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

Summary:

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

Reference (modeling A) is calculated using *Code_Aster* with "classical" elements of beam Euler Bernoulli (POU_D_E).

1 General characteristics

1.1 Geometry

It is about a beam simply supported on its two supports [Figure 1.1-a].

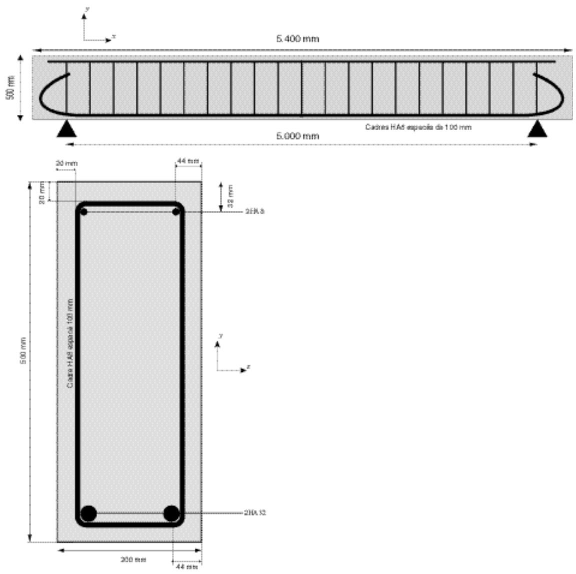

Figure 1.1-a: geometry of the structure

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 modes 1 and 2

1.3 Boundary conditions and loadings

Simple support in B : $dy=0$
Support "doubles" in A : $dx=dy=0$
To avoid the clean modes except plan, one blocks the following degrees of freedom on all the beam: $rx=ry=dz=0$

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

NB: the transverse reinforcements are not taken into account in calculations

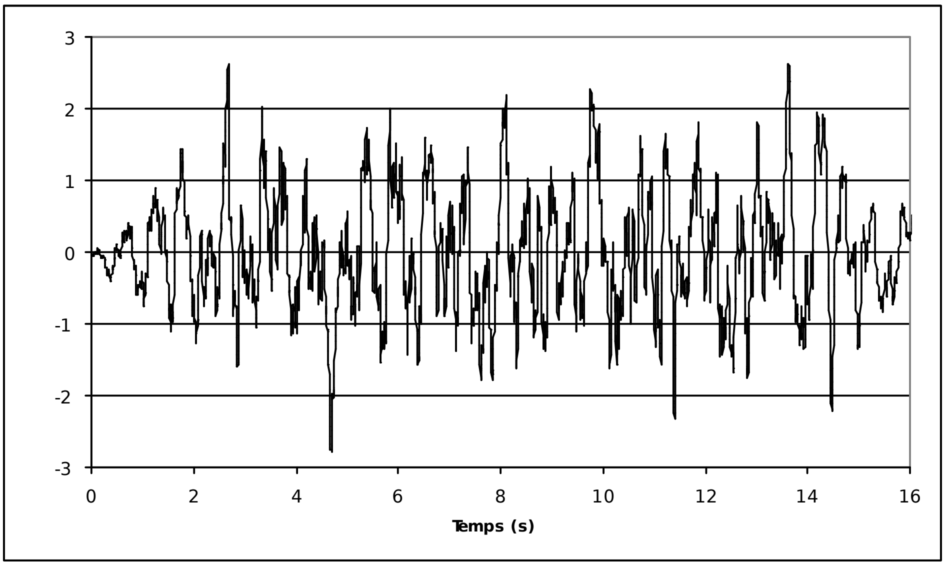

Figure 1.3-a: Accélérogramme ac_s2_c_1 imposed on the structure

2 Reference solution – Modeling A

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

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

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

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

3 Modeling B (POU_D_EM)

3.1 Characteristics of modeling

Longitudinal grid of the 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 the beam:
The concrete is modelled by a grid (DEFI_GEOM_FIBRE/ SECT) composed of 2×20 quadrilaterals (40 fibres)

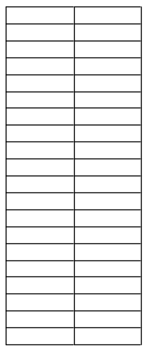

Figure 3.1-a: Discretization of the section

Steel is modelled by 4 specific fibres (DEFI_GEOM_FIBRE/FIBRE)

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 and 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 depreciation of 5%, we find: $\alpha=8.5\,10^{-5}$ and $\beta=18.985$.

For the calculation of the temporal answer, the step of selected time is 1/100ème from second.

3.2 Sizes tested and results

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

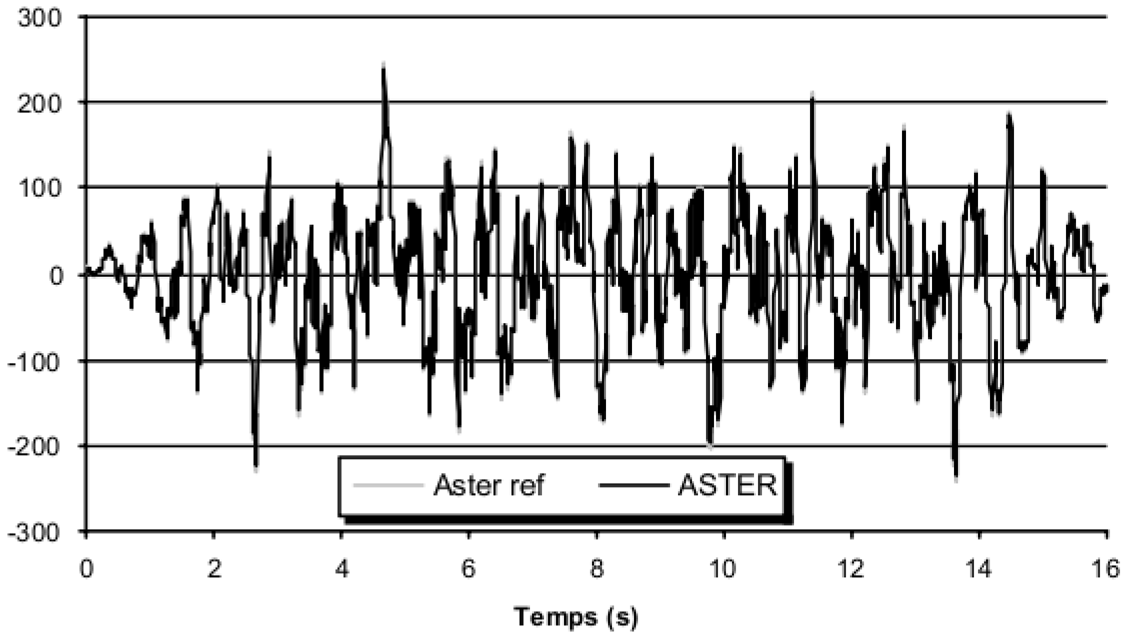

Figure 4-a: Reaction to the first supports according to time

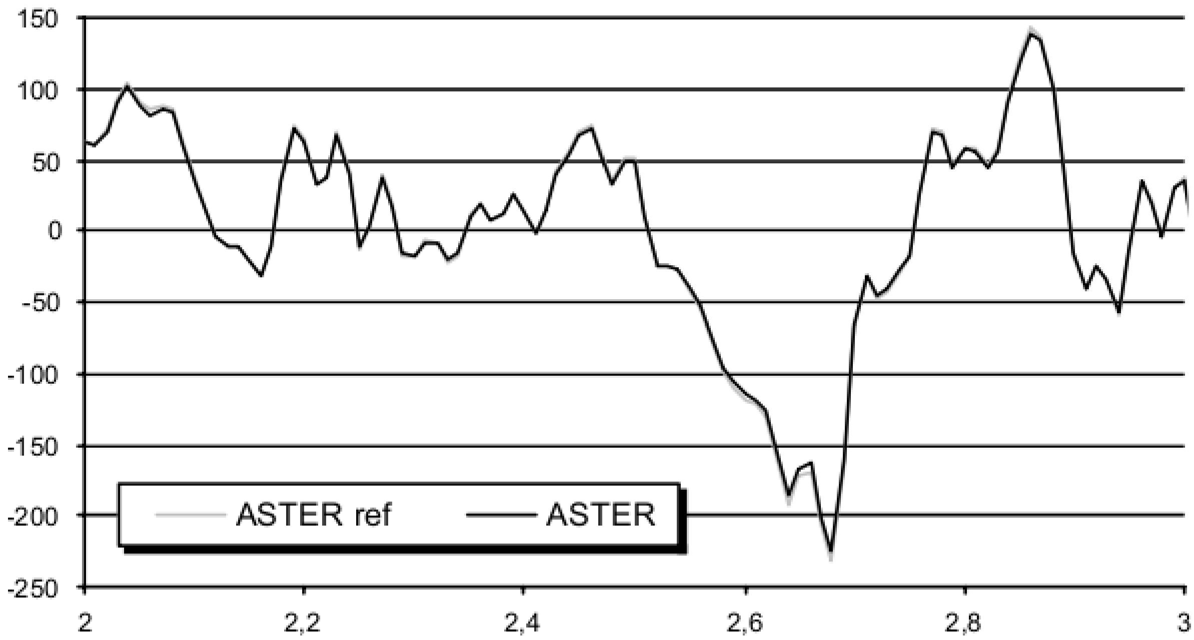

Figure 4-b: Detail of the reaction between 2 and 3 seconds

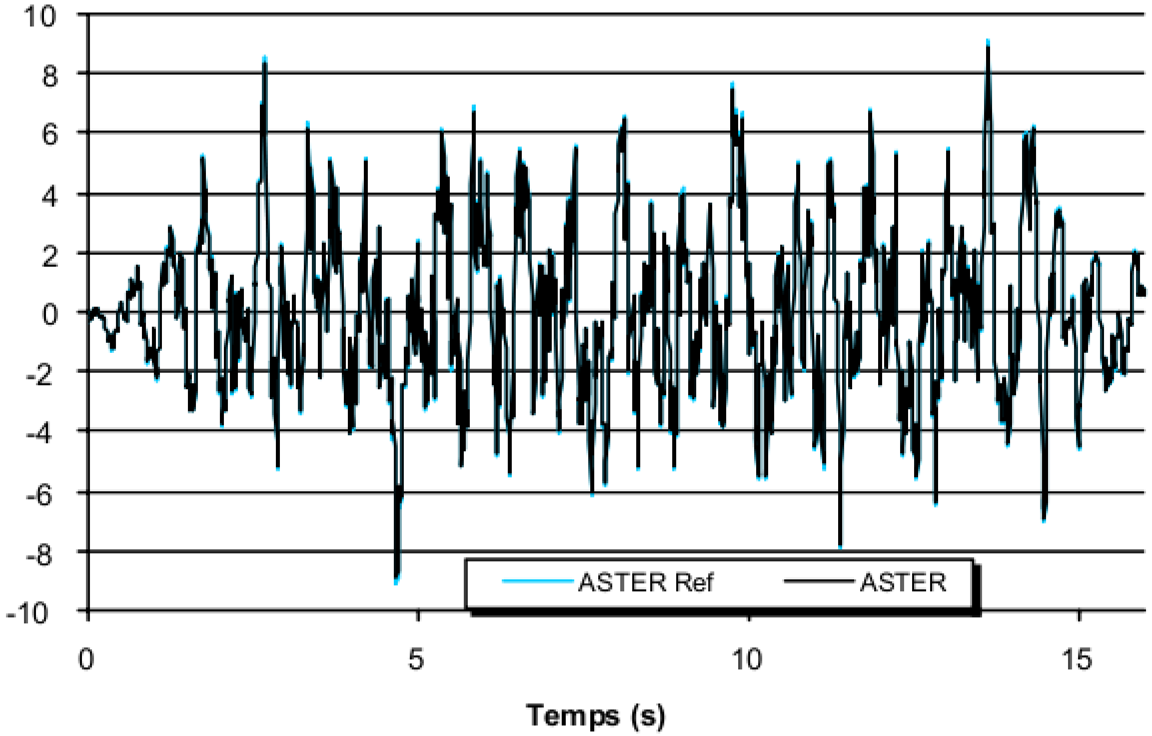

Figure 4-c: Arrow in the center according to time

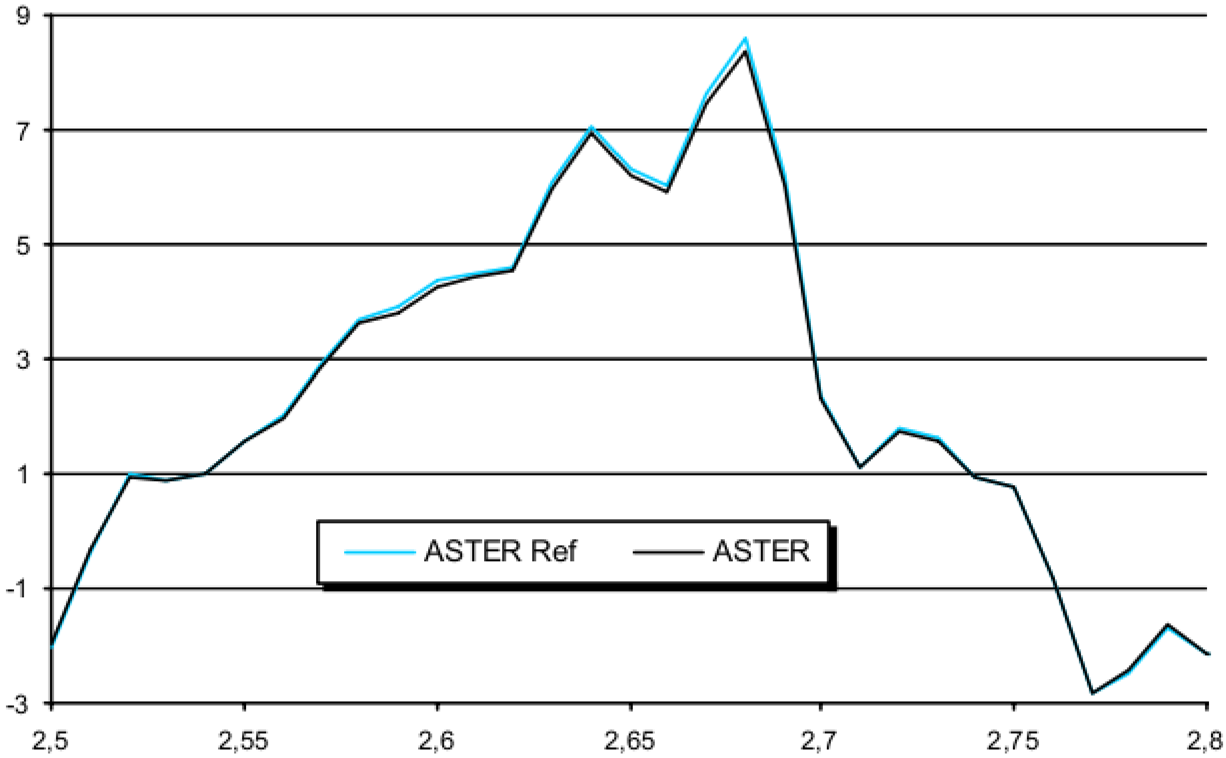

Figure 4-d: Detail of the arrow between 2.5 and 2.8 seconds

Tests of results (TEST_RESU) are carried out for the first three Eigen frequencies. One also tests the reaction on the first support and the arrow in the center is tested at the moments $1s$ (not 100) and

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

Eigen frequency	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	Error relative %
$1{,}00\,s$	$1{,}8878.10^4$	$1{,}8479.10^4$	2.1
$2{,}00\,s$	$6{,}3393.10^4$	$6{,}2184.10^4$	1.9
$2{,}68\,s$	$-2{,}3222.10^5$	$-2{,}2443.10^5$	3.4
$4{,}68\,s$	$2{,}4692.10^5$	$2{,}3979.10^5$	2.9

MARKS WITH ARROWS	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

Results got using modeling beam multifibre (POU_D_EM) are in concord with the classical modeling of right beam of Euler (POU_D_E) of *Code_Aster*.