SSLX103 – Bending of a reinforced concrete beam 3D with reinforcements modelled by bars

Summarized:

The purpose of this test is to validate the modelization of steels by linear elements bars SEG2 in concrete modelled by quadratic voluminal elements.
Two modelizations are compared:

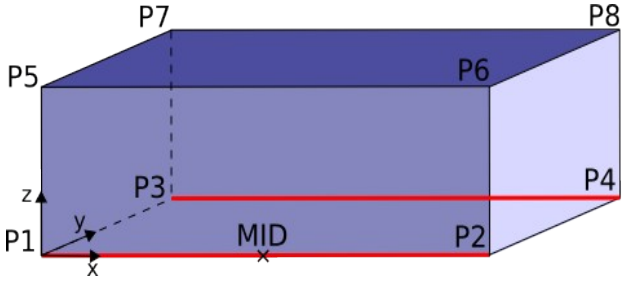
- a quadratic voluminal element contains an element bars linear
- a quadratic voluminal element contains two elements linear bars

with a computation of reference where the elements bars quadratic are obtained with Castem.

1 Problem of reference

1.1 Geometry

One considers a concrete beam length $l=5\,m$ and square section of $w=h=1\,m$ of with dimensions. It contains two longitudinal reinforcements $P1P2$ and $P3P4$. The section of the two bars is of $0{,}003\,m^2$.



1.2 Properties of the material

concrete material is elastic isotropic with the following properties:

- $E=30\,GPa$
- $\nu=0.2$

The material steel is elastic isotropic with the following properties:

- $E=200\,GPa$
- $\nu=0.25$

1.3 Boundary conditions and loadings

the edge $P1P3P7P5$ is blocked.
One imposes a displacement of $0{,}001\,m$ according to the direction z on edge $P2P4P8P6$.

1.4 Initial conditions

Nothing

2 Reference solution

It is a question of validating the use of linear elements to represent steels present in concrete represented by voluminal elements.

Two modelizations are possible:

- Modelization a: a quadratic voluminal element contains an element bars linear. The medium nodes of the quadratic voluminal elements are not connected to the bars (L) .
- Modelization b: a quadratic voluminal element contains two elements linear bars. All the voluminal nodes are connected to nodes of steels (LL) .

The reference solution was obtained with CASTEM 2000. The mesh used the same number of meshes contains but the elements bars modelling reinforcements are quadratic (Q).

The results in term of stress in the concrete, displacement and force in steel are compared.

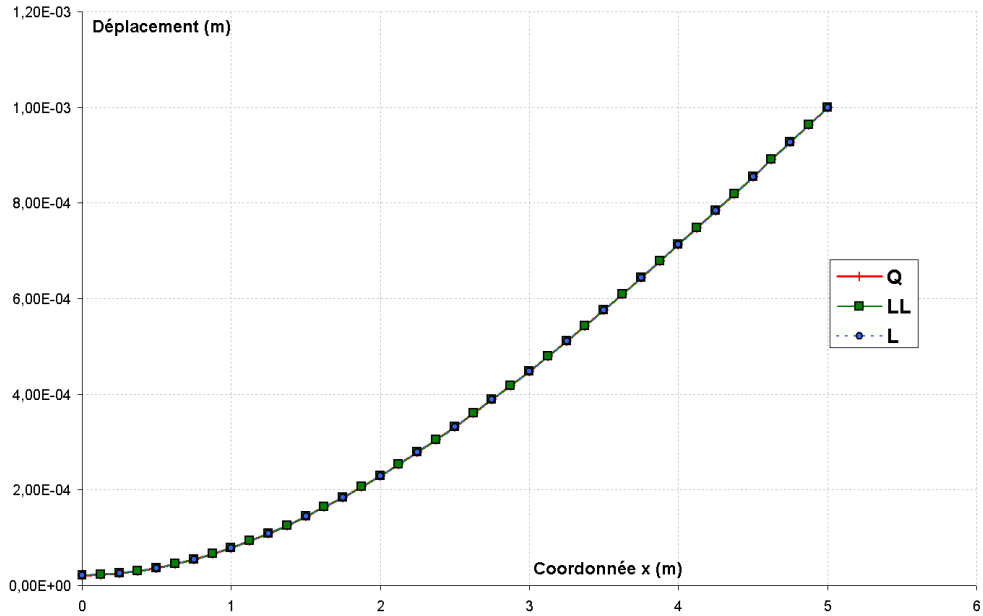


Illustration 1: Displacement along the beam

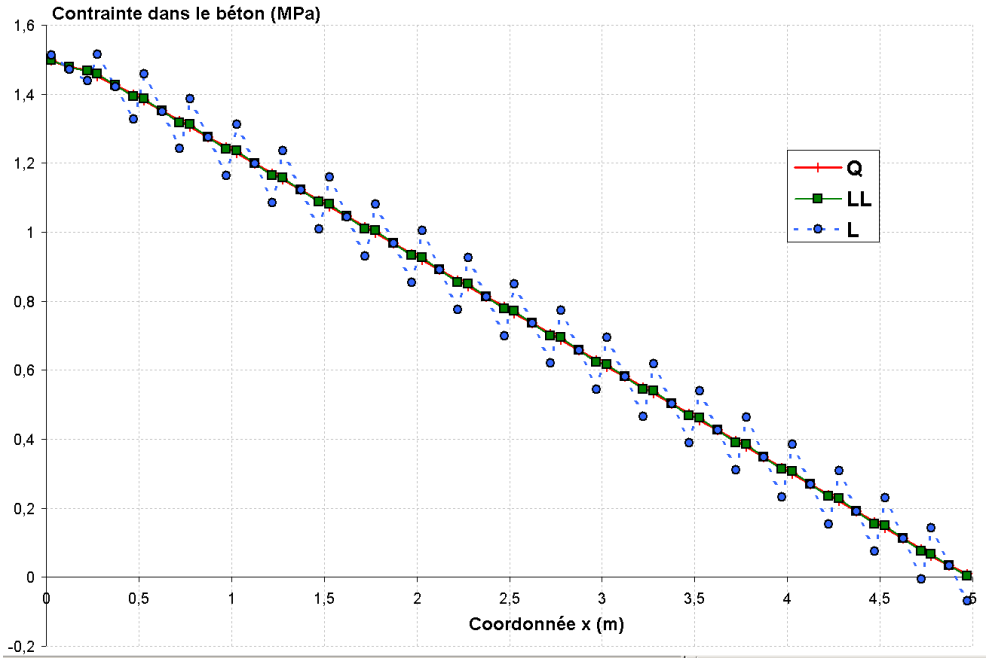


Illustration 2: Stresses in the concrete

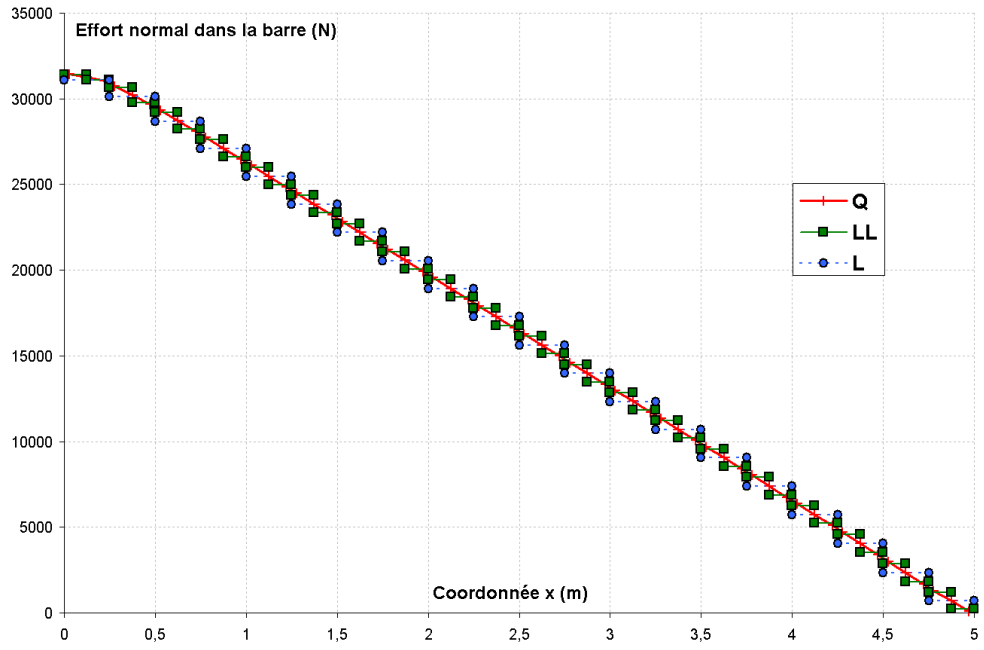


Illustration 3: Force in the bar

It results from it that the modelization B (LL) is very close to the quadratic Castem model Q . The modelization A (L) is not sufficient and one can observe oscillations on the stresses in the concrete.
The model (LL) is thus recommended for the modelization of elements bars in conjunction with voluminal quadratic elements.

2.1 Bibliographical references

[1] NECS. NOTE STUDY: Study of the modelization reinforced concrete: net quadratic concrete with element bars linear. N001_A301_2012_ET_EDF. 2012.

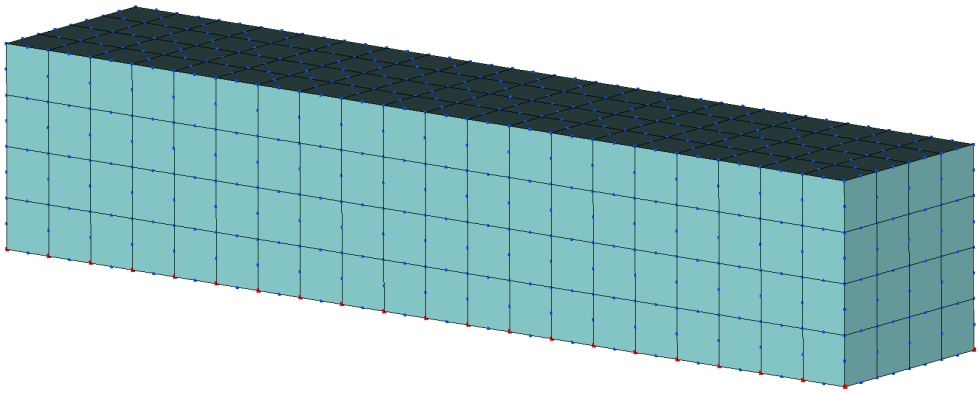
3 Modelization A

3.1 Characteristic of the modelization

One uses the modelizations 3D and BARS.

3.2 Characteristics of the mesh

The mesh contains 320 elements of the type HEXA20 and 40 elements of the type SEG2.



3.3 Quantities tested and results

One tests displacement, the stresses in the concrete and the force in the bar $P1P2$ in the middle of the beam.

Standard	identification of reference	Value of reference	Tolerance
Not MID - DZ	"SOURCE EXTERNE"	3.31642E-04	1%
Point MID - DZ	"NON_REGRESSION"	3.3164387632833E-04	0.1%
Element 755 - $SIXX$ not 19	formula "SOURCE"	7.65317E+05	12%
Element 755 - $SIXX$ not 19	"NON_REGRESSION"	8.4944649489882E+05	0.1%
Element 11 - N	formula "SOURCE"	16260	5%
Element 11 - N	"NON_REGRESSION"	15620.717115628	0.1%

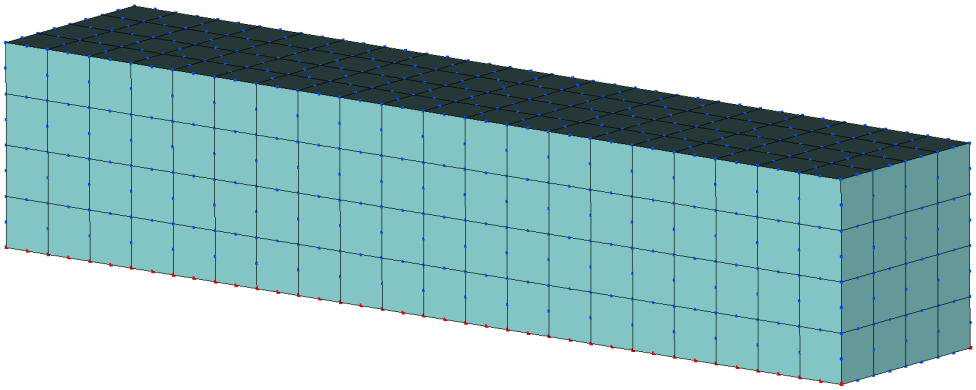
4 Modelization B

4.1 Characteristic of the modelization

One uses the modelizations 3D and BARS.

4.2 Characteristics of the mesh

The mesh contains 320 elements of the type HEXA20 and 80 elements of the type SEG2.



4.3 Quantities tested and results

One tests displacement in the corner high left of the plate.

Standard	identification of reference	Value of reference	Tolerance
Not MID - DZ	formula "SOURCE"	3.31642E-04	1%
Point MID - DZ	"NON_REGRESSION"	3.3164387632833E-04	0.1%
Element 795 - $SIXX$ not 19	formula "SOURCE"	7.65317E+05	1%
Element 795 - $SIXX$ not 19	"NON_REGRESSION"	7.7144384489479E+05	0.1%
Element 21 - N	formula "SOURCE"	16260	1%
Element 21 - N	"NON_REGRESSION"	16131.31000564	0.1%

5 Summary of the results

One notes that the modelization B (LL) is very close to the quadratic Castem model Q . The modelization A (L) is not sufficient and one can observe oscillations on the stresses in the concrete.

To use two linear elements by voluminal elements is thus recommended for the modelization of the reinforced concrete .