SDLL130 - Seismic response of a reinforced concrete beam (rectangular section) with linear behavior

Abstract:

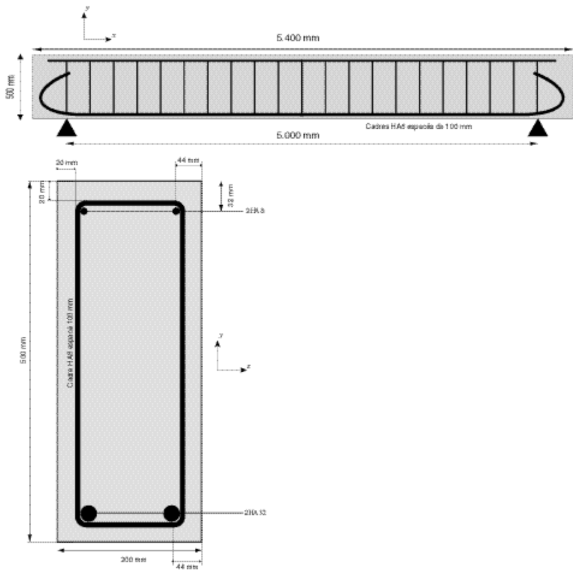
The problem consists in a beam modelization analyzing the seismic response of a reinforced concrete beam via multifibre (`POU_D_EM`, modelization B).

The computation of reference (modelization A) is made using *Code_Aster* with "classical" elements of beam Eulerian Bernoulli (`POU_D_E`).

1 General characteristics

1.1 Geometry

It acts of a beam simply supported on its two bearings [Figure 1.1-a].



Appear 1.1-a: geometry of the structure

1.2 Material properties

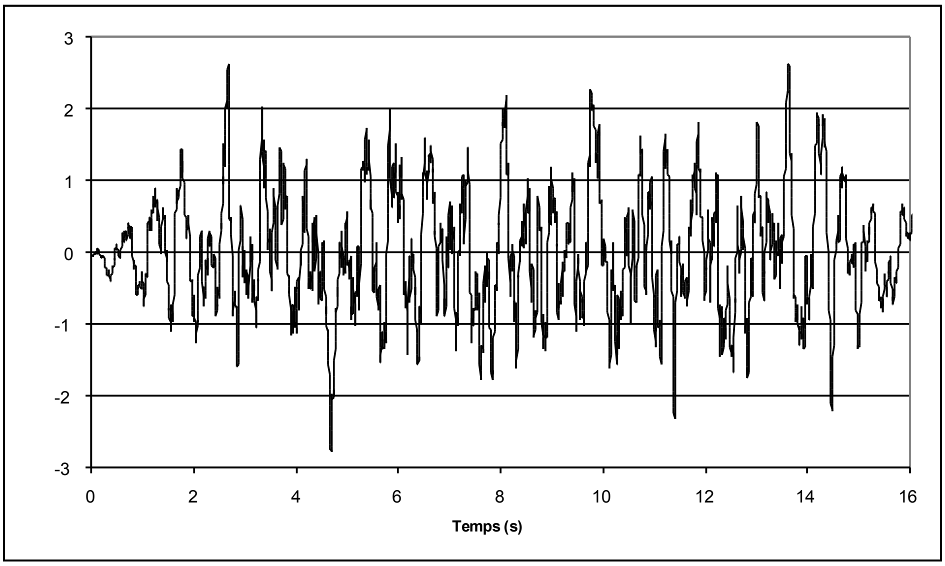
- Concrete: $E=37272\,MPa$ $\nu=0.2$, $\rho=2400\,kg/m^3$
- steel : $E=200000\,MPa$ $\nu=0.33$, $\rho=7800\,kg/m^3$
- damping: of Rayleigh type ($\alpha K+\beta M$), with 5% on the modes 1 and 2

1.3 Boundary conditions and loadings

simple Bearing in B : $dy=0$
Bearing "doubles" in A : $dx=dy=0$
To avoid the eigen modes except plane, one beam: blocks the following degrees of freedom on all $rx=ry=dz=0$

Loading: seisme *ac_s2_c_1* [Figure 1.3-a], in the axis OY applied to the two bearings (factor of amplification of the signal = 137).

NB: transverse reinforcements are not taken into account in computations



Appears 1.3-a: Accelerogram ac_s2_c_1 imposed on the structure

2 Reference solution – Modelization To

the reference is obtained by a computation *Code_Aster* with classical elements of beam of Eulerian (POU_D_E). The characteristics for this computation of reference are obtained by homogenizing the steel-concrete section:

Section: $S_{eq} = S_b + \frac{E_a}{E_b} S_a = 0{,}1 + \frac{200000}{37272} \times 0{,}0017 = 0{,}109 \ m^2$

Quadratic moment: $I_{eq} = I_b + \frac{E_a}{E_b} I_a = 2{,}078.10^{-3} + \frac{200000}{37272} \times 8{,}122.10^{-5} = 2{,}514.10^{-3} \ m^4$

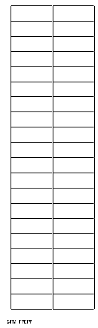
The density selected is that of the concrete (the weight of steel is neglected).

3 Modelization B (POU_D_EM)

3.1 Characteristic of the modelization

longitudinal Mesh of beam:
It is composed of 17 nodes and 16 pairs of elements POU_D_EM (16 elements for the concrete and 16 for steel).

Cross section of beam:
The concrete is modelled by a mesh (DEFI_GEOM_FIBRE/ SECT) composed of 2×20 quadrilaterals (40 fibers)



Appears 3.1-a: Discretization of the section

steel is modelled by 4 specific fibers (DEFI_GEOM_FIBRE/FIBER)

the coefficients α and β for damping are calculated using the following formula

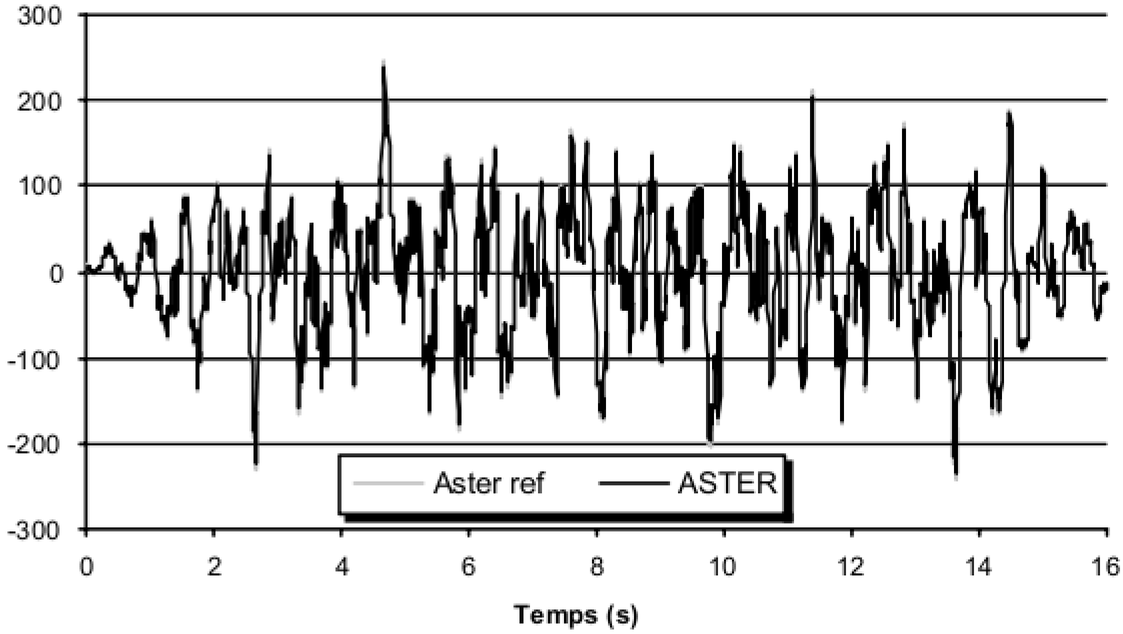
$$\begin{Bmatrix}\alpha\\\beta\end{Bmatrix}=2\frac{\omega_1\omega_2}{\omega_2^2-\omega_1^2}\begin{pmatrix}\frac{1}{\omega_2} & \frac{1}{\omega_1}\\ \omega_2 & -\omega_1\end{pmatrix}\begin{Bmatrix}\xi_1\\\xi_2\end{Bmatrix}$$

where ω_1 and ω_2 are the first two own pulsations $(\omega=2\pi f)$ and ξ_1 ξ_2 are the depreciation wished on the first two modes.
With $f_1=37.8\,Hz$ and $f_2=149.2\,Hz$ (see paragraph [§4]), for modal dampings of 5%, we find: $\alpha=8.5\,10^{-5}$ and $\beta=18.985$.

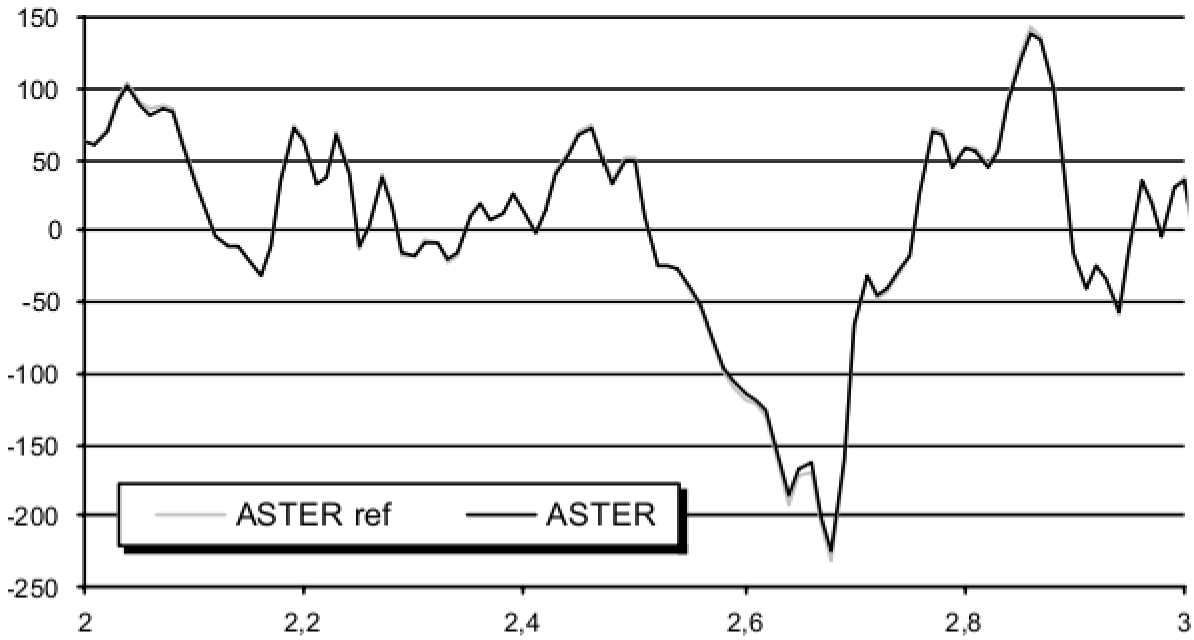
For the computation of the temporal response, the time step selected one is 1/100ème of second.

3.2 Quantities tested and results

the curves of reaction according to time and deflection in the center according to time are presented on the figures [Figure 4-a] with [Figure 4-d].



Appear 4-a: Reaction to the first bearings according to time



Appears 4-b: Detail of the reaction between 2 and 3 second

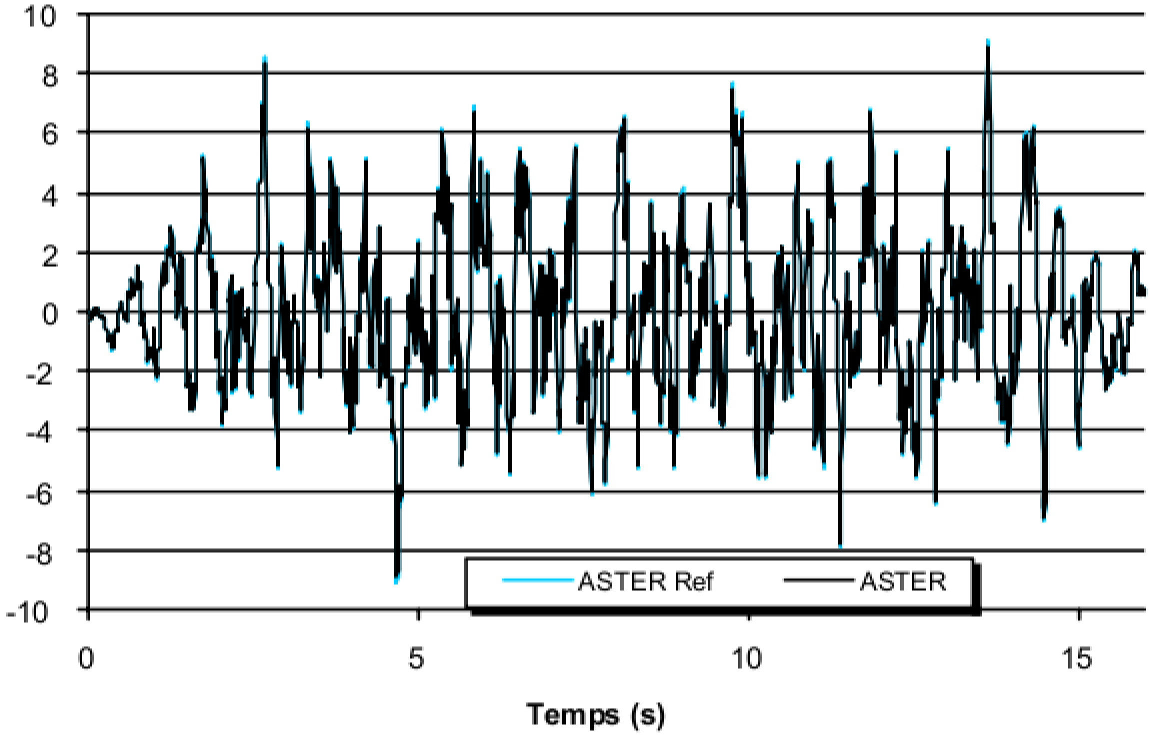
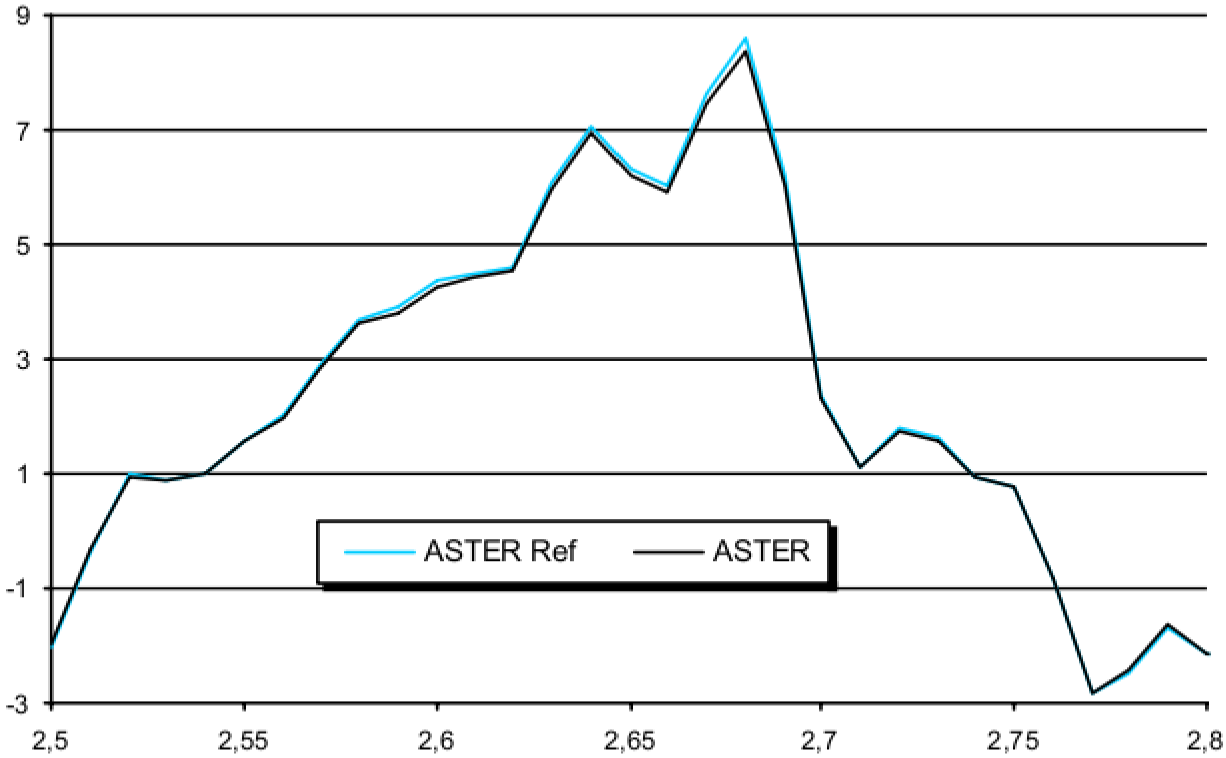


Figure 4-c: Marks with arrows in the center according to time



Appears 4-d: Detail of the deflection between 2,5 and 2,8 seconds

Of the tests of results (`TEST_RESU`) are carried out for the first three eigenfrequencies. One also tests the reaction on the first bearing and the deflection in the center is tested at times $1s$ (not 100) and

2s (not 200), then for the 2 first extremums of the curves, at times $2{,}68\,s$ (not 268) and $4{,}68\,s$ (not 468).

Eigenfrequency	ASTER ref.	ASTER	relative Error %
1	37,80	37,83	0,07
2	149,20	149,28	0,05
3	200,30	200,39	0,04

REACTION	ASTER ref.	ASTER	relative Error %
$1{,}00\,s$	1,8878.104	1,8479.104	2,1
$2{,}00\,s$	6,3393.104	6,2184.104	1,9
$2{,}68\,s$	– 2,3222.105	– 2,2443.105	3,4
$4{,}68\,s$	2,4692.105	2,3979.105	2,9

DEFLECTION	ASTER ref.	ASTER	relative Error %
1,00 S	– 6,0694.10-4	– 5,9846.10-4	1,4
2,00 S	– 2,3507.10-3	– 2,3362.10-3	0,6
2,68 S	8,5790.10-3	8,3929.10-3	2,2
4,68 S	– 9,1084.10-3	– 8,9530.10-3	1,7

4 Summary of the results

the results got using the modelization beam multifibers (POU_D_EM) are in concord with the classical modelization of straight beam of Eulerian (POU_D_E) of *Code_Aster*.