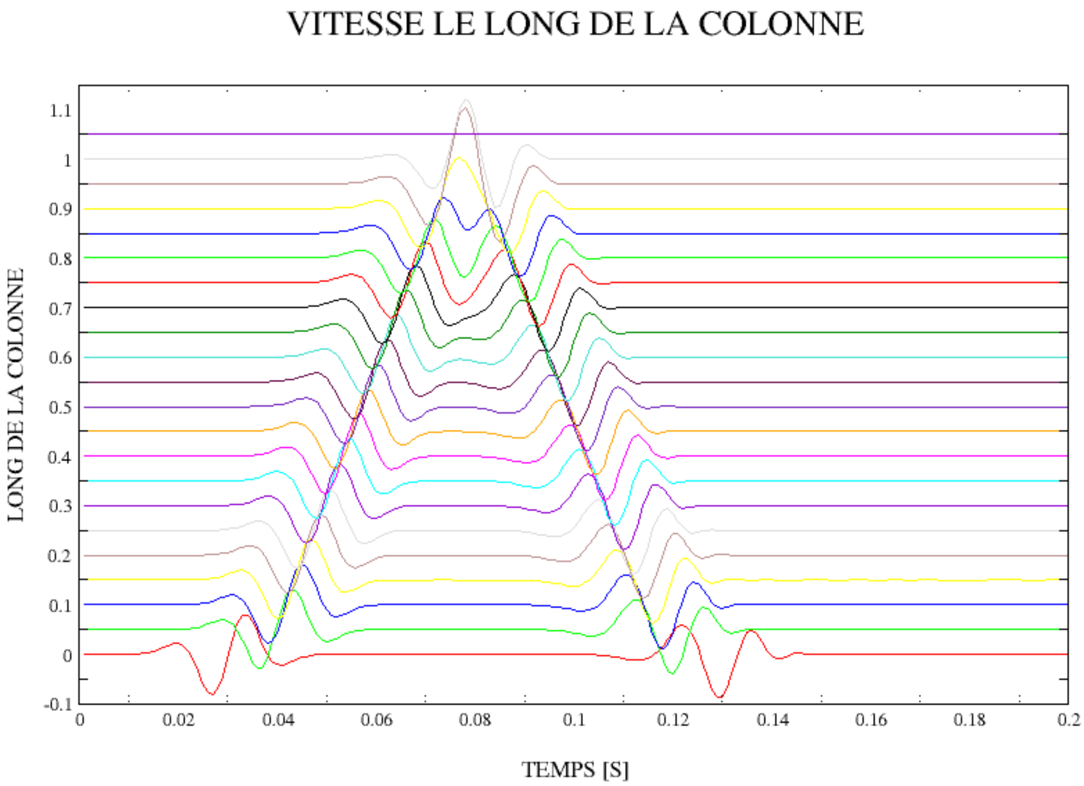


Image 2.2.1 : Propagation velocity along the column

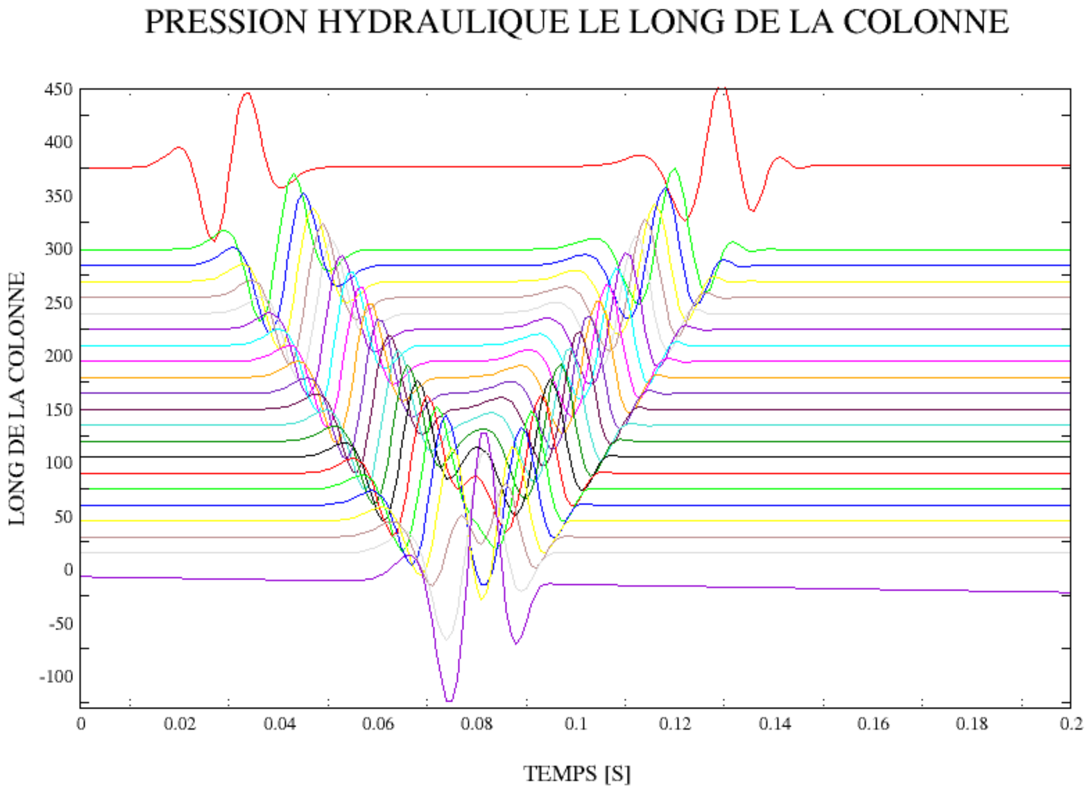


Image 2.2.2 : Propagation of the water pressure along the column

2.3 Values tested

This case test does not have a value of reference, one thus makes a case of non regression of them. One carries out tests on three values for the velocity fields and of water pressure.

Y (m)	Time (s)	VITY *Aster*
10	0,062s	0.085759174
10	10.0,1s	0.085229778
10	0,18s	0

Table 2.3-1

Y (m)	Times (s)	PRE1 *Aster*
10	0,062s	219.5247
10	10.0,1s	219.0596
10	0,18s	149.4430

Table 2.3-2

3 Modelization B

3.1 Characteristic of the modelization B

three-dimensional Case in modelization HM in plane strains.

The discretization in time is of $10^{-3} s$ until $0,2\, s$.

3.2 Results

the figures below present the profiles velocity and water pressure along the column according to time. One observes well a reflection of the wave at the top of the column, followed by a opposite considered wave propagation. This considered wave is then absorbed at the base by the absorbing border.

This benchmark differs from benchmark SDLV121 on the following points:

it shows that the paraxial elements are also functional with modelization HM;

it constitutes a reference closer to the encountered real problems, where it is necessary to start from a state initially balanced by taking account of a field of forces geostatics;

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Y (m)	Times (s)	PRE1 *Aster*
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