SSNL107 - Embedded plate subjected to an inflection by beams in contact with the free edge

Summary:
This test validates the unilateral contact between elements of beam `POU_D_E` (right beam of Euler) and of the elements of hull `DKQ`.

The main features are:
- linear behavior,
- elastic analysis,
- unilateral contact,
- 2 modelings: elements `POU_D_E` and `DKQ` while using `CONTACT` in `AFFE_CHAR_MECA` and in `AFFE_CHAR_MECA_F`.

The reference solution is analytical and the got results are of good quality.

1 Problem of reference

1.1 Geometry

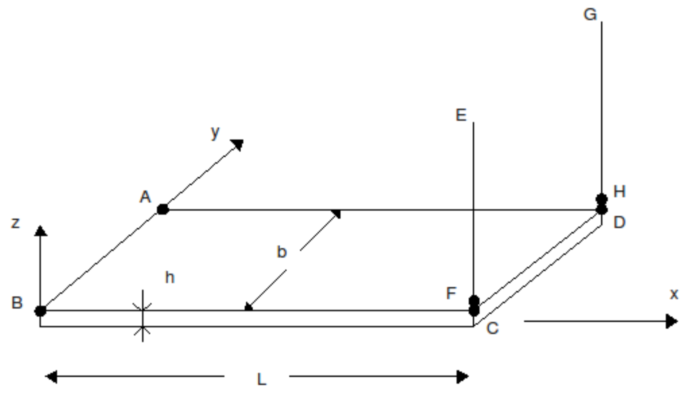
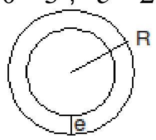


Plate ABCD	of length	$L=10\text{mm}$
	of width	$B=1\text{mm}$
	of thickness	$H=0.1\text{mm}$
2 beams EF and GH		
	Of length	$I=1\text{mm}$
	Of section circulars	$R=2.10-3$, $e=2.10-4$



1.2 Material properties

Linear elasticity: $E=2\,10^5\,MPa$, $\nu=0.3$
Identical for the plate and the two beams.

1.3 Boundary conditions and loadings

Embedding on AB : $DX=DY=DZ=DRX=DRY=DRZ=0$
Displacement imposed in E and G : $DZ=-0.2\,mm$
Unilateral contact enters F and C and enters H and D

1.4 Initial conditions

Without object.

2 Reference solution

2.1 Method of calculating used for the reference solution

Analytical

The plate undergoes a pure bending. The solution is of the type '' poutre' ':

$$V = DZ(C) = DZ(D) = \frac{PL^3}{3E.I_y} \qquad \text{with } I_y = \frac{bh^3}{12}$$

The arrow V and charges it P are unknown.

The two beams are in pure compression:

$$-P = 2.\frac{ES}{L}(V-U) \qquad \text{with } U = DZ(E) = DZ(G)$$

One can thus find P and V starting from these two equations. One obtains:

$$P = \frac{6E\ S\ I\ U}{2SL^3 + 3I_y l}$$

$$V = \frac{2SL^3\ U}{2SL^3 + 3I_y l}$$

2.2 Results of reference

$V = -0.19005 \ mm$

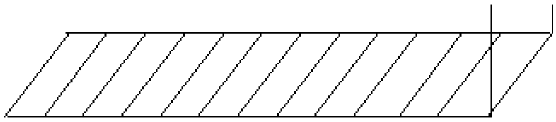
$P = -9.5025 \ 10^{-3} \ N$

2.3 Uncertainty on the solution

Worthless. Analytical solution.

3 Modeling B

3.1 Characteristics of modeling



20 elements of hull DKQ
2 elements of beam POU_D_E

There exists a game ($0.2\,mm$) between the points H and D in the grid.
One introduces a fictitious game ($0.2\,mm$) between the points F and C by the keyword DIST_ESCL of DEFI_CONTACT with FORMULATION=' DISCRETE'.
The contact is treated between the meshs POI1 thanks to the keyword ESCL_FIXE of DEFI_CONTACT.

3.2 Characteristics of the grid

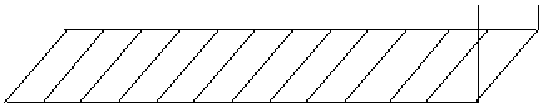
Many nodes: 46
Many meshs and types: 20 QUAD4, 2 SEG2

3.3 Sizes tested and results

Identification			Reference	% tolerance
C	DZ	$N46$	– 0.19005	0.03
D	DZ	$N45$	– 0.19005	0.03
EF	N	$M22$	– 4.75126 10^{-3}	0.58
GH	N	$M21$	– 4.75126 10^{-3}	0.58

4 Modeling C

4.1 Characteristics of modeling



20 elements of hull DKQ
2 elements of beam POU_D_E

There exists a game ($0.2\,mm$) between the points H and D in the grid.
One introduces a fictitious game between the points F and C by the keyword DIST_ESCL of DEFI_CONTACT. This game is declared like a function of time, of constant value equalizes with $0.2\,mm$.
This problem is solved in FORMULATION=' DISCRETE'.

4.2 Characteristics of the grid

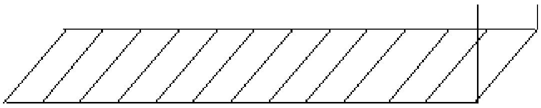
Many nodes: 46
Many meshs and types: 20 QUAD4, 2 SEG2

4.3 Sizes tested and results

Identification			Reference	% tolerance
C	DZ	$N46$	– 0.19005	0.10
D	DZ	$N45$	– 0.19005	0.10
EF	N	$M22$	– 4.75126 10^{-3}	1.00
GH	N	$M21$	– 4.75126 10^{-3}	1.00

5 Modeling D

5.1 Characteristics of modeling



20 elements of hull DKQ
2 elements of beam POU_D_E

There exists a game ($0.2\,mm$) between the points H and D in the grid.
One introduces a fictitious game between the points F and C by the keyword DIST_ESCL of DEFI_CONTACT. This game is declared like a constant equalizes with $0.2\,mm$.
This problem is solved by the algorithm GCP in FORMULATION=' DISCRETE'.

5.2 Characteristics of the grid

Many nodes: 46
Many meshs and types: 20 QUAD4, 2 SEG2

5.3 Sizes tested and results

Identification			Reference	% tolerance
C	DZ	$N46$	– 0.19005	0.10
D	DZ	$N45$	– 0.19005	0.10
EF	N	$M22$	– 4.75126 10^{-3}	1.00
GH	N	$M21$	– 4.75126 10^{-3}	1.00

6 Summary of the results

The results are very close to the analytical solution (0.58%). They are not exact because they depend on the smoothness of the grid of the plate.

The results show the good performance of the unilateral contact between the beams and the plate.