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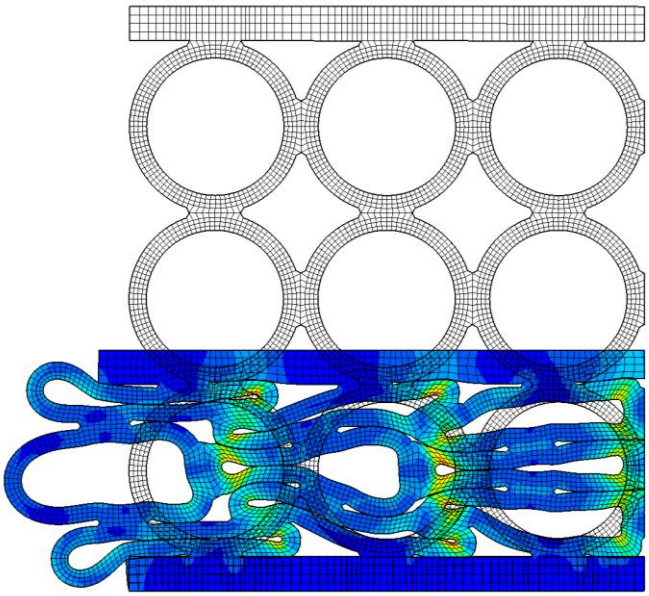
J R C T E C H N I C A L R E P O R T S

Pinball-based Contact-Impact Model with Parabolic Elements in EUROPLEXUS



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EUROPLEXUS Software

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1. Introduction

Contact-impact algorithms are an important component of numerical simulation software in fast transient dynamics. Traditionally, contact algorithms have been based on so-called sliding lines and sliding surfaces, see e.g. the work of Hallquist and Benson [1-2].

However, sliding-based algorithms may present some difficulties in detecting contact in complex geometrical situations, especially in 3D. Therefore, starting from the mid-eighties, an alternative formulation based on a so-called pinball metaphor has been proposed by Belytschko and co-workers, see [4-10]. This approach is much more robust in detecting the contact.

The pinball contact-impact method has been implemented in EUROPLEXUS in [12-14], initially based upon a strong, Lagrange-multiplier based solution strategy of the contact constraints (see [11] for details of the method). Recently, the so-called Assembled Surface Normal (ASN) algorithm of Belytschko [3] and an alternative penalty-based solution of the contact constraints have also been introduced as an option in the code, see [15].

EUROPLEXUS [16] is a computer code for fast explicit transient dynamic analysis of fluid-structure systems jointly developed by the French Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA Saclay) and by the Joint Research Centre of the European Commission (JRC Ispra).

Until now the pinball model was applicable only to linear-displacement elements, both of continuum and of structural (beam/shell) type. Recently, at Onera Lille (F) some crash calculations involving many contacts were attempted, initially with linear-displacement continuum elements (CAR4 in 2D). However, to improve accuracy and to help mitigate spurious locking phenomena, it was desired to perform the same calculations with parabolic elements [19], namely by the 9-node Lagrange element Q93.

The present work considers two different approaches to modeling contact with parabolic elements. The first approach uses a phantom mesh of linear-displacement elements, used only for contact detection, and superposed to the structural mesh made of parabolic elements. Such a technique is fully general and could be useful also in other special contact situations, not only with parabolic elements. The second approach is based on a (new) 'native' pinball formulation for the parabolic elements, which has now been developed and implemented in EUROPLEXUS.

This document is organized as follows:

- Section 2 presents the practical contact problem of interest, its solution with linear elements (including some solutions with an ALE formulation for solids) and its solution with parabolic elements using the phantom linear mesh for contact detection.

- Section 3 presents the new “native” pinball formulation for parabolic (continuum) elements, both in 2D (Q9 element shape, i.e. nine-node quadrilateral) and in 3D (C27 element shape, i.e. 27-node hexahedron). Some simple numerical examples are considered to check the new formulation.
- Section 4 presents the solution of the contact problem introduced in Section 2 by the new native parabolic pinball method.
- Some conclusions are given in Section 5.

The Appendix contains a listing of all the input files mentioned in the present report.

2. Practical contact problem

At Onera Lille a crash problem is being considered, in which a structure composed by an assembly of metallic rings is pressed between two metallic plates. A sketch of (a simplified version of) the problem in its initial configuration is given in Figure 1. A 2D plane strain analysis is performed and only one half of the structure is modelled thanks to symmetry.

The bottom plate is blocked in the vertical direction while the upper plate is subjected to an imposed displacement at constant velocity (apart from a short initial transient where the velocity is zero) of 1 mm/s. The model, shown in Figure 1, measures approximately 15 mm horizontally by 17 mm vertically. The final time of the calculation is set to 10 s, when the structure is completely crashed. The problem is therefore practically static and it can be anticipated that its solution with an explicit fast-transient dynamic code such as EUROPLEXUS will be expensive in terms of CPU time.

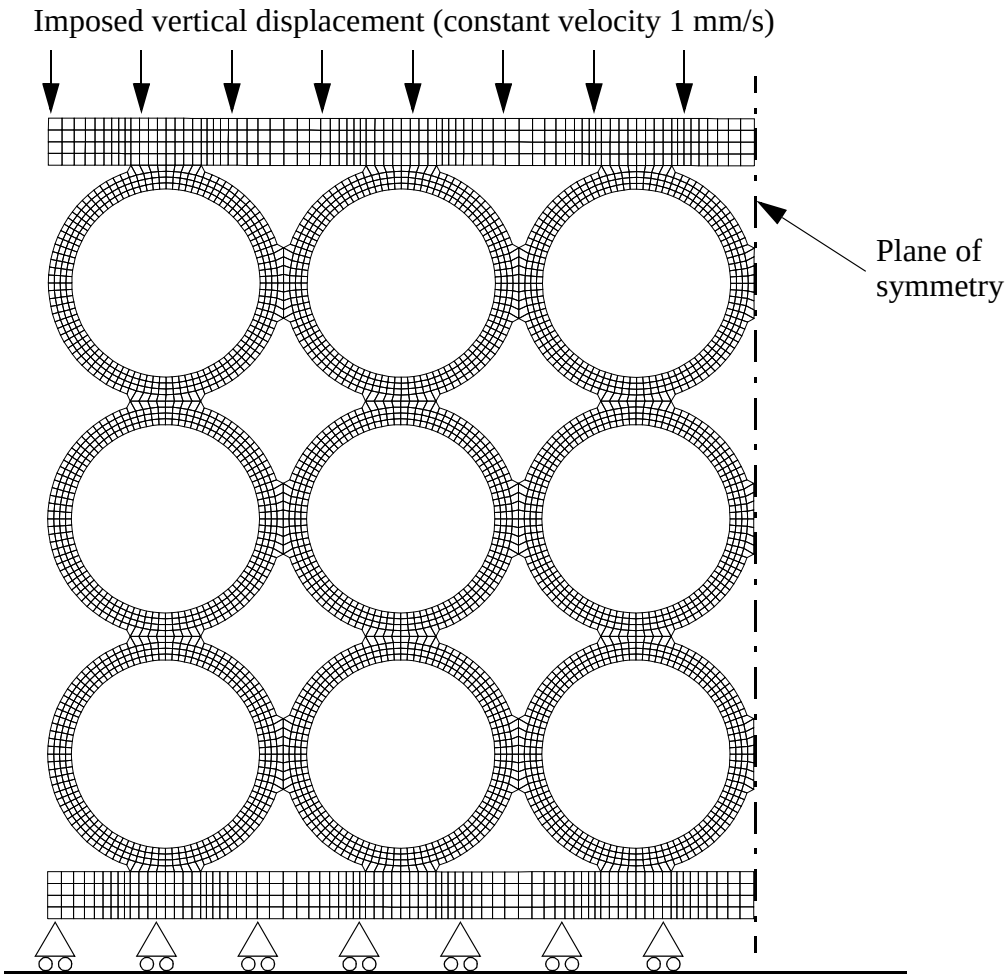


Figure 1 - Sketch of the structure crash problem (simplified version)

2.1 Solutions with CAR4 and CAR1

First, solutions are obtained with the linear-displacement elements. The CAR4 quadrilateral with 4 nodes and full integration (2×2 Gauss points) is employed. All performed calculations are summarized in Table 1.

Table 1 - Calculations of the structure crash problem by CAR4

Case	Mesh	Notes	Steps	CPU [s]	Els*step
CAR401	4080 CAR4	25 PINB SELF DMIN 0.1	741,850	5,463	3.03×10^{9}
CAR101	4080 CAR1	25 PINB SELF DMIN 0.1 CSTA 0.5	[1,000,000] t = 6.1 s	[6,803]	[4, 1×10^{9}]
CAR102	4080 CAR1	25 PINB SELF DMIN 0.1 CSTA 0.5 NMAX 90000000	[1,387,817] t = 7.2 s	[9,977]	[5.7×10^{9}]
CARM01	3264 CAR1 816 CAR4	1 PINB SELF DMIN 0.1 EQVF	[133,362] t = 0.75 s	[944]	[5.4×10^{8}]
CARM02	3264 CAR1 816 CAR4	1 PINB SELF DMIN 0.1 EQVF CSTA 0.5	[1,813,754] t = 7.2 s	[14,386]	[7.4×10^{9}]

CAR401

This calculation uses standard pinballs in the CAR4 elements. There are 25 zones with embedded pinballs, see Figure 2. Each of these is declared as a self-contacting body (`PINB SELF`). Hierarchic pinballs are activated by specifying a minimum pinball diameter of 0.1 mm (`DMIN 0.1`). A fast search of pinball contacts is activated for efficiency of the computation by the option `OPTI PINS GRID`.

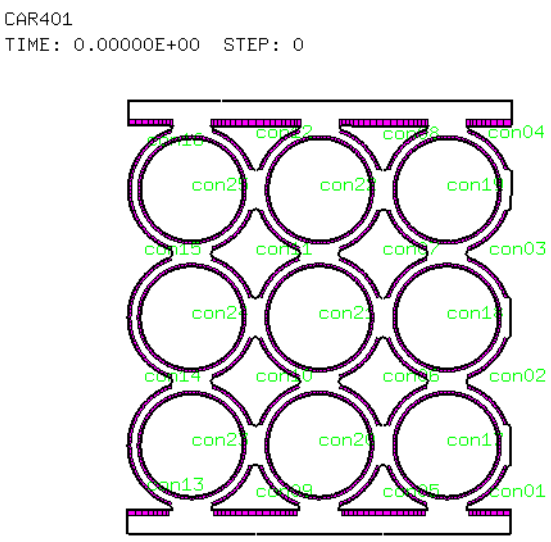


Figure 2 - Pinball zones

The progressive crushing of the structure (every 2.5 s) is illustrated in Figure 3. Figure 4 shows the final plastic strain. The first contacts appear at about 3.65 s. Figure 5 shows the final contacts in the structure. One can see that most of the contacts are physical, but there are some spurious self-contacts in the severely crashed internal parts of the rings (see inset in Figure 5), where the local radius of curvature becomes very small. This is due to the use of the `SELF` keyword, which allows self-contact between pinballs belonging to the same zone (i.e. to the same body), in contrast to the `BODY` keyword, that allows contact only between pinballs belonging to different bodies.

Figure 6 shows the imposed vertical displacement of the top plate which, as anticipated, was linear in time. Figure 7 shows the resulting crushing force vs. displacement of the top plate. The force is obtained by adding up all vertical nodal forces in the nodes on the upper part of the top plate.

Since the experiment is quasi-static (very low crushing velocity) the effect of stress waves is very small and measuring the force on the bottom plate would give almost exactly the same result (apart from the sign of the force, of course). By comparison with some experimental results available at Onera, the crushing force has the right shape but it is too high (over-stiff behavior). This might be due to locking of the element and also partly (but to a much smaller extent) to the spurious contacts.

Hence, the interest in performing the same calculation with parabolic elements, which could be less prone to the locking phenomenon.

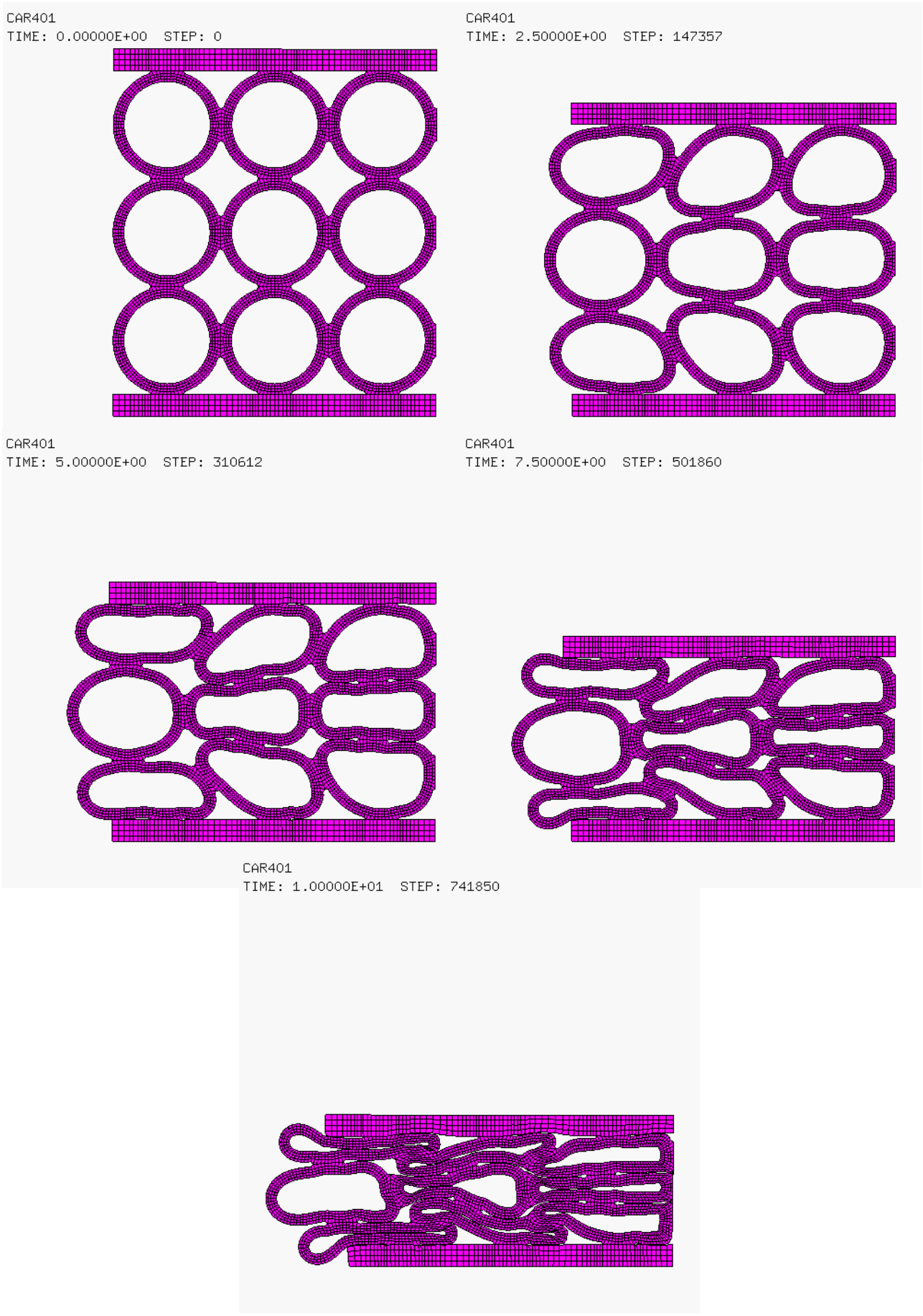


Figure 3 - Structure crushing in case CAR401

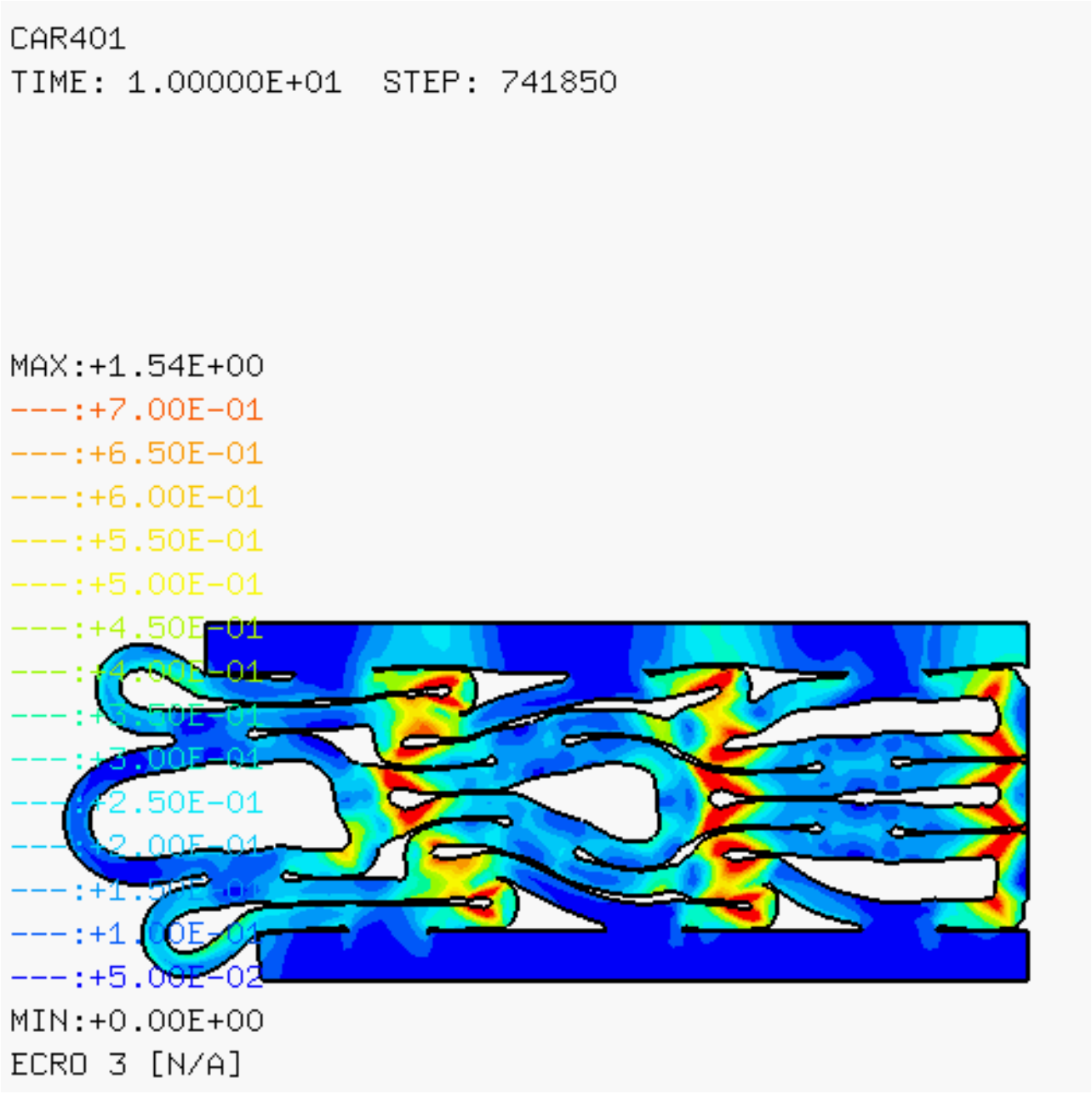


Figure 4 - Final plastic strain in case CAR401

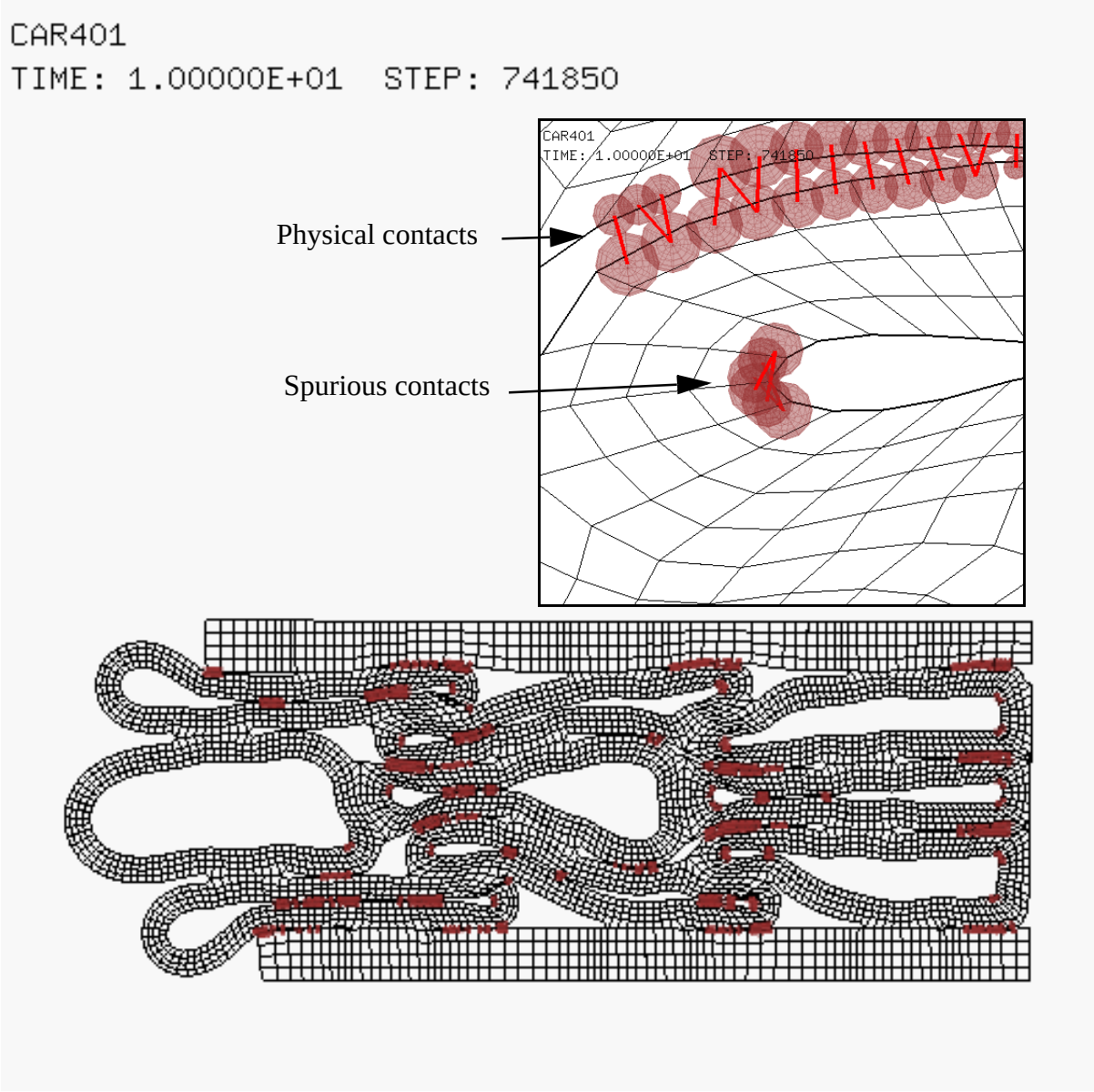


Figure 5 - Final contacts in case CAR401

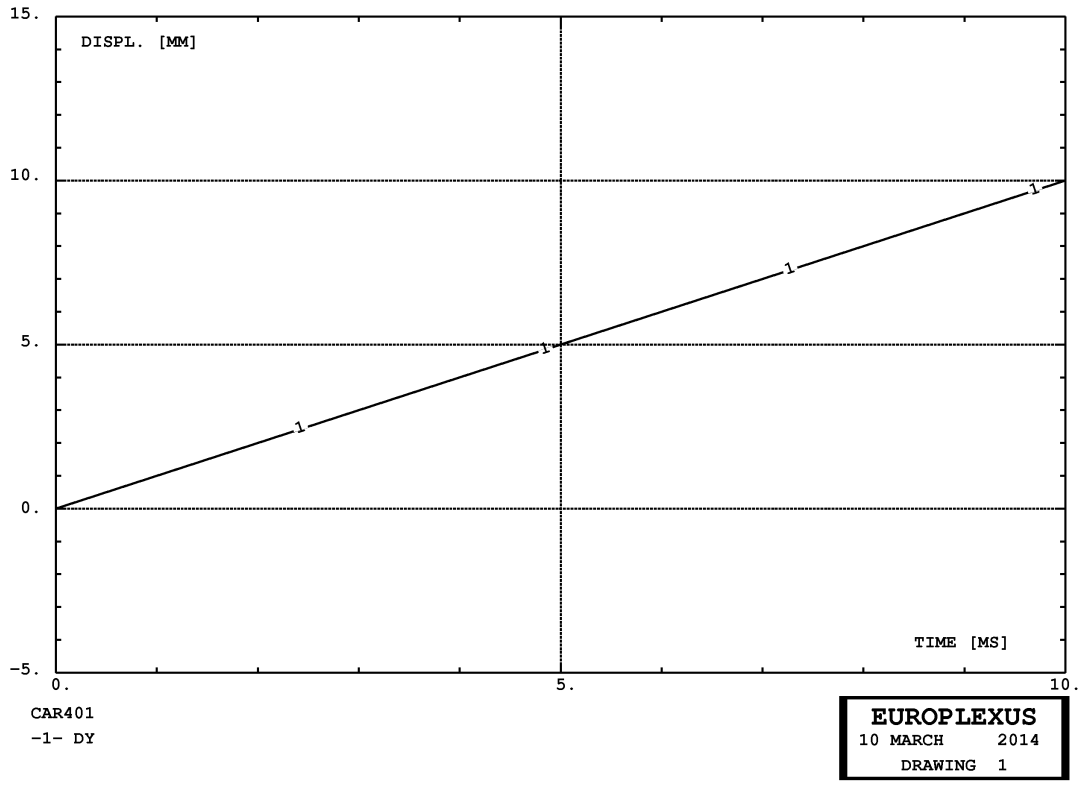


Figure 6 - Imposed displacement in case CAR401

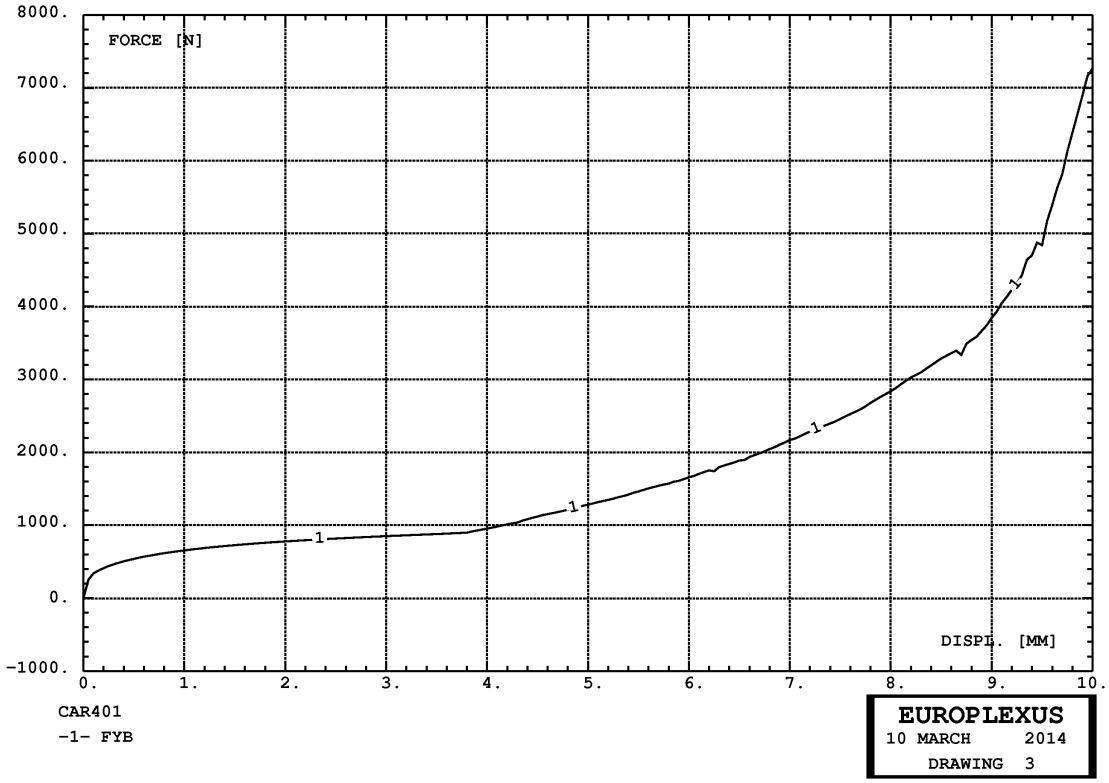


Figure 7 - Crushing force vs. imposed displacement in case CAR401

CAR101

This calculation is similar to CAR401 but uses the under-integrated linear quadrilateral CAR1 instead of the fully integrated CAR4. By using the standard critical step coefficient (`CSTA 0.8`) the calculation fails at step 142, time 1.4 ms, due to strong instabilities, as shown in Figures 8 (configuration), 9 (equivalent plastic strain) and 10 (spurious contacts).

By reducing the stability coefficient to `CSTA` 0.5 the calculation proceeds but stopped at step 1,000,000 which is the normal limit in EUROPLEXUS calculations, at time 6.1 s (it had been forgotten to increase this limit by specifying `NMAX` in the input file). Figure 11 shows the deformed shape and the contacts at this time. Some slight hourglassing is visible, but it is not likely to affect the results much. There are a few spurious contacts, as indicated by the red circles.

The equivalent plastic strain is shown in Figure 12 and reaches a maximum of about 46%.

CAR102

This calculation is identical to CAR101 (with CSTA 0.5) but NMAX 90000000 is specified in order to avoid premature stopping. The calculation was killed by hand at step 1,387,817, time 7.2 s, because the critical time step was decreasing rapidly (2.7×10^{-6} at that moment) so the calculation was not likely to be able to arrive at 10 s anyway.

Figure 13 shows the deformed configuration and the contacts at 7.2 s. Some hourglassing is evident, and this is probably one of the causes (together with strong folding) of the drastic decrease in stability step. The equivalent plastic strain is shown in Figure 14 and reaches a maximum of about 70%.

Finally, Figure 15 compares the crushing force with CAR4 (CAR401) and CAR1 (CAR102). The latter solution, although plagued by some mechanisms which make it fail prematurely, is much more ductile and in line with experimental results.

CARM01

This calculation is similar to CAR401 and CAR101 and uses a mixture of CAR1 and CAR4 elements in an attempt to obtain a solution without (strong) mechanisms, and as ductile as the case CAR102. One over every five elements is a CAR4, the remaining four being CAR1. The mixed mesh is obtained by a simple Cast3m procedure starting from the original CAR4 mesh (see Figure 16), where CAR4 elements are colored in red, CAR1 elements in green).

An initial attempt is done to run this case with the standard `CSTA` (`0.8`), which worked for case CAR401 (all CAR4). However, the calculation stopped at step 133,362 and time 0.75 s because of strong instabilities, see Figure 16. Some high spurious plastic strain develops because of the instability, see Figure 17.

CARM02

This calculation is identical to CARM01 but with `CSTA 0.5`. The calculation proceeded without instabilities, but it was intentionally stopped at step 1,813,754, time 7.2 s, because the critical step was becoming very low (1×10^{-6}), so that the calculation was unlikely to reach 10 s anyway.

Figure 18 shows the deformed mesh at time 7.2 s, Figure 19 shows the contacts (interestingly, there are no spurious contacts at this time), and Figure 20 shows the equivalent plastic strain, which attains a maximum value of 79%.

Indeed, this calculation shows very little overall hourglassing. Some hourglassing is still present in the strong folds, and this (combined with severe crushing) causes the drop of the stability step.

Finally, Figures 21 and 22 compare the crushing forces in the three solutions with linear quadrilaterals (CAR401, CAR102 and CARM02). Indeed, the two solutions with either CAR1 or a mix-up of CAR1 and CAR4 are in good agreement among them and in better agreement than the full CAR4 solution with the experimental results.

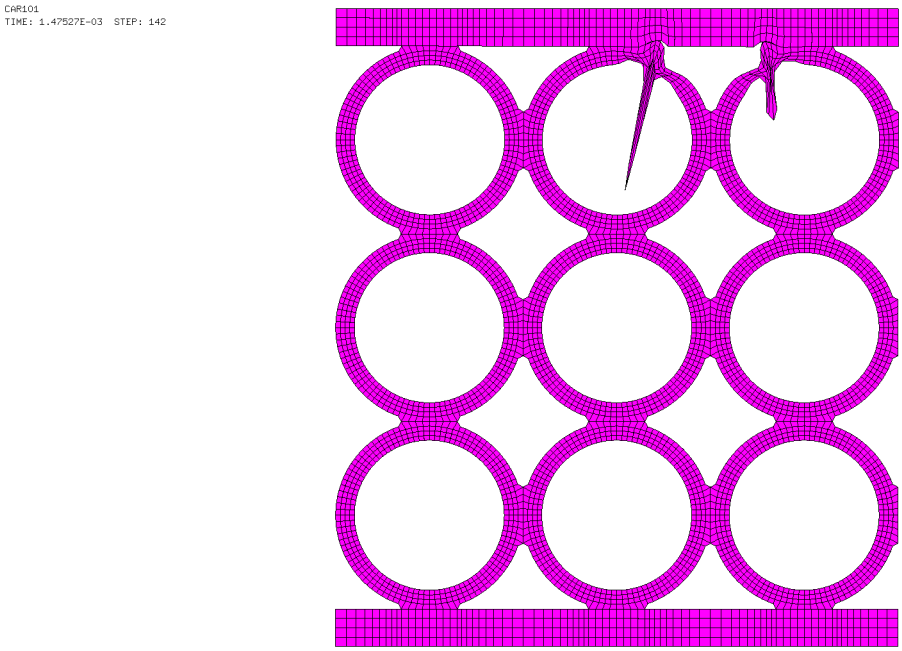


Figure 8 - Deformed shape with instabilities in case CAR101 with CSTA 0.8

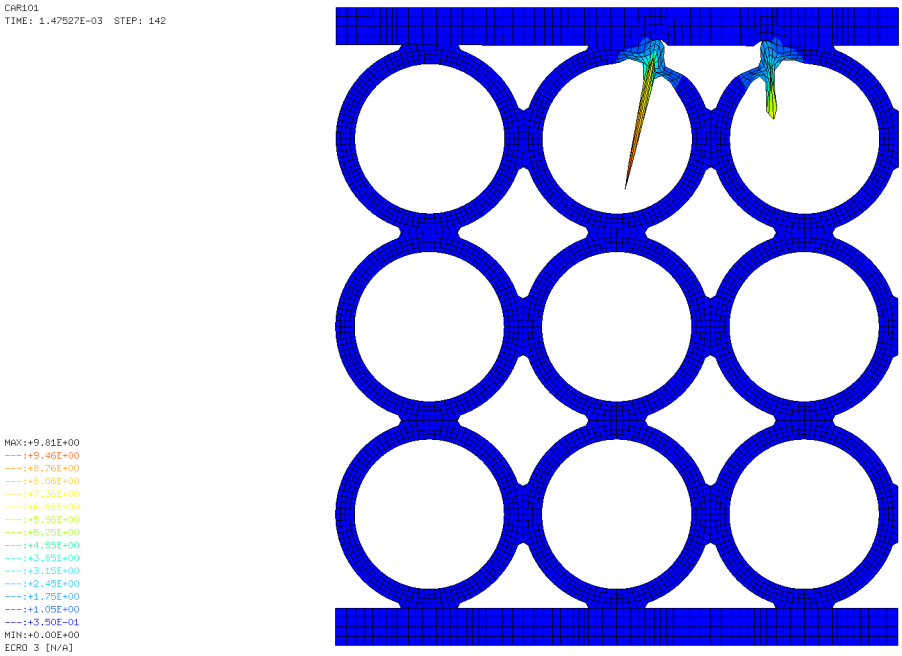


Figure 9 - Equivalent plastic strain in case CAR101 with CSTA 0.8

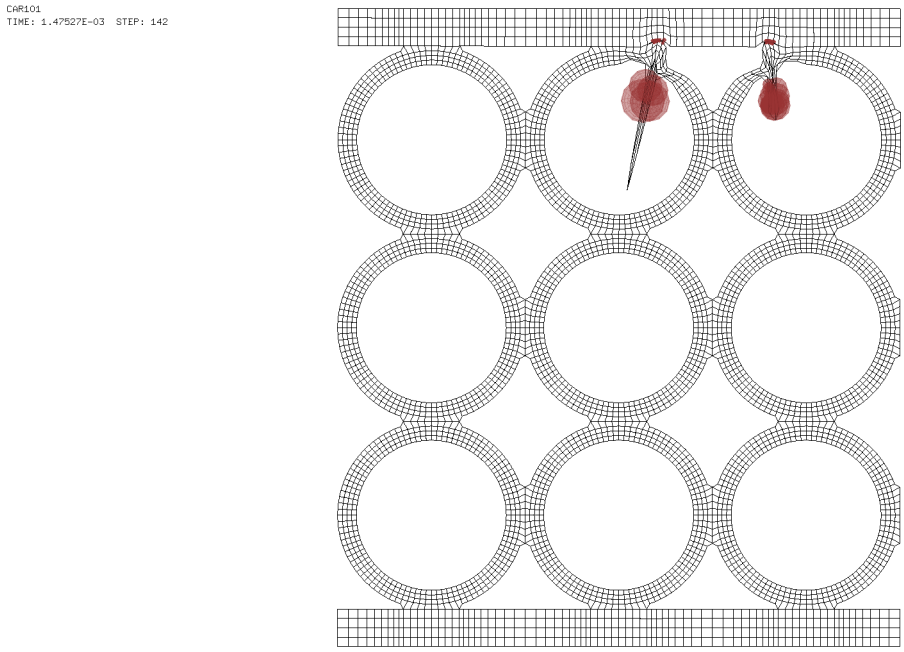


Figure 10 - Instabilities and spurious contacts in case CAR101 with CSTA 0.8

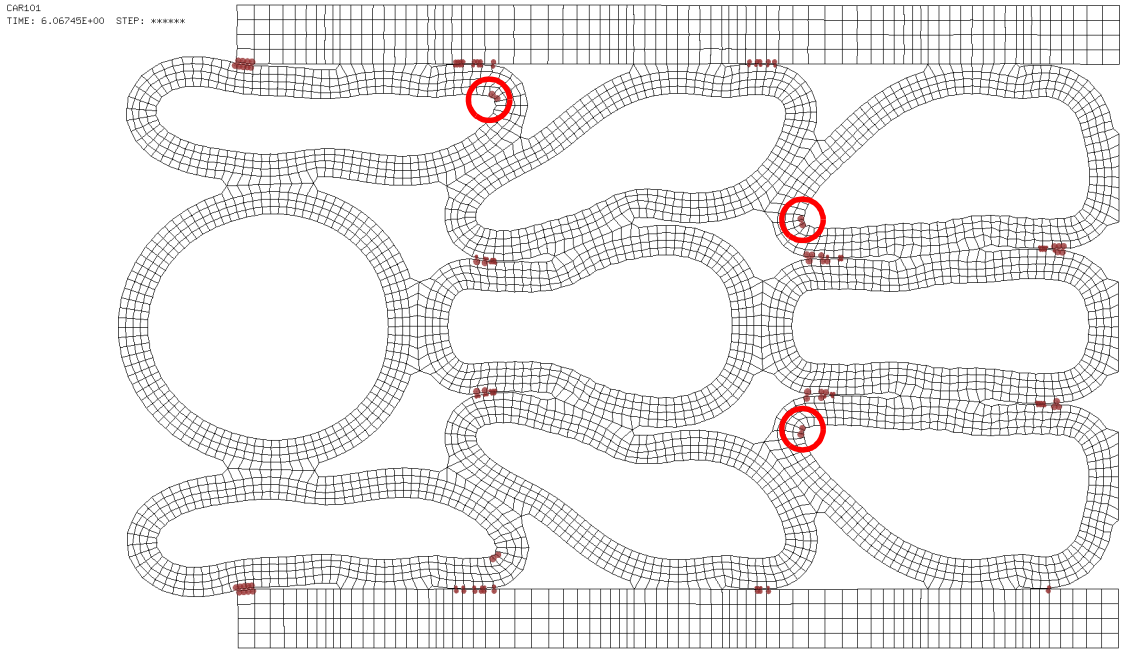


Figure 11 - Contacts in case CAR101 with CSTA 0.5 at 6.1 s

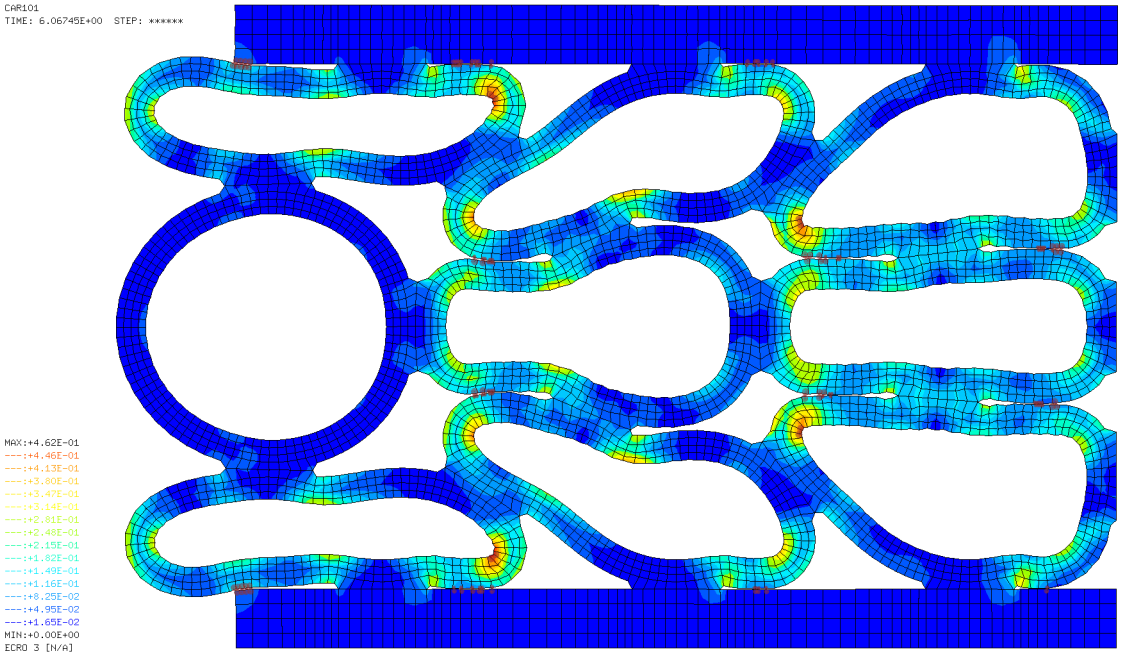


Figure 12 - Equivalent plastic strain in case CAR101 with CSTA 0.5 at 6.1 s

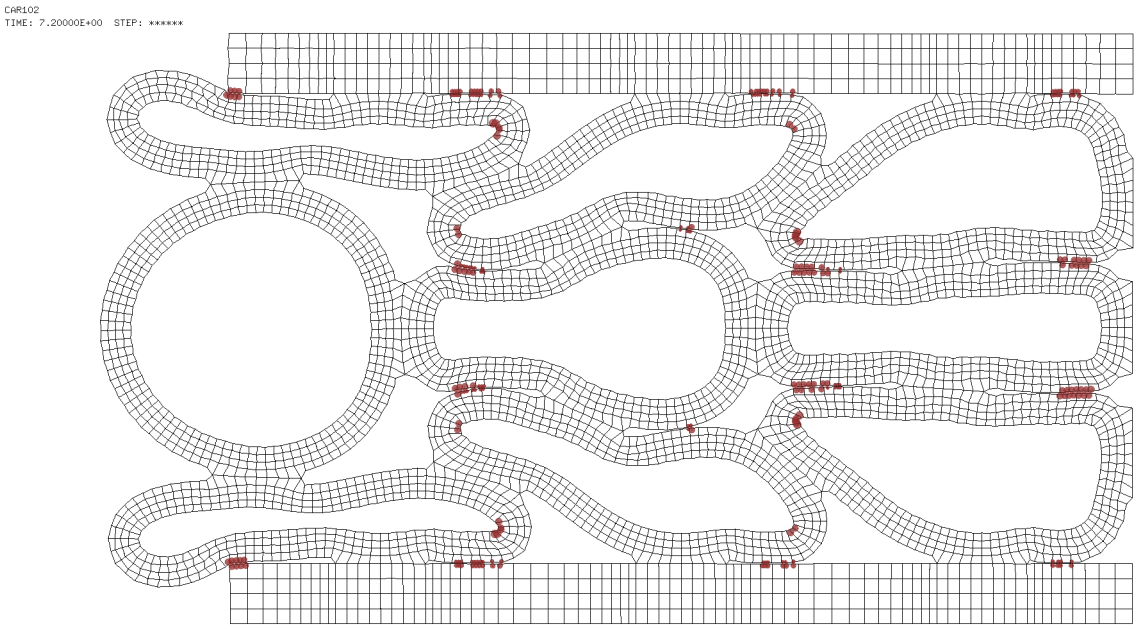


Figure 13 - Contacts in case CAR102 with CSTA 0.5 at 7.2 s

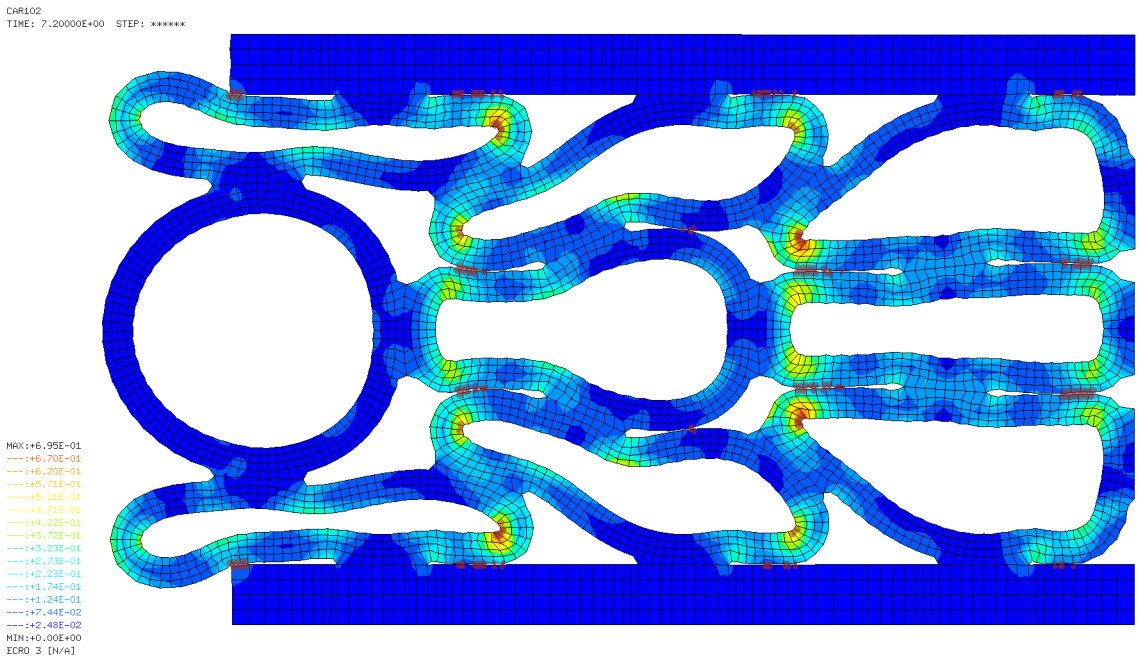


Figure 14 - Equivalent plastic strain in case CAR102 with CSTA 0.5 at 7.2 s

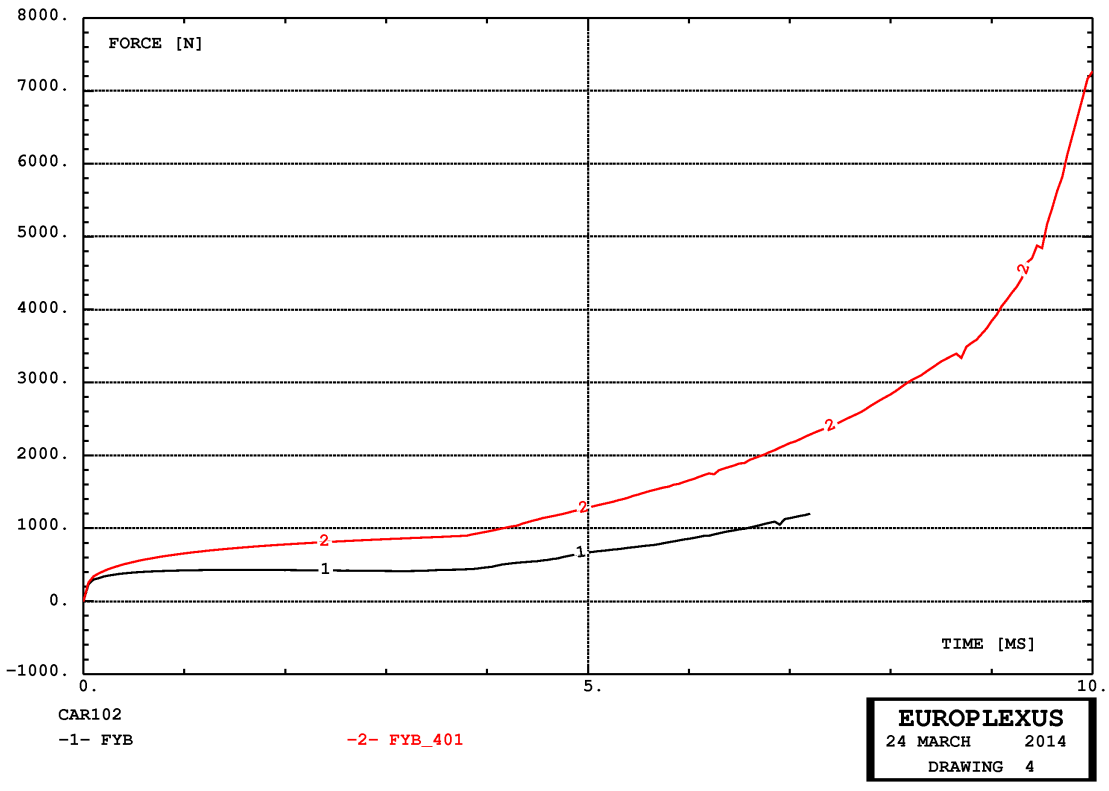


Figure 15 - Crushing force in case CAR102 compared with CAR401

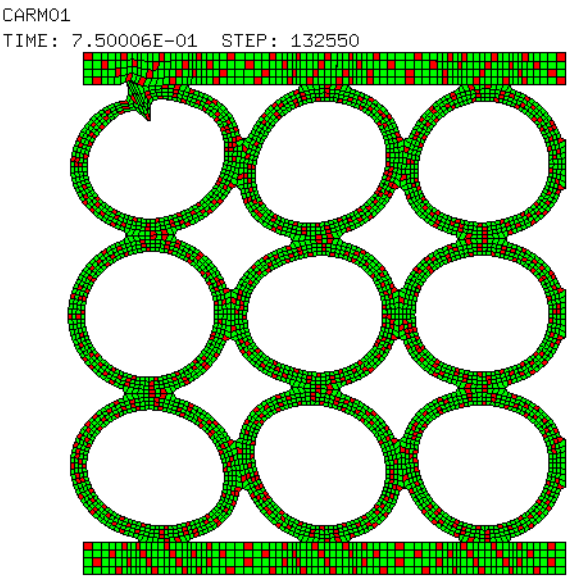


Figure 16 - Instabilities and spurious contacts in case CARM01 with CSTA 0.8

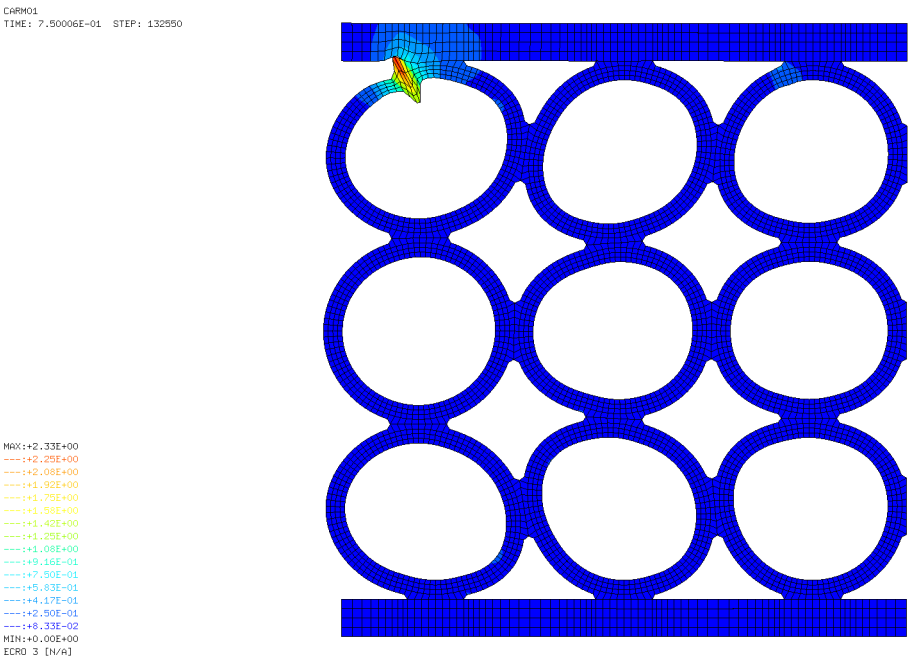


Figure 17 - Equivalent plastic strain in case CARM01 with CSTA 0.8

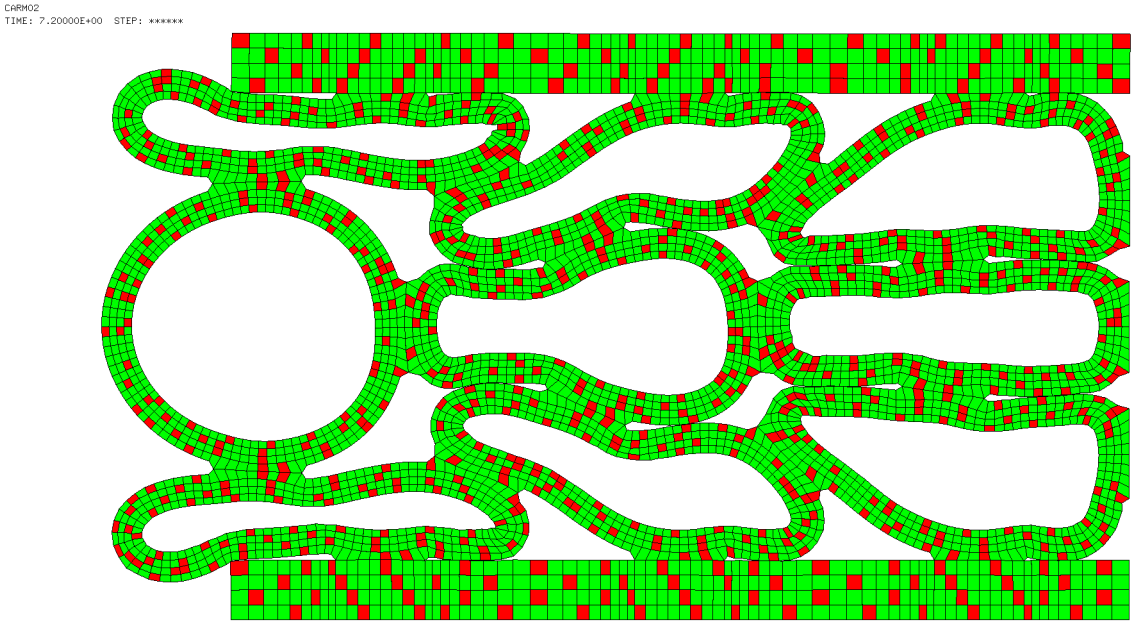


Figure 18 - Deformed mesh in case CARM02 with CSTA 0.5 at 7.2 s

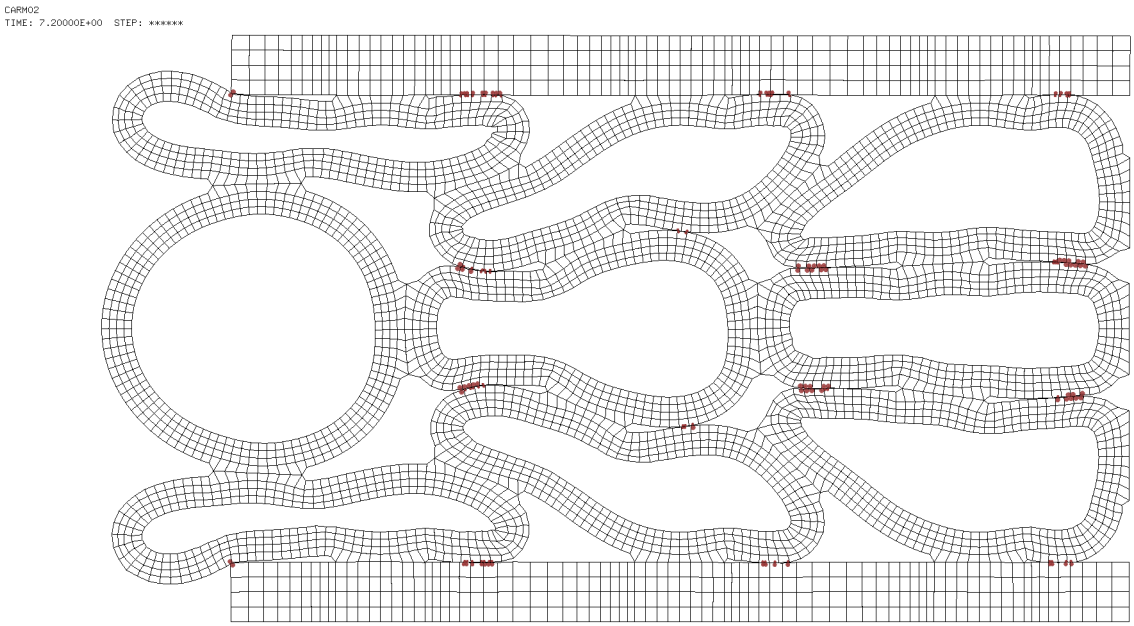


Figure 19 - Contacts in case CARM02 with CSTA 0.5 at 7.2 s

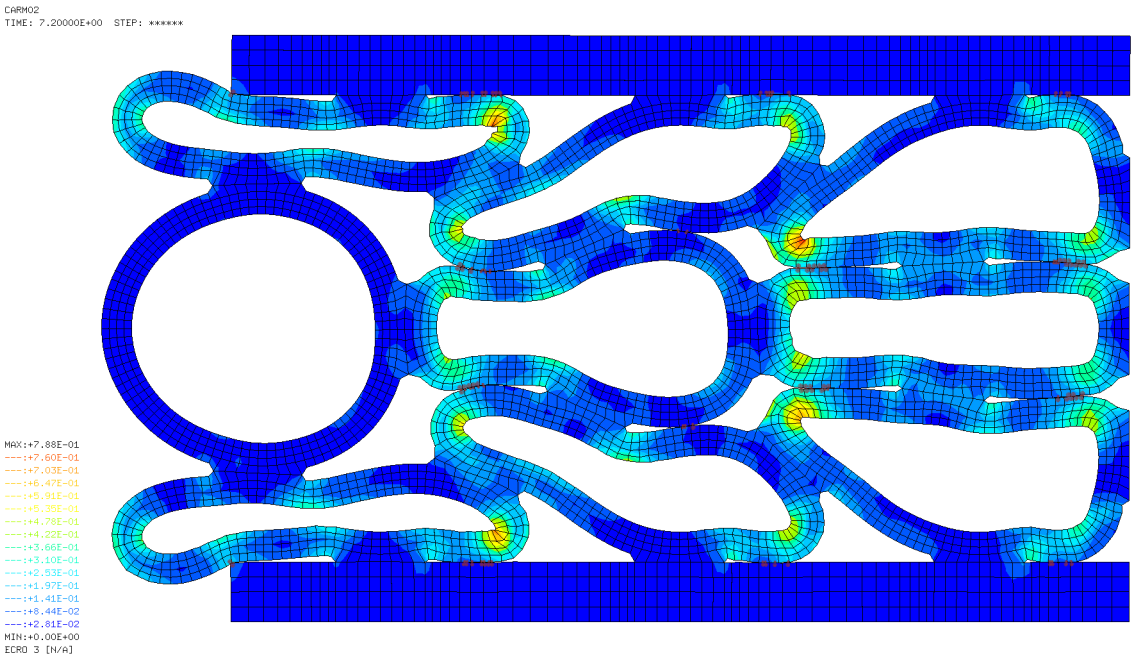


Figure 20 - Equivalent plastic strain in case CARM02 with CSTA 0.5 at 7.2 s

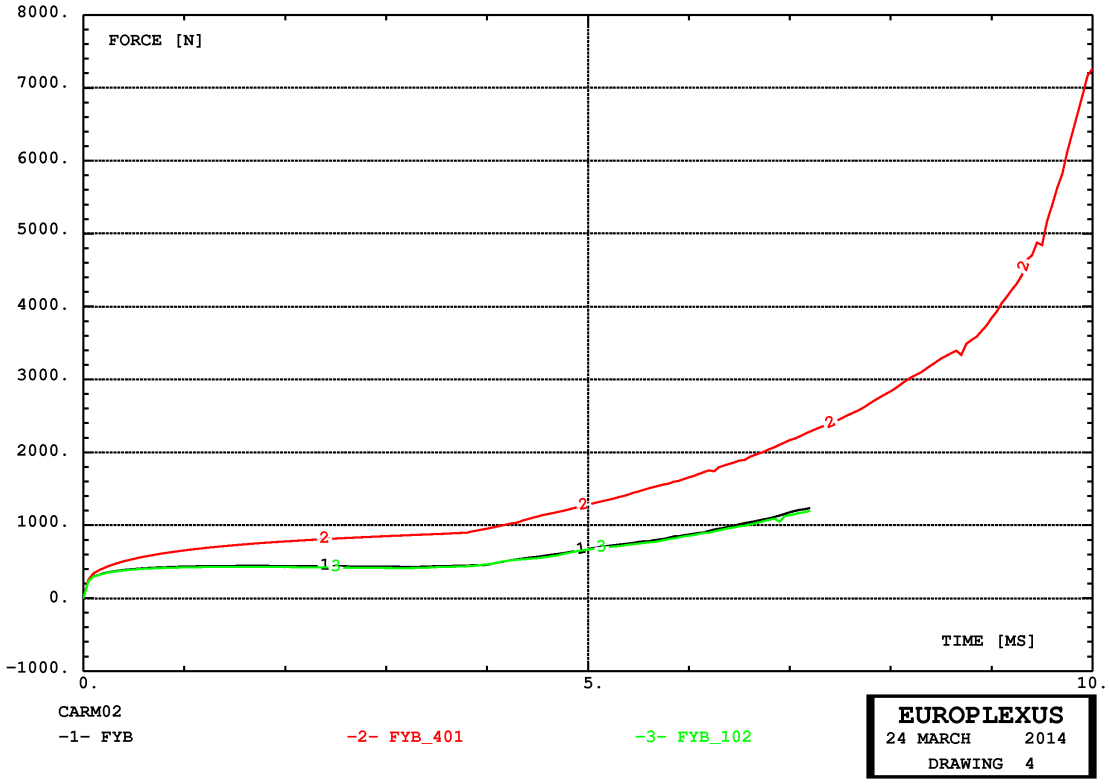


Figure 21 - Crushing force in case CARM02 compared with CAR401 and CAR102

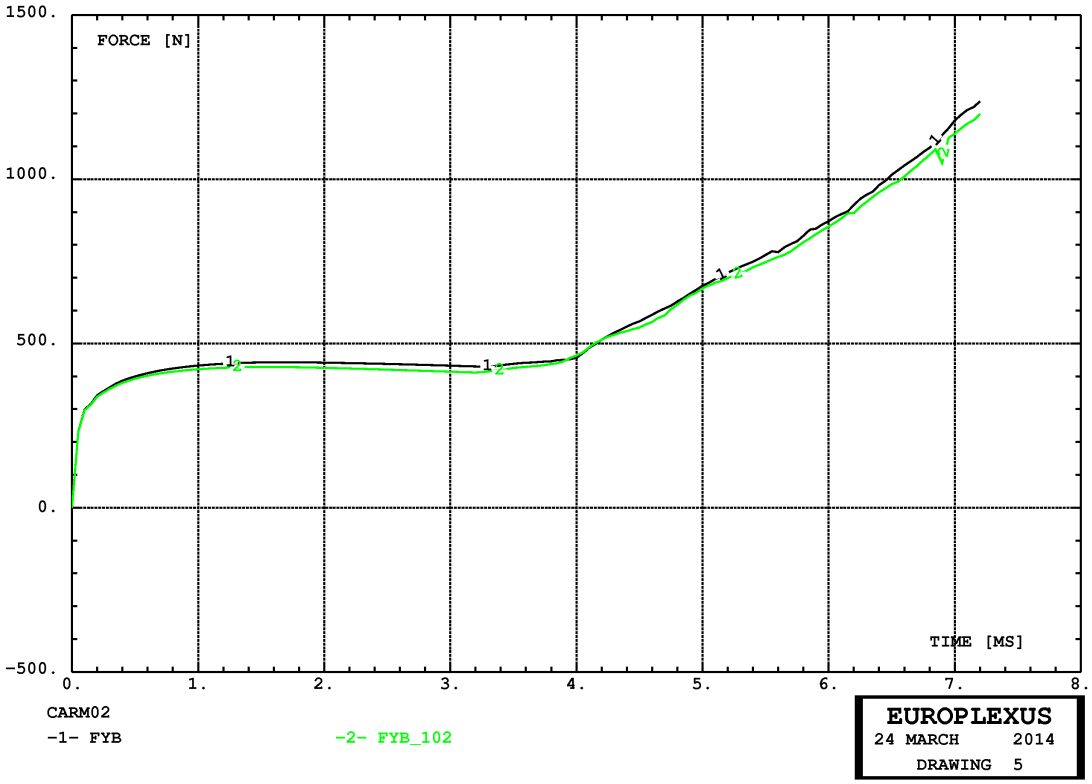


Figure 22 - Crushing force in case CARM02 compared with CAR102

2.2 ALE solutions

The simulations presented so far used a Lagrangian description of the continuum, whereby the mesh is "attached" to the material particles. This simplifies treatment of the structural problem, but suffers from a drastic reduction of the stability step as some of the elements (in the folds) get severely distorted, towards the end of the transient.

An alternative approach is to use an Arbitrary Lagrangian Eulerian (ALE) formulation, whereby the mesh moves in an arbitrary manner. Such technique is most commonly used with fluids, but an implementation for solid materials is present in EUROPLEXUS (although limited to 2D applications), see e.g. references [23-27].

All performed calculations are summarized in Table 2.

Table 2 - ALE calculations of the structure crash problem

Case	Mesh	Notes	Steps	CPU [s]	Els*step
CARA02	4080 Q42G	1 PINB SELF DMIN 0.1 PINS GRID EQVF CNOR	1,132,701	15,688	4.62×10^{9}
CARA03	4080 Q41N	1 PINB SELF DMIN 0.1 PINS GRID EQVF CNOR	[117,658] [1.06 s]	[886]	[4.8×10^{8}]
CARA04	4080 Q42G	1 PINB SELF DMIN 0.1 PINS GRID EQVF CNOR crushing velocity 10 mm/s	114,118 1 s	1,929	4, 66×10^{8}
CARA05	4080 Q42G	1 PINB SELF DMIN 0.1 PINS GRID EQVF CNOR density 100 times larger	114,261 10 s	1,925	4.66×10^{8}
CARA06	4080 Q42N	1 PINB SELF DMIN 0.1 PINS GRID EQVF CNOR crushing velocity 10 mm/s	[102,455] 0.96 s	[1,762]	4.18×10^{8}
CARA07	4080 Q42	1 PINB SELF DMIN 0.1 PINS GRID EQVF CNOR crushing velocity 10 mm/s	90,068 1 s	1,618	3.67×10^{8}
CARA08	4080 Q41	1 PINB SELF DMIN 0.1 PINS GRID EQVF CNOR crushing velocity 10 mm/s	[23,705] 0.13 s	[304]	[9.67×10^{7}]

CARA02

This calculation is similar to test CAR401 presented in Section 2.1, but uses the Q42G fully integrated four-node element in an ALE formulation. The mesh is read from a Cast3m file, produced via the READ operator (see file `readq4.dgibi` in Appendix) from the mesh embedded in the CAR401 input file.

For simplicity (of the user) a single zone of pinballs is declared (`SELF DMIN 0.1`) containing all the elements on the surface of the model (`elepin` object, defined in `readq4.dgibi`).

Giuliani's automatic rezoning algorithm is used to drive the ALE mesh motion, i.e., for all nodes internal to the model. The nodes on the surface are Lagrangian.

Figure 23 shows the initial configuration with, highlighted, the surface nodes which are treated as Lagrangian. Figure 24 shows the final deformed configuration with the contacts. No spurious contacts (not even in the folds) are observed. Note how the mesh rezoning algorithm keeps the mesh more regular internally than in the Lagrangian solutions presented previously. Despite this, the calculation is more expensive in terms of CPU, partly because of the necessary transport calculation (which are avoided in Lagrangian), partly because the solution requires more steps. In fact, the critical time step becomes smaller than in the case CAR401 since the behavior of the model is more ductile (and thus in better overall agreement with the experiments), and very high local plasticization (perhaps not physical) is observed in the folds.

Figure 25 shows the final plastic strain distribution, which attains huge values (2,200%) at a tiny spot in a fold. The same map but at a slightly earlier time (8.85 s instead of 10 s) is shown in Figure 26, where the maximum strain is "only" 149%.

Figure 27 shows the crushing force as a function of the imposed displacement. Since the imposed displacement is linear in time (10 mm in 10 s), this curve also represents the crushing force in time (by just changing the horizontal scale units from mm to s). Figure 28 compares the upper and lower plate forces, with a change in sign to make the two directly comparable. The two curves are practically exactly superposed, showing that this case is static, i.e. wave propagation (and inertia forces) plays no role. Finally, Figure 29 compares the crushing forces of cases CAR401 (in red), CAR102 (in green) and CARA02 (present case, in black). The present solution is more ductile than the CAR4 solution, but stiffer than the CAR1 solution.

CARA03

This calculation is similar to test CARA02 but uses the Q41N reduced-integrated four-node element in an ALE formulation. The calculation stopped prematurely (at 1.06 s of physical time) due to strong mechanisms, see Figure 30.

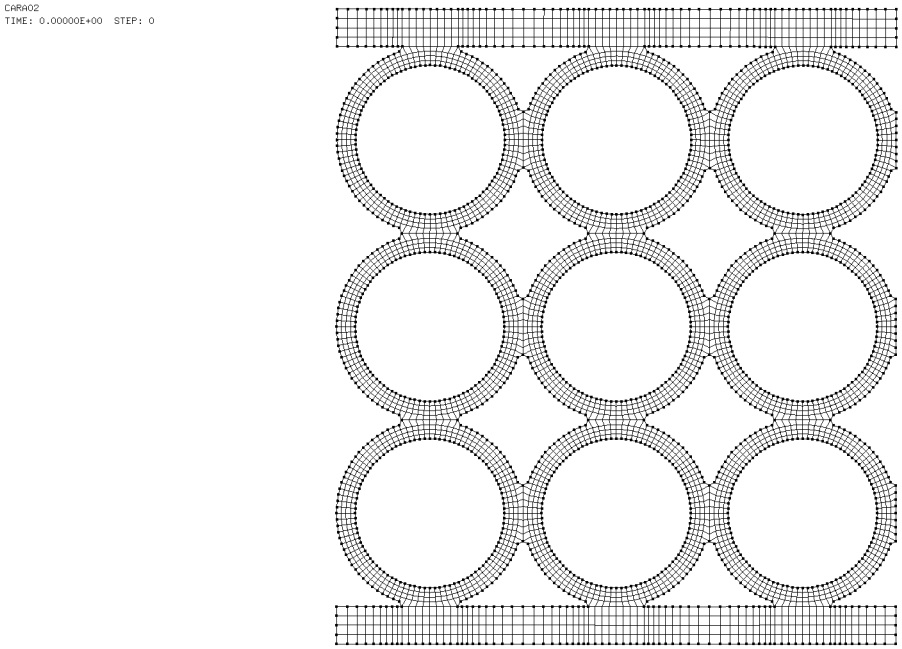


Figure 23 - Initial configuration and Lagrangian (surface) nodes in case CARA02

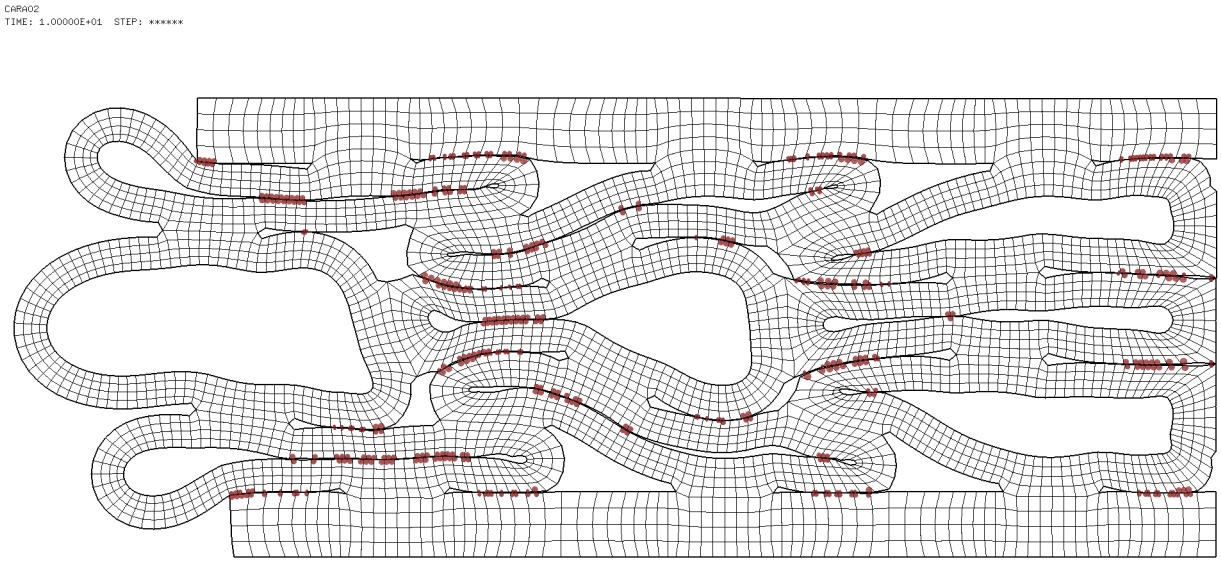


Figure 24 - Final configuration with contacts in case CARA02

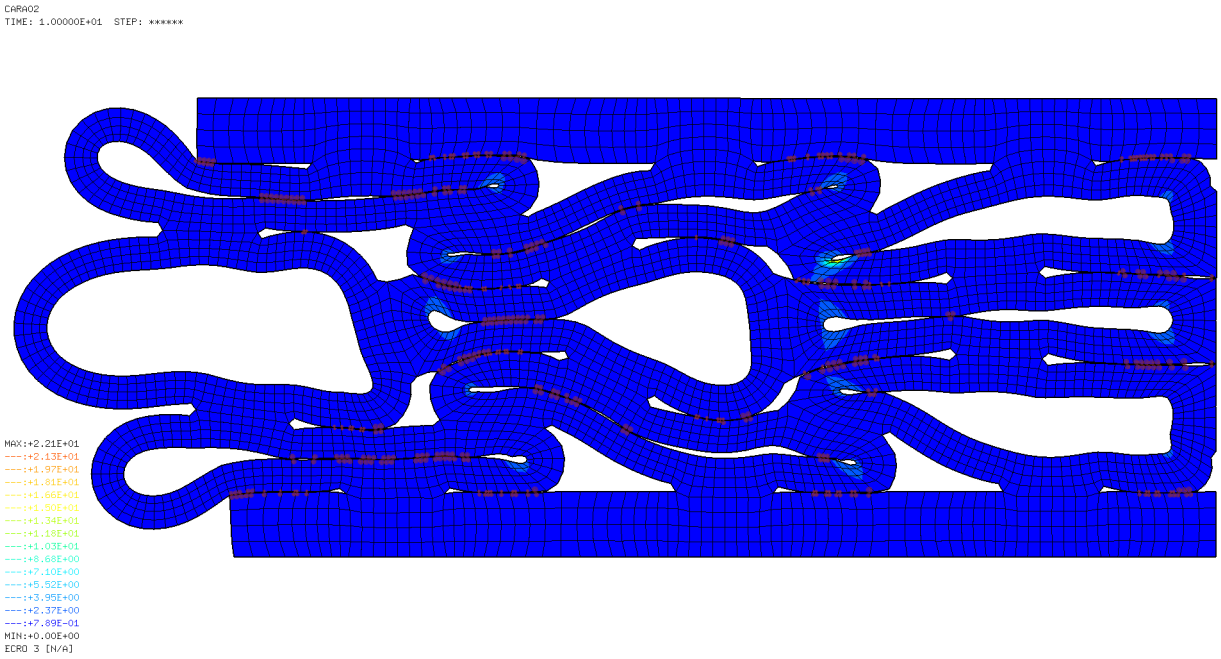


Figure 25 - Final configuration with plastic strain in case CARA02

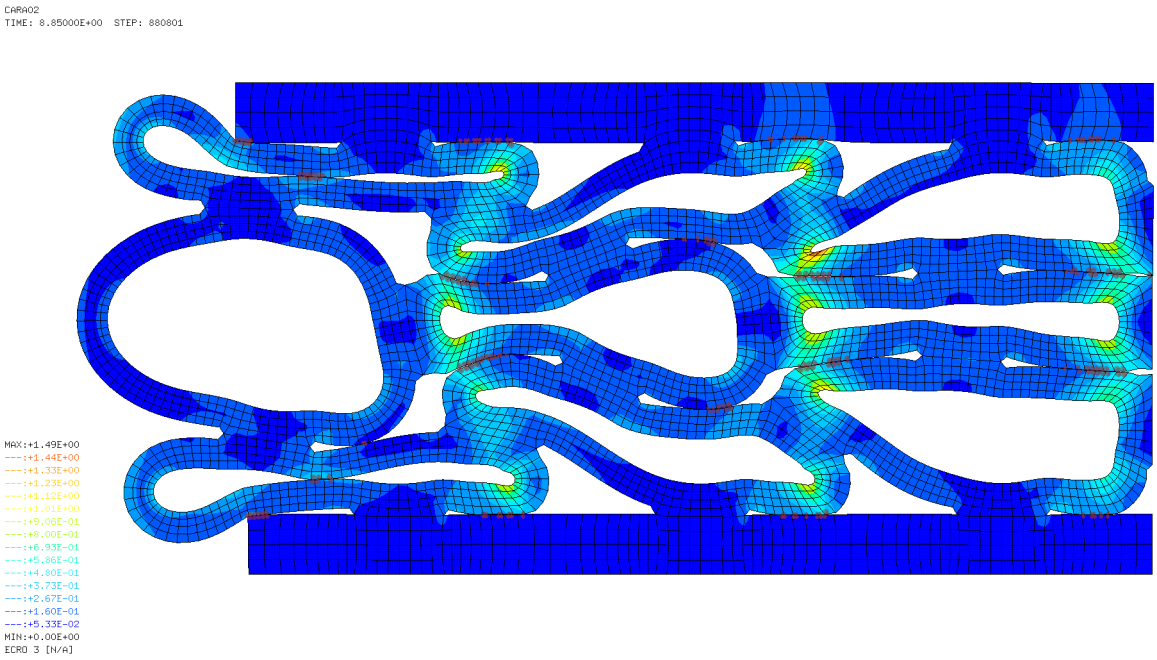


Figure 26 - Configuration at 8.85 s with plastic strain in case CARA02

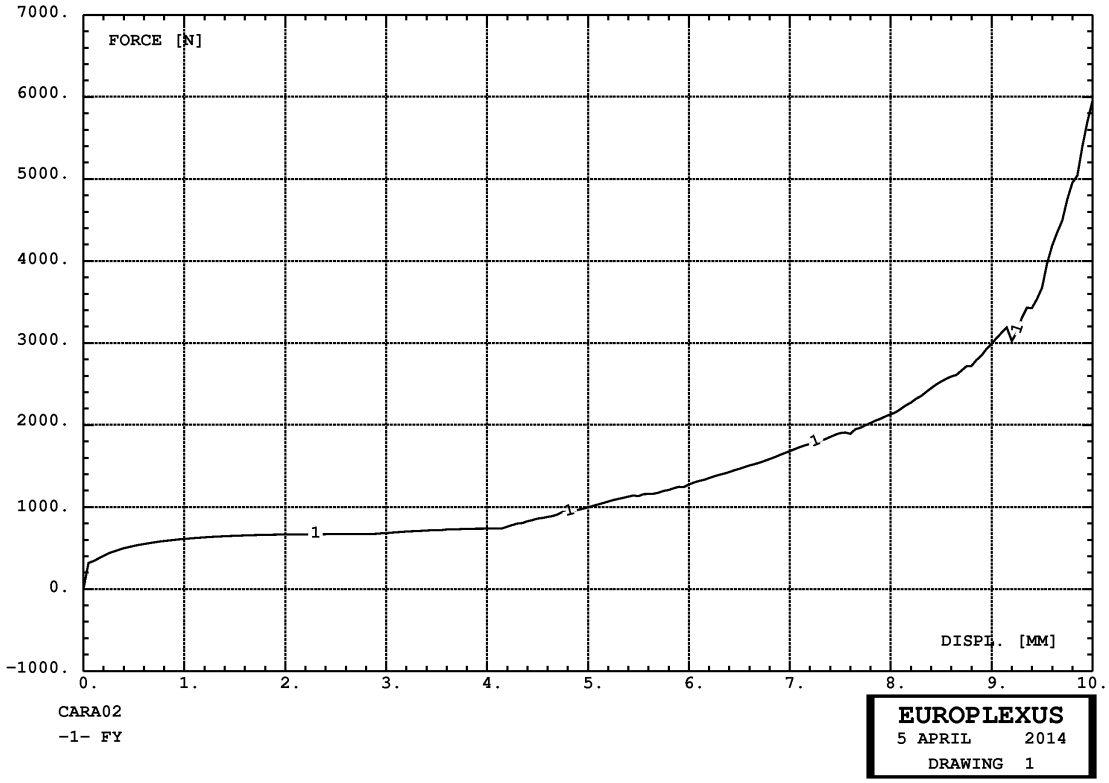


Figure 27 - Crushing force vs. imposed displacement in case CARA02

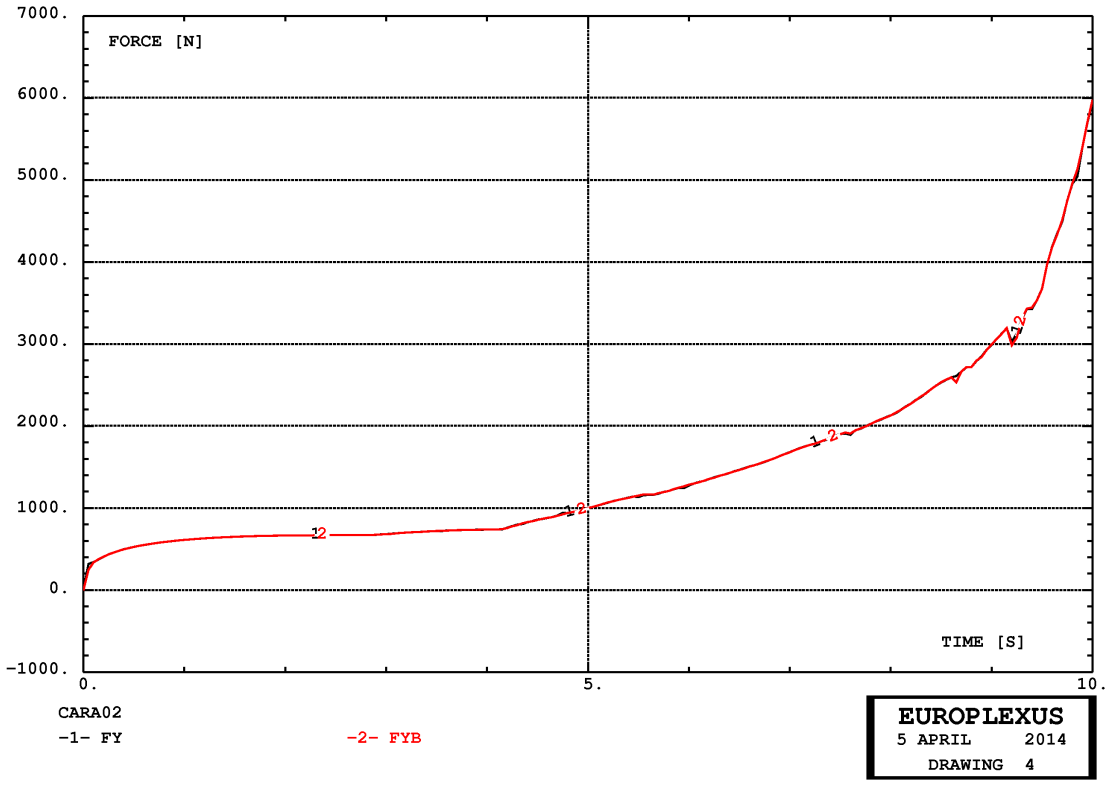


Figure 28 - Upper plate and lower plate forces in case CARA02

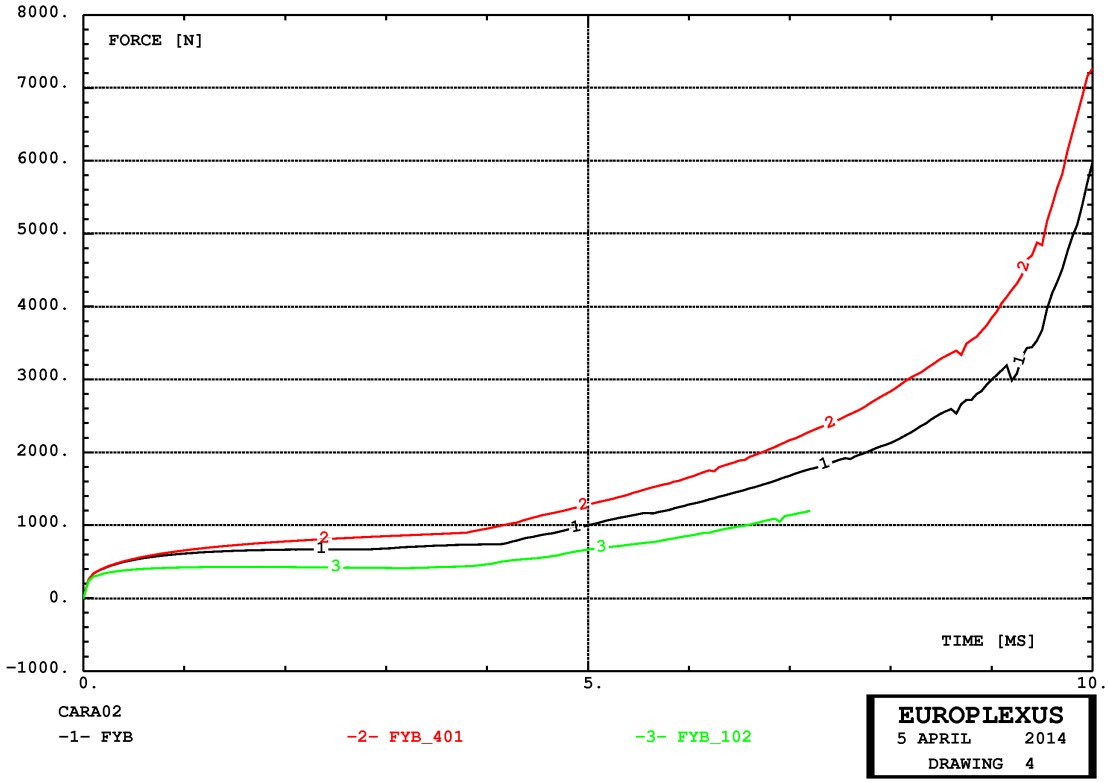


Figure 29 - Comparison of crushing forces in cases CARA02, CAR401 and CAR102

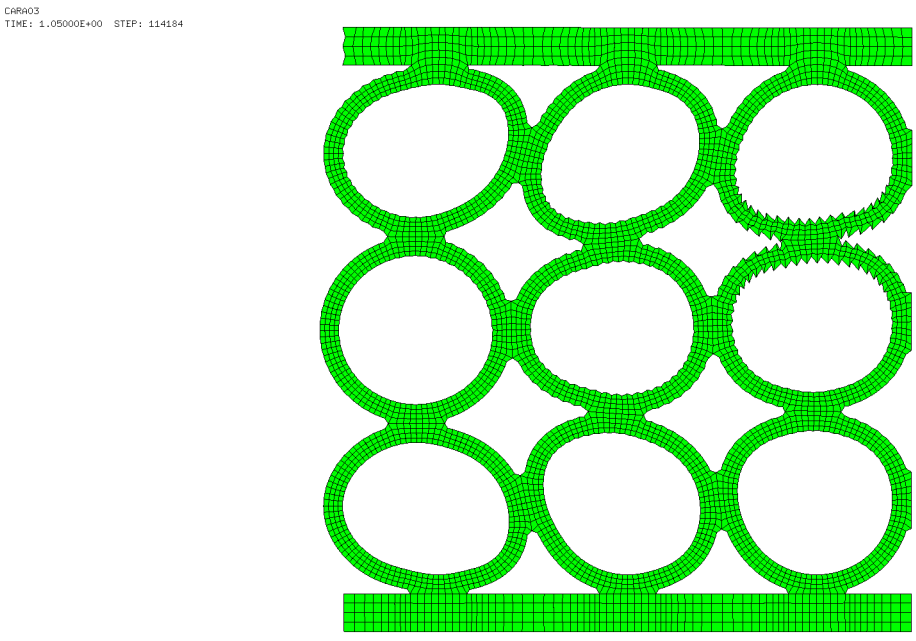


Figure 30 - Deformed mesh with mechanisms in case CARA03

2.2.1 Speeding up the calculations

From what observed previously e.g. in case CARA02 (Figure 28), it appears that the present test case can be considered as static and therefore it lends itself very badly to simulations by an explicit code such as EUROPLEXUS, which aims at fast transient dynamics. Solutions require millions of steps and thus the CPU time is large, although these are just 2D calculations and with relatively few elements.

It makes therefore sense trying to reduce the CPU time, possibly without sacrificing the quality of the solutions. Two alternative (but similar) approaches are tested here:

I *Increase the crushing velocity. For example, by using a 10 times larger crushing velocity (10 mm/s instead of 1 mm/s) the total number of steps, and thus the CPU time, should become about ten times smaller. A speed of 10 mm/s is still so small that no significant dynamic effects should be observed (but this will have to be verified a posteriori). Of course, the time scale of the response will become 10 times shorter (for the same crushing displacement).*

II *Increase the density of the material. For example, by multiplying the density by a factor 100, the critical time step will be increased by a factor 10, again resulting in a speed-up of about 10. In this case the time scale remains the same.*

CARA04

This calculation is similar to test CARA02 but uses a ten times larger (10 mm/s instead of 1 mm/s) crushing velocity. The calculation completed in 10% of the steps and 12.3% of the CPU of the previous case, as expected, i.e. a speed-up factor of 8.1.

Figure 31 shows the initial contour and the deformed mesh at 0.35 s, when the first contacts occur. Figure 32 shows the final mesh with the contacts and Figure 33 the plastic strain, which reaches a local maximum of 580%.

The crushing forces in the upper and lower plates are shown in Figure 34. They are identical, except in a very short time interval at the beginning of the transient. This is partly due to the fact that an imposed velocity is applied without setting an initial velocity in the upper plate nodes. However, the test can still be considered as static, since the two curves are identical over the large majority of the transient, and in particular in the last phase when most contacts and plasticization occur.

As a matter of fact, the crushing forces in the three cases CARA02, CARA03 and CARA04 are practically identical, as shown in Figure 35, despite the fact that the latter calculation costs only 1/10 of the others. In particular, the curves of cases CARA02 and CARA04 (complete calculations) are almost superposed.

CARA05

This calculation is similar to test CARA02 but uses a hundred times larger material density, so that the stability time step is ten times larger. Again, the calculation completed in 10% of the steps and 12.3% of the CPU of case CARA02, as expected, i.e. a speed-up factor of 8.1 (the same as in case CARA04).

Figure 36 shows the final deformed mesh with the contacts and Figure 37 the final plastic strain that reaches a local maximum of 166%.

Figure 38 shows the upper and lower plate forces and Figure 39 compares the crushing force with those of the previous solutions from CARA02 on. All these solutions are very similar.

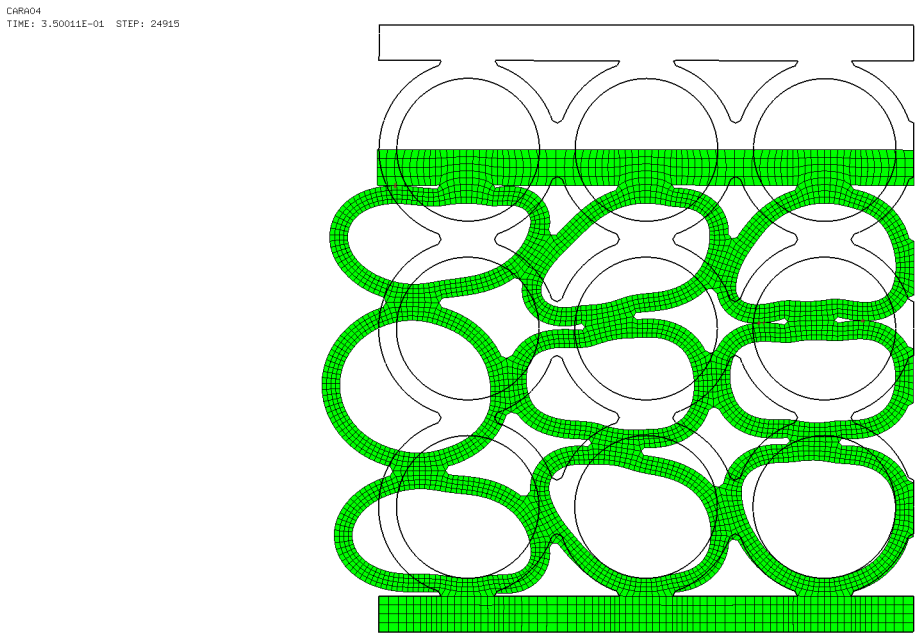


Figure 31 - Initial contour and deformed mesh at 0.35 s in case CARA04

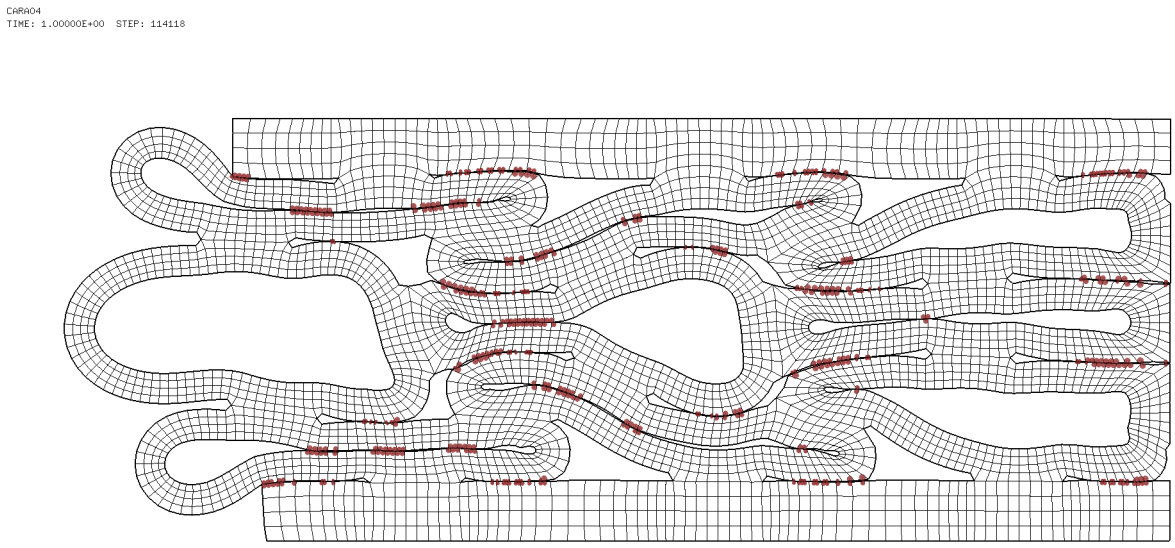


Figure 32 - Final mesh with contacts in case CARA04

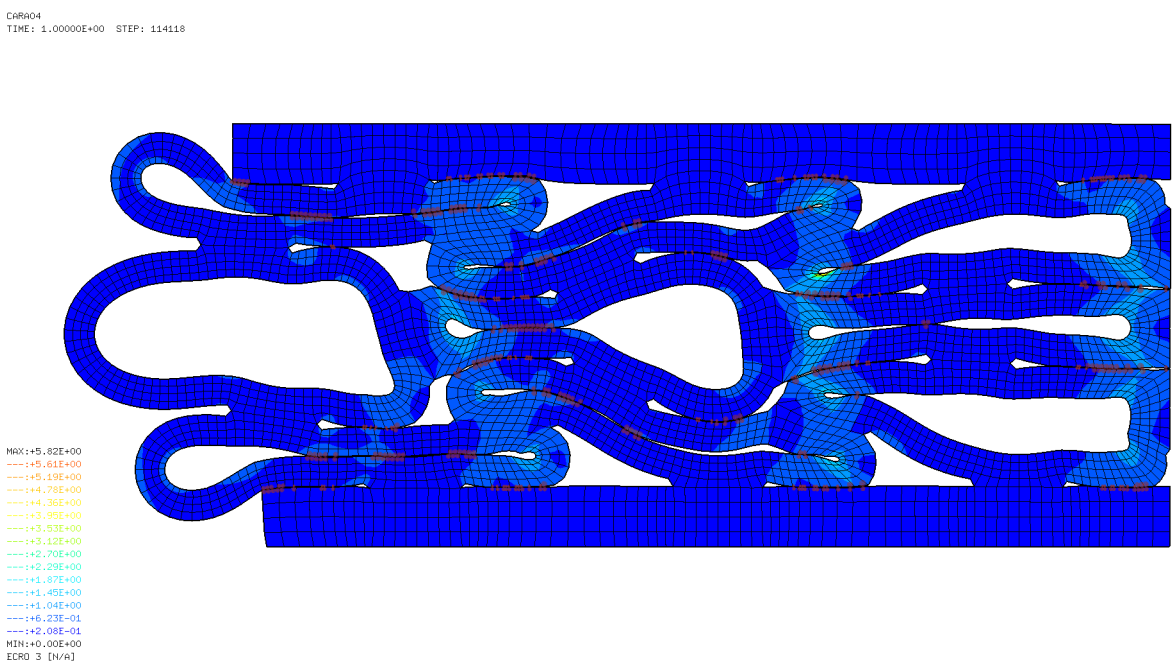


Figure 33 - Final mesh with plastic strain in case CARA04

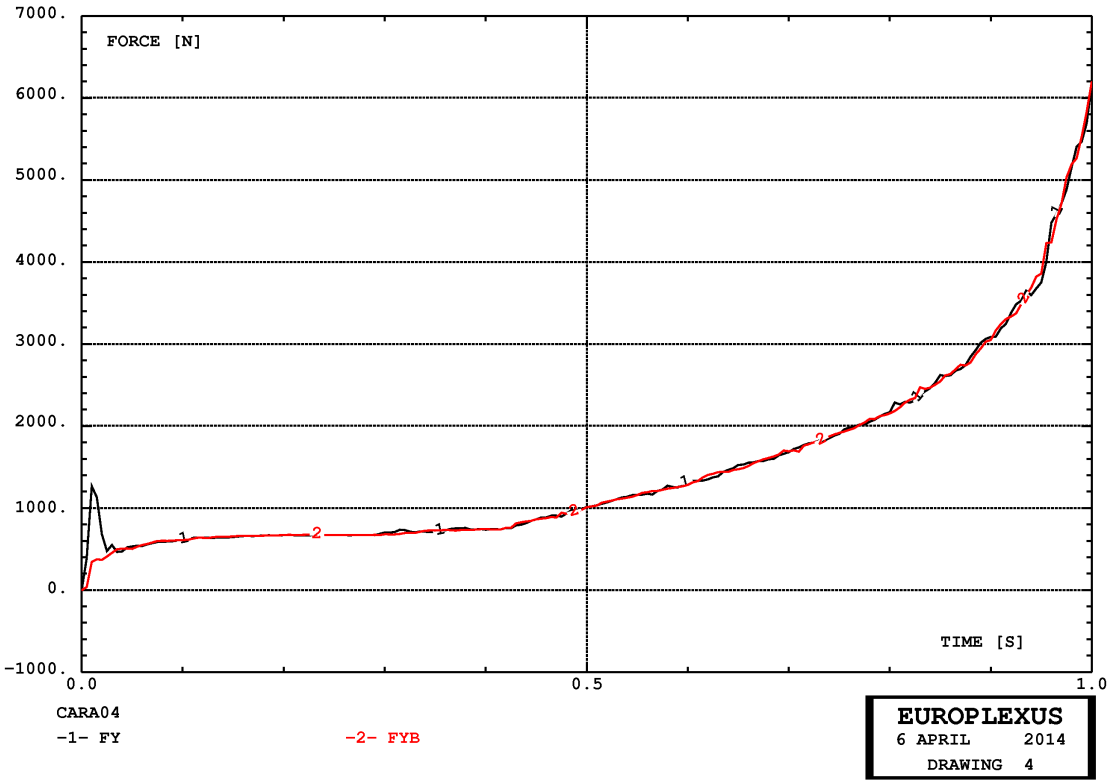


Figure 34 - Upper and lower plate forces in case CARA04

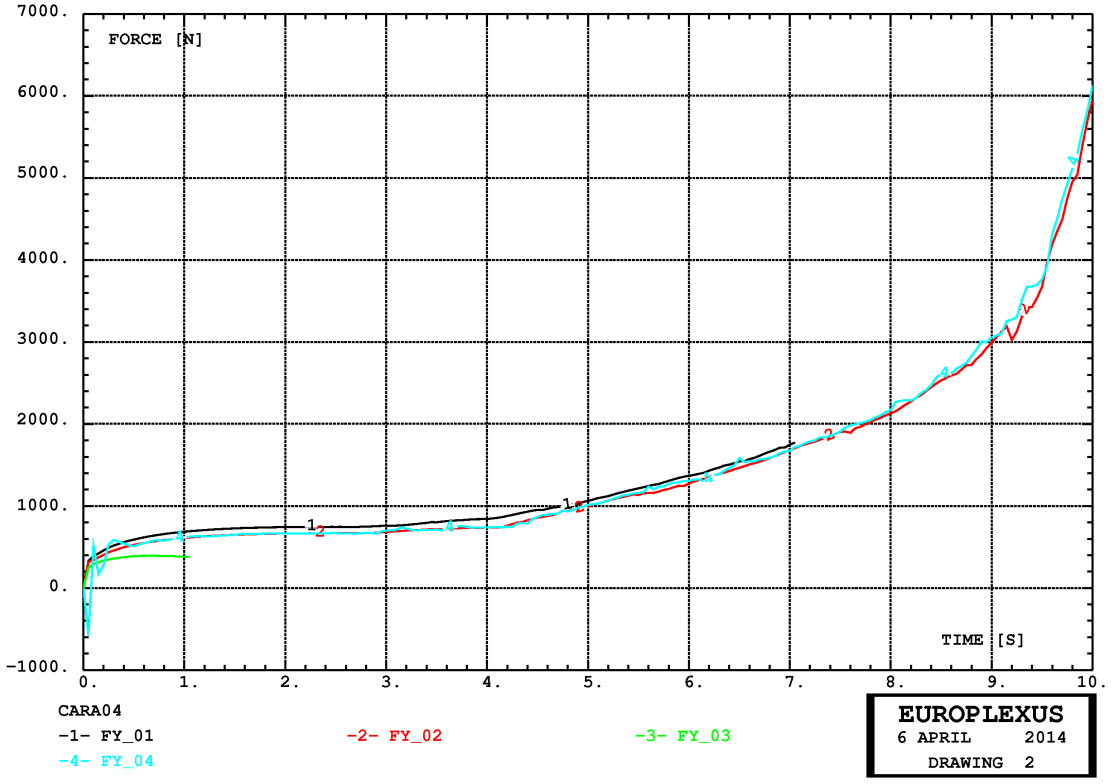


Figure 35 - Comparison of crushing forces in cases CARA02, CARA03 and CARA04

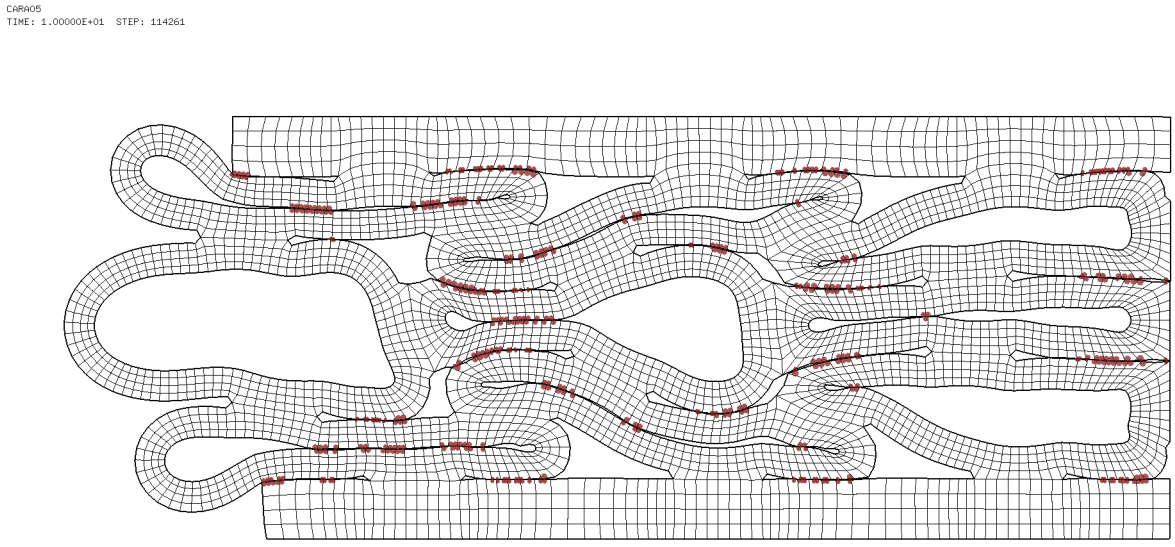


Figure 36 - Final mesh with contacts in case CARA05

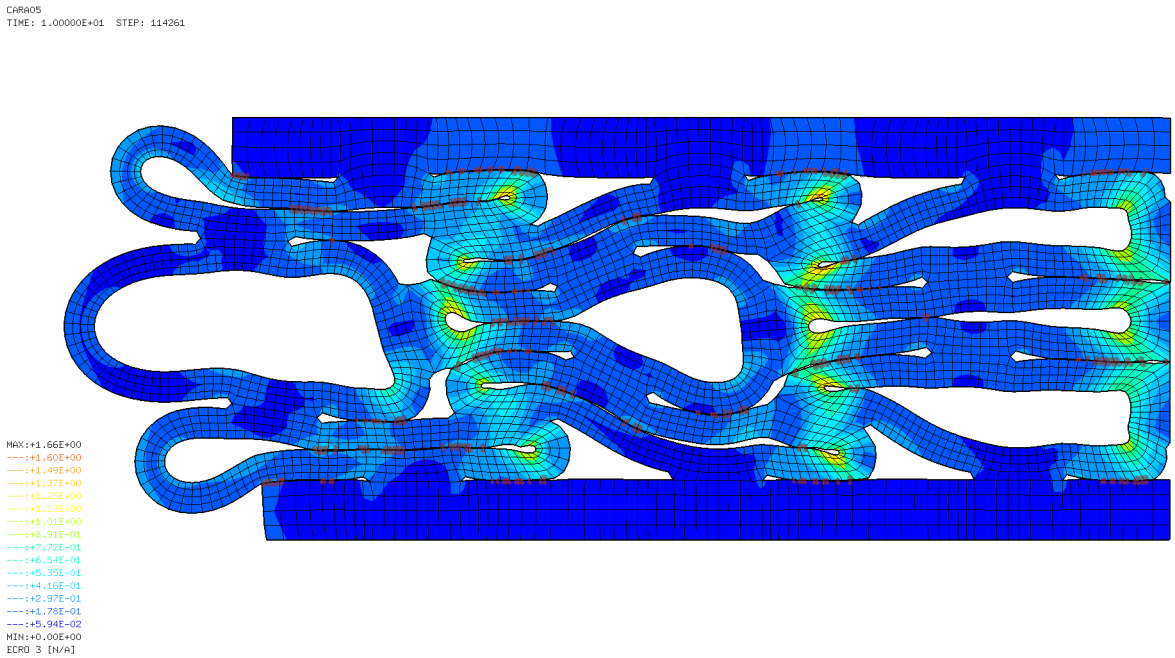


Figure 37 - Final mesh with plastic strain in case CARA05

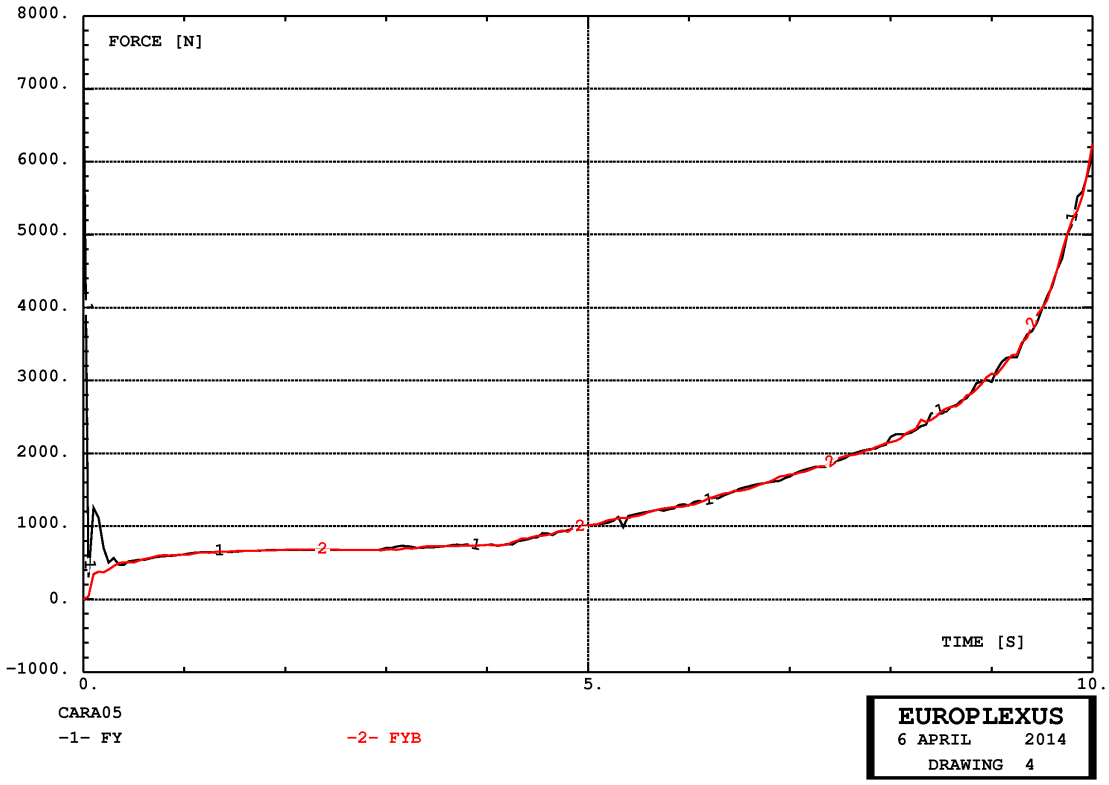


Figure 38 - Upper and lower plate forces in case CARA05

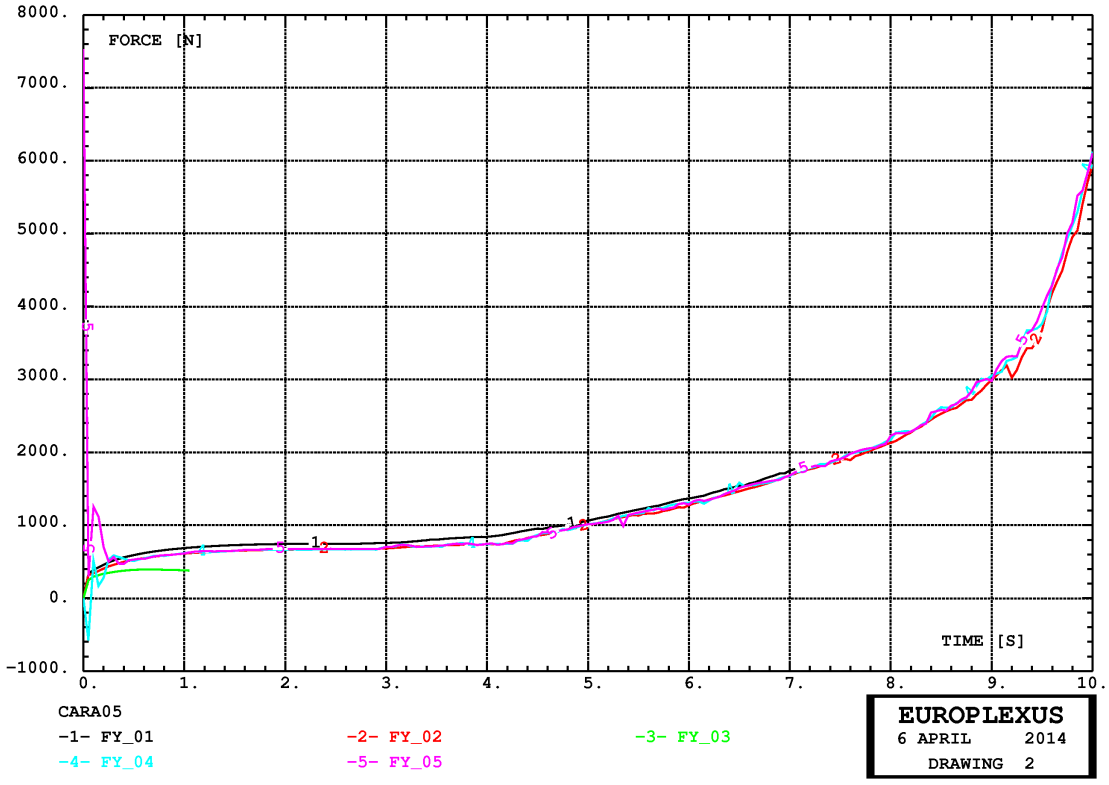


Figure 39 - Crushing forces in cases CARA02, CARA03, CARA04 and CARA05

In the next three solutions, a constant crushing velocity is imposed instead of a (nearly) linear imposed displacement. Moreover, all nodes of the upper surface of the upper plate have an initial velocity equal to the crushing velocity, so as to minimize the initial oscillations and jumps in the (upper) crushing force. Moreover, the lower-plate force is used in the plots rather than the upper one since initially it is more regular and after a very short period the two forces are identical anyway.

CARA06

This calculation is similar to test CARA04 (crushing velocity of 10 mm/s) but uses the Q42N fully-integrated 4-node quadrilateral for ALE formulation in solids. The calculation stopped at 0.96 s, i.e. almost at the final time of 1 s, because the Jacobian of an element became zero due to excessive local deformation.

Details of the solution are shown in Figures 40 to 43. The crushing forces are shown in Figures 44 and 45 and are similar to the previous solutions.

CARA07

This calculation is similar to test CARA06 but uses the Q42 fully-integrated 4-node quadrilateral for ALE formulation in solids. The calculation arrives at the final time of 1 s, in about the same steps and CPU time as the previous ones.

Details of the solution are shown in Figures 46 and 47. The crushing forces are shown in Figures 48 and 49 and are slightly higher (stiffer solution) the previous solutions.

CARA08

This calculation is similar to test CARA06 but uses the Q41 reduced-integrated 4-node quadrilateral for ALE formulation in solids. The calculation was plagued by strong mechanisms and stopped at 0.13 s, see Figure 40.

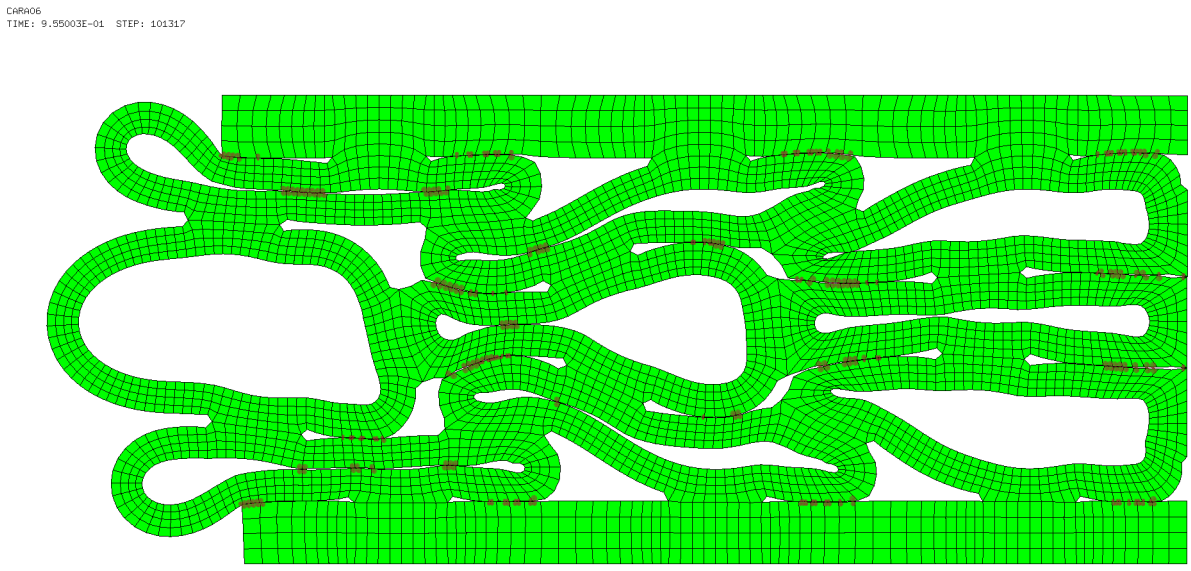


Figure 40 - Near-final mesh with contacts in case CARA06

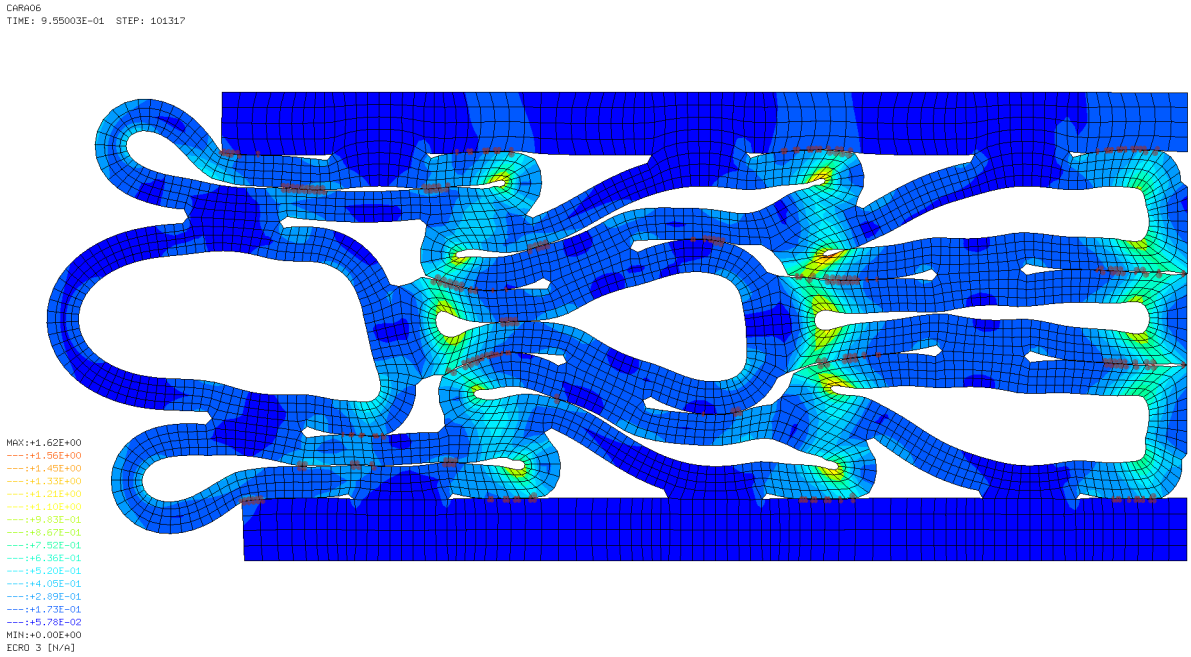


Figure 41 - Near-final plastic strains in case CARA06

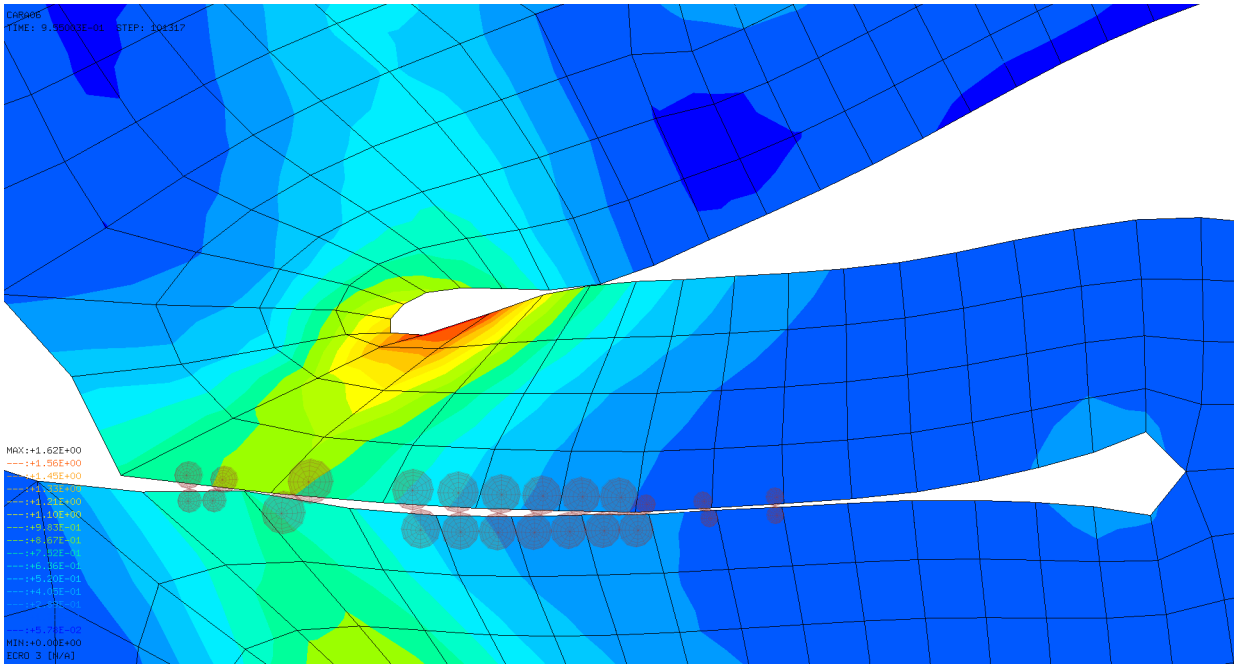


Figure 42 - Near-final plastic strains in case CARA06 (detail)

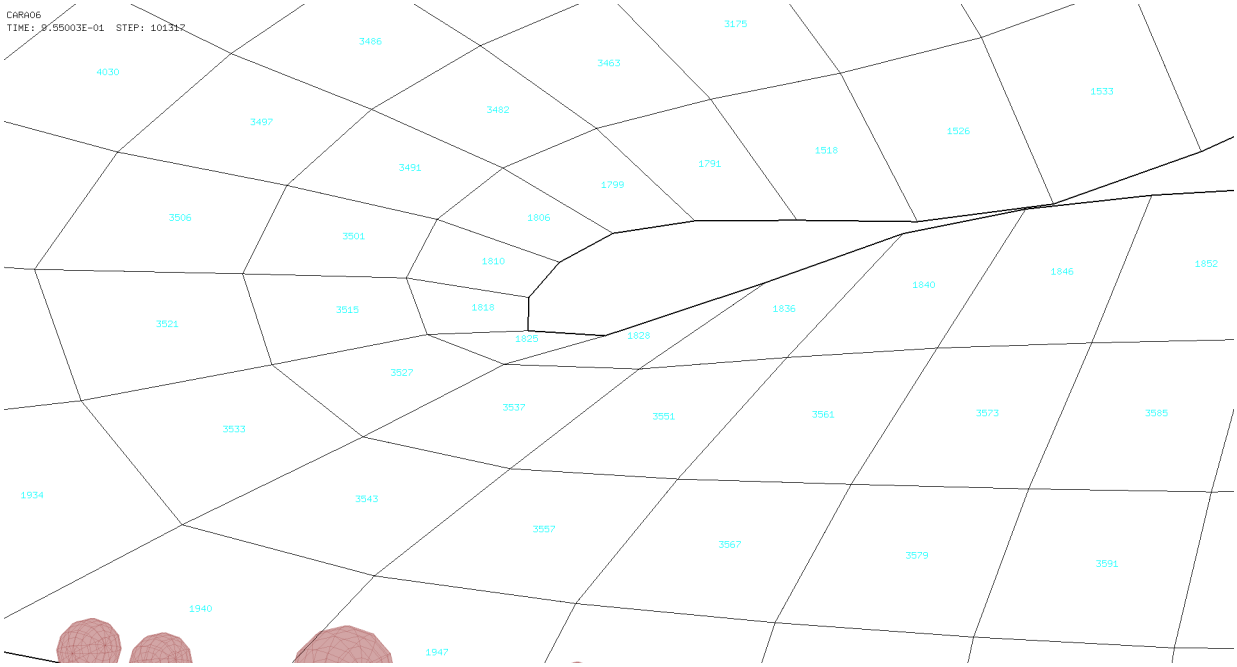


Figure 43 - Excessively deformed element in case CARA06

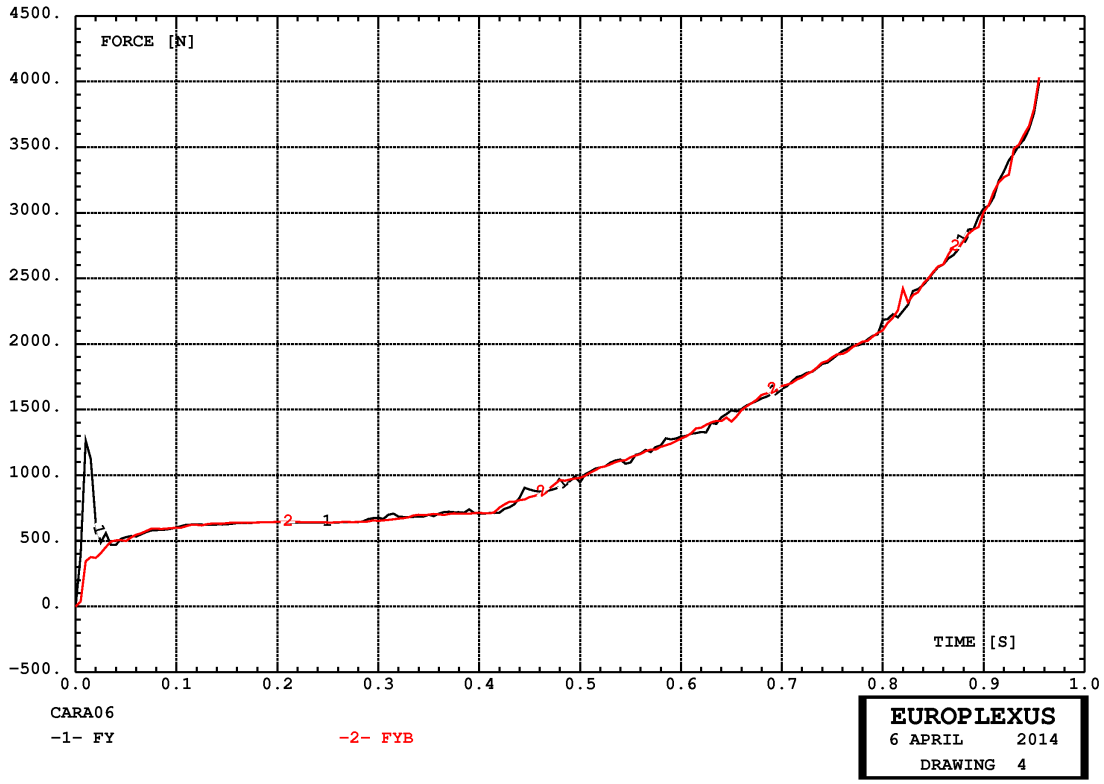


Figure 44 - Upper and lower plate forces in case CARA06

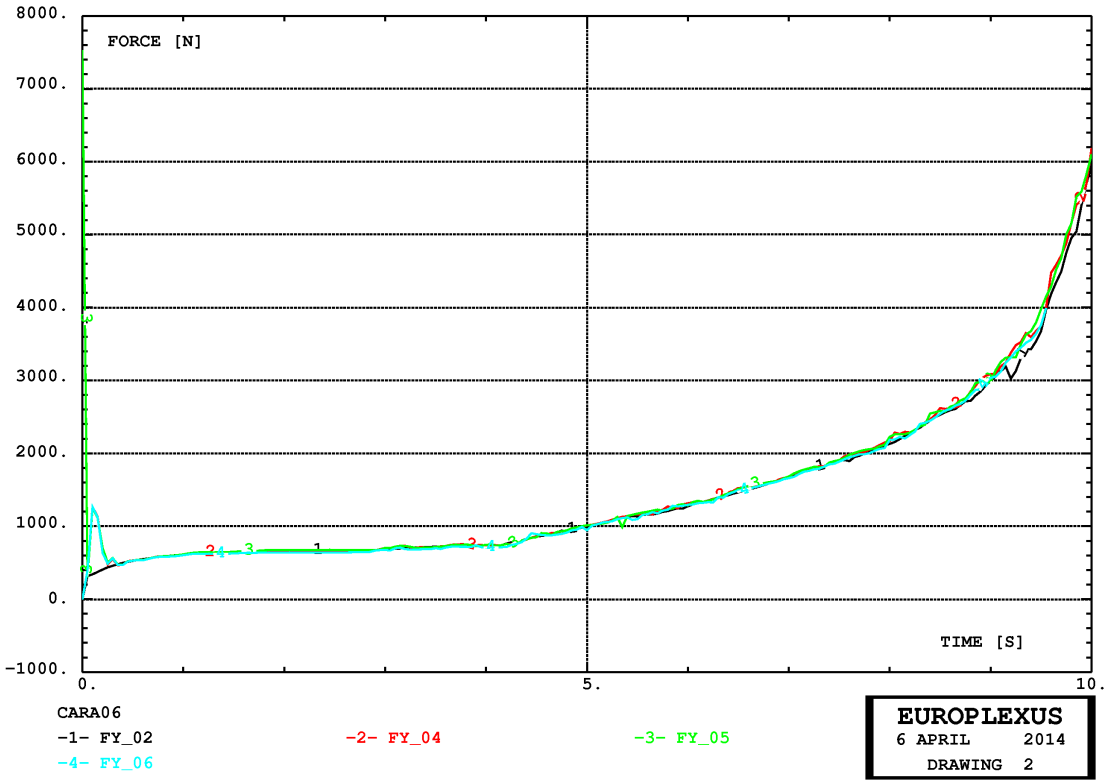


Figure 45 - Crushing forces in cases CARA02, CARA04, CARA05 and CARA06

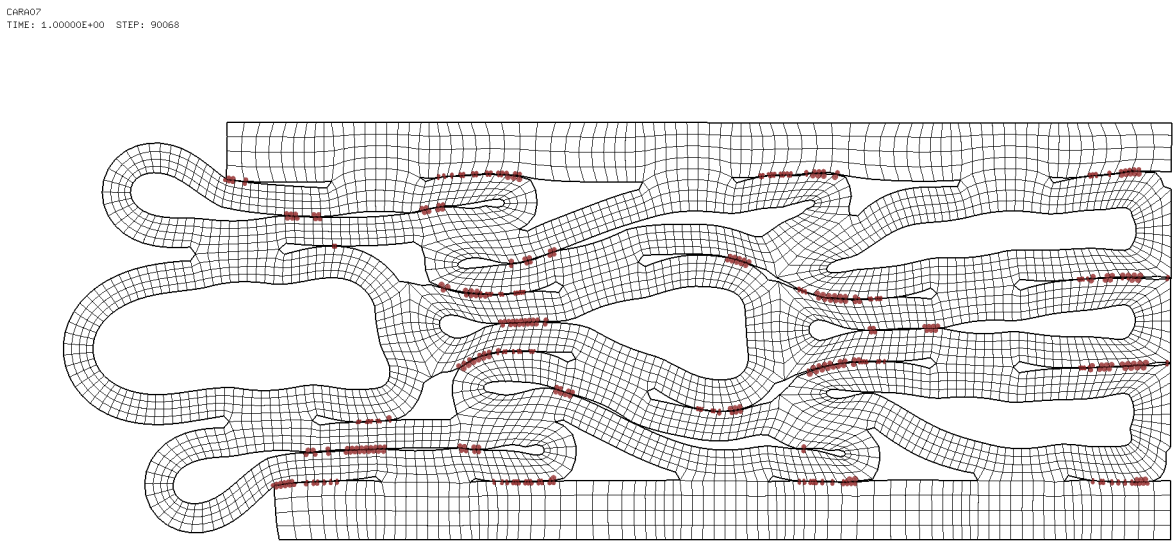


Figure 46 - Final mesh with contacts in case CARA07

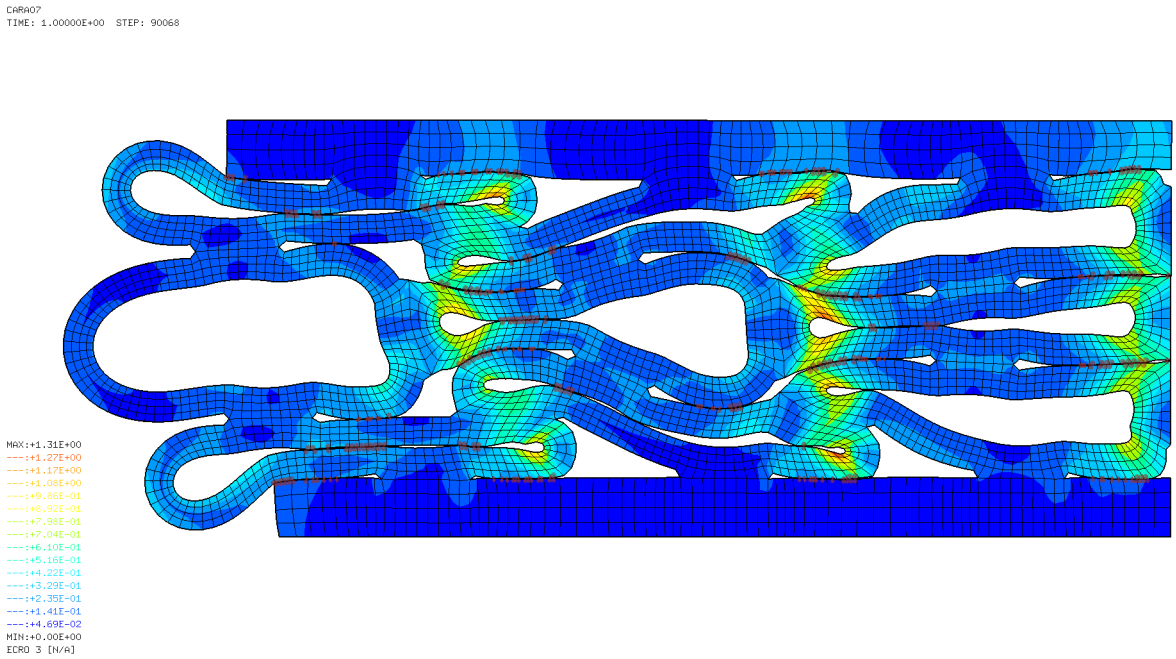


Figure 47 - Final plastic strains in case CARA07

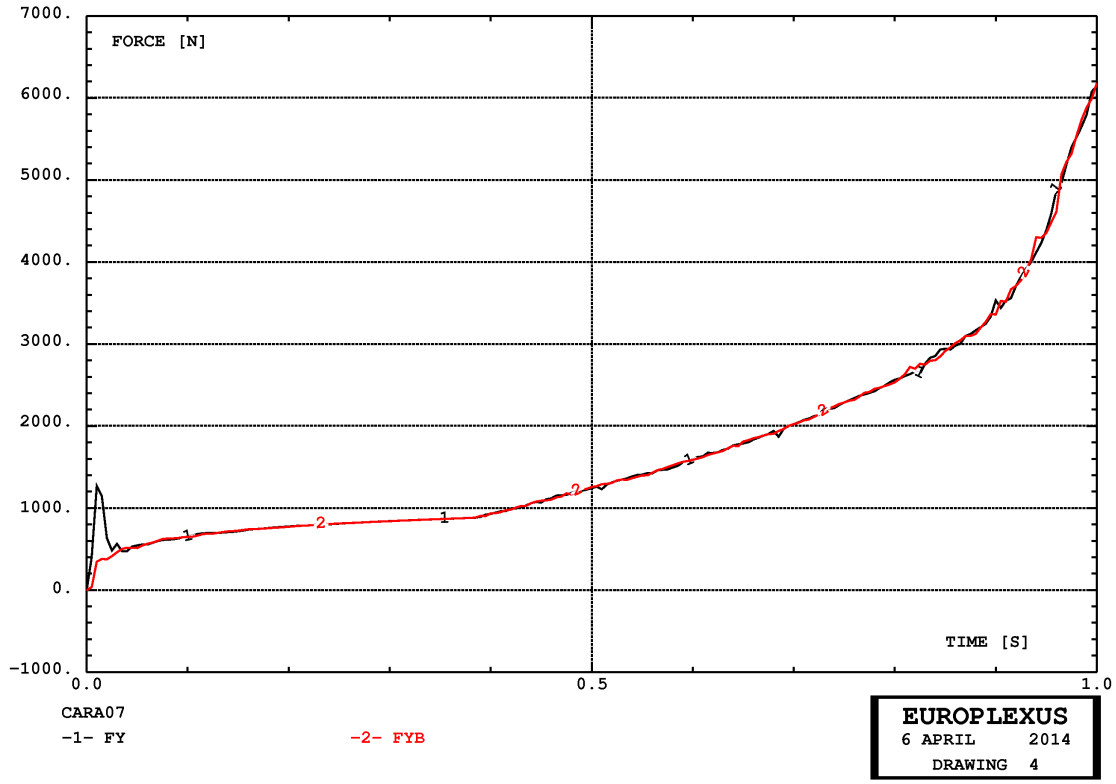


Figure 48 - Upper and lower plate forces in case CARA07

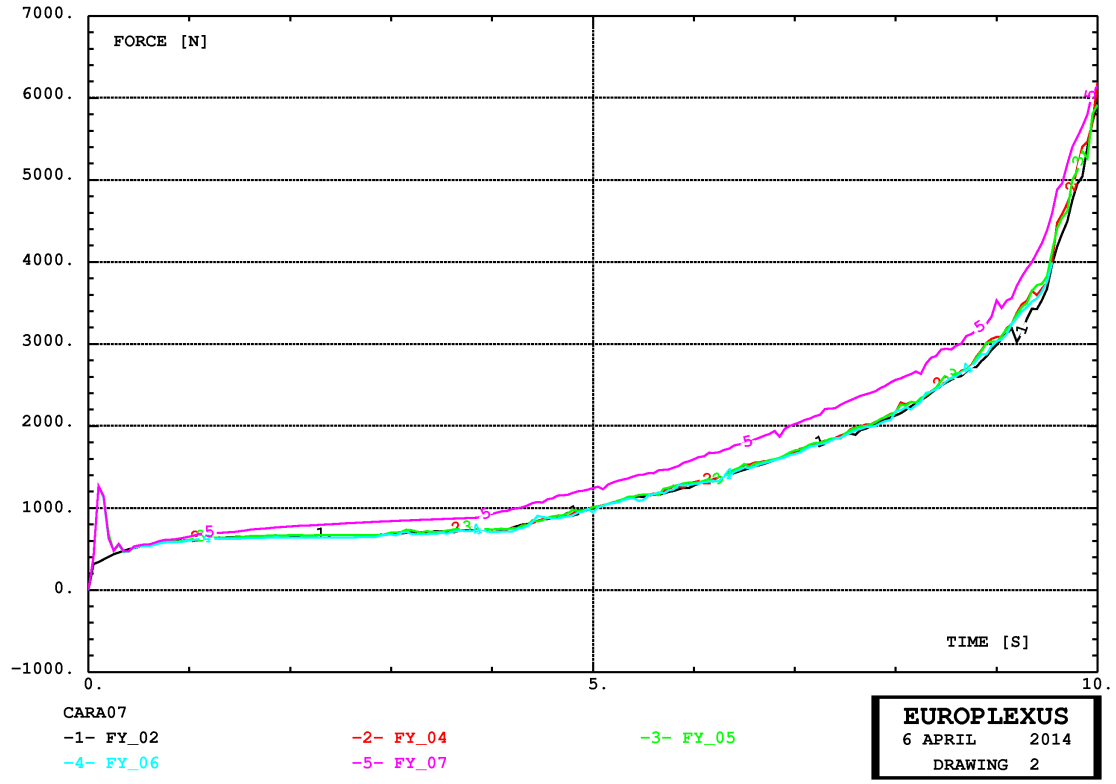


Figure 49 - Crushing forces in cases CARA02, CARA04, CARA05, CARA06 and CARA07

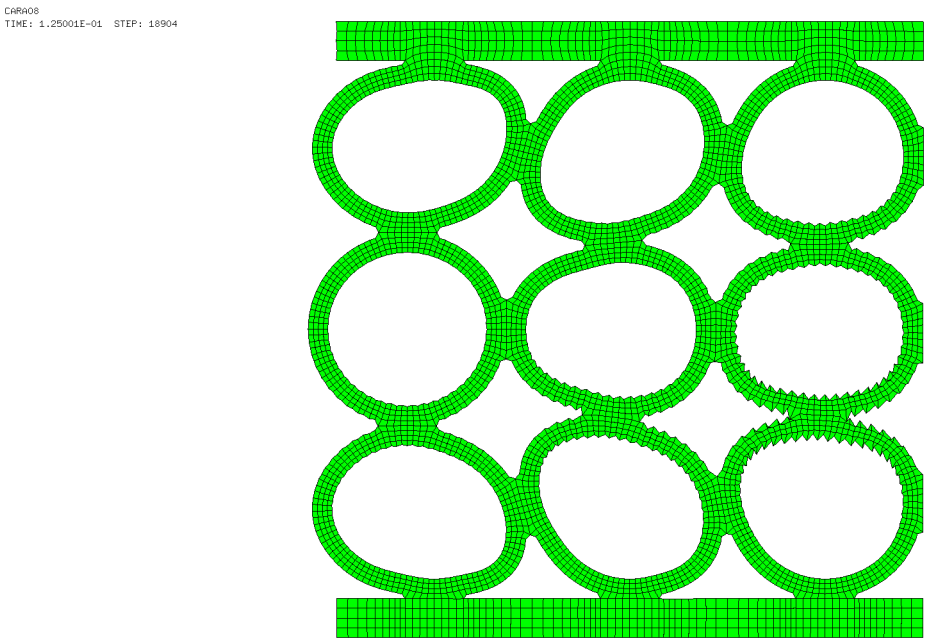


Figure 50 - Deformed mesh with mechanisms in case CARA08

2.3 Solutions with Q93 and phantom elements for the contact

As mentioned in the Introduction, one way of modeling contact in elements which are not capable of hosting pinballs (such as the parabolic elements, *prior to the present work*) is to use a “ghost” or “phantom” mesh of other elements (allowing for pinballs) in addition to the elements used to model the actual structure.

The ghost mesh is simply superposed to the physical mesh, and the nodes of the two meshes are merged. For example, in the Cast3m mesh generator one would “eliminate” the (repeated) nodes of the two meshes by giving a small tolerance `tol`:

```
elim tol (mesh1 et mesh2);
```

In this way, the (contact) forces applied to the ghost mesh are “felt” also by the physical mesh. The ghost mesh is assigned a `FANT` material with zero density in EUROPLEXUS. This means that the ghost elements are not calculated during the transient, i.e. their internal forces are always zero.

The only purpose of the ghost elements is to detect the contact. Pinballs are assigned to the ghost elements in the normal way.

This technique is fully general and can be used in different ways.

Let us consider a first example. EUROPLEXUS currently lacks a directive for associating pinballs to the nodes, rather than to the elements. However, this can be done by the following strategy (we assume Cast3m as pre-processor for simplicity). Let us say that we want to assign pinballs of a given (small) diameter D to all nodes on the surface of a 3D projectile named `proj`, and meshed by continuum elements. Then in Cast3m:

```
surproj = ENVE proj;

projnod = CHAN POI1 surproj;
```

The first command extracts the “envelope” of the (solid) projectile, resulting in a surface mesh made (for example) of triangles and quadrangles. The second command generates a mesh of material point elements (single-node elements) occupying the nodes of the surface.

Once read the mesh in EUROPLEXUS, we assign PMAT (material point one-node) elements to the `projnod` object. Next, we assign a diameter to these elements in the `COMP EPAI` directive: note that this is only for visualization of the nodes, and is not used for the contact. Next, we assign a `FANT` material with zero density to these elements. Finally, we assign pinballs of the desired diameter D to these “elements” (in fact, to the nodes). Since these elements possess just one node, the diameter of the associated pinball is fixed and hierarchic pinballs cannot be used with them.

Returning now to the case of interest here, there are several ways in which one can use the ghost mesh technique. Some possibilities are illustrated in Figure 51.

In the top part of the Figure, we use linear 4-node quadrilaterals as ghost elements. Two such elements, labeled Q4_1 and Q4_2, respectively, are superposed and merged with the nine-node element considered, covering the “quadrants” of the element adjacent to the face possibly subjected to contact. These elements and the corresponding (parent) pinballs are drawn in cyan and magenta, respectively, for clearness. Of course, to increase the precision of contact detection one could use hierarchic pinballs. All the options for “normal” pinballs are available.

In the bottom part of the Figure, we use linear 2-node (segment) elements as ghosts. They are attached to the bottom face of the Q9 element. Again only the associated parent pinballs are shown, but of course one should in this case prescribe a thickness associated with these pinballs in order to increase contact detection accuracy.

Yet another possibility (not shown) would be that of placing pinballs only at the nodes by using the PMAT as ghost elements, as explained previously. In this case, however, contact could be overlooked if the diameter of such pinballs is too small. Normally in such cases one would have to assign nodal pinballs to one contacting surface and body or line pinballs to the other contacting surface, but this of course can be very difficult (if not impossible) in the present case because we are dealing with self-contact.

In the calculation of the ring crash problem with Q9 elements we have adopted the first technique shown in Figure 51, i.e. we have used quadrilaterals (Q41L) as ghost elements.

Generation of the parabolic elements mesh

A mesh composed of parabolic rather than linear elements can be directly generated in the Cast3m mesh generator as follows. First of all, in the declaration of the element types to be used one should take the parabolic type rather than the linear type. In our 2D case, this means `OPTI ELEM QUA8` instead of `OPTI ELEM QUA4`.

Note that in this way 8-node quadrilaterals (and/or 6-node triangles) are generated, since Cast3m is primarily a static code and does not use the 9-node elements typical of dynamics. However, once a mesh composed of QUA8 (say `sur8`) has been generated, it is possible to transform it in QUA9 (by adding the central node), ready to be sent to EUROPLEXUS, using the `CHAN` command:

```
sur9 = CHAN QUA9 sur8;
```

In the present case we have chosen not to generate the mesh anew, but to convert the existing QUA4 4-node mesh used in test QUA401 of Section 2.1 into a QUA9 mesh with the same number of ele-

ments (i.e., each QUA4 is transformed into an equivalent QUA9). Thus, not only central but also mid-side nodes should be generated and added and the above mentioned technique based on the `CHAN` operator cannot be used for this.

To this end, two Gibiane procedures have been written (listed in the Appendix):

- `pxq42q92.proc` takes a single QUA4 element (4 nodes) in input, generates 4 new mid-side nodes and a central node and outputs a single QUA9 element.
- `pxq92q4.proc` takes a single QUA9 element in input and generates four new QUA4 elements, one for each “quadrant” of the QUA9. This procedure can be used to generate the phantom elements for the contact.

Then, we have proceeded as follows (see file `readq4.dgibi` in the Appendix):

- The QUA4 mesh (in free format in file QUA401.epx) has been extracted from the input file and set in the so-called “write” format of Cast3m in a file called `mesh4.write`. This means simply adding an initial line giving the space dimension (2) and the total number of nodes (4948), then the list of x and y coordinates of nodal points (4948 lines), then a line specifying the number of nodes per element (4), the number of elements (4080) and the element type (QUA4), and finally the element connectivity, i.e. 4080 lines, each containing the four node indexes of an element.
- The mesh (`sur4`) has been read into Cast3m by means of the `READ` operator (note that the `READ` and `WRITE` operators have been developed in the JRC version of Cast3m and are only available in this version).
- An equivalent QUA9 mesh `sur9` has been obtained by the `pxq42q92` procedure applied to each QUA4 element in a loop. Duplicated nodes are simply removed by Cast3m’s `ELIM` operator.
- The “external” elements of the sur9 mesh, i.e. those having at least one side on the mesh envelope, have been extracted:

```
peau9 = CONT sur9;

elpeau9 = sur9 ELEM APPU LARG peau9;
```

- The ghost elements for contact have been obtained by transforming each `elpeau9` element into four QUA4 via the `pxq92q4` procedure.

The resulting QUA9 mesh and the corresponding ghost QUA4 mesh are shown in Figures 52 and 53. Note that with this technique, two layers of ghost QUA4 elements are produced along the surface of the structure mesh. Only one layer would suffice of course and the “internal” layer is redundant (as

long as there is no element failure and erosion). However, the two layers have been retained for simplicity of mesh generation.

Another simplification is that here a single `SELF` zone is declared for pinball contact, rather than distinguishing the 25 separate zones like in case QUA401. This drastically simplifies the contact input directive (but at the expense of some more laborious calculations for the code) and the risk of obtaining more spurious contacts than in case QUA401.

All performed calculations are summarized in Table 3.

Table 3 - Calculations of the structure crash problem by Q93 with ghost elements for contact

Case	Mesh	Notes	Steps	CPU [s]	Els*step
Q93_02	4080 Q93 + 7328 Q41L	1 PINB SELF DMIN 0.1 OPTI PINS GRID EQVF CNOR	1,595,017[a]	40,313	6.51×10^{9}

a. The calculation stopped at 9.1 s of physical time instead of 10 s due to an unexpected reboot of the PC

Q93_02

This calculation uses Q93 nine-node parabolic elements for the structure and Q41L four-node linear quadrilaterals for the ghost mesh, see Figure 53. The calculation was brutally stopped at 9.1 s of physical time instead of 10 s, due to an unexpected reboot of the computer (MS-Windows Update).

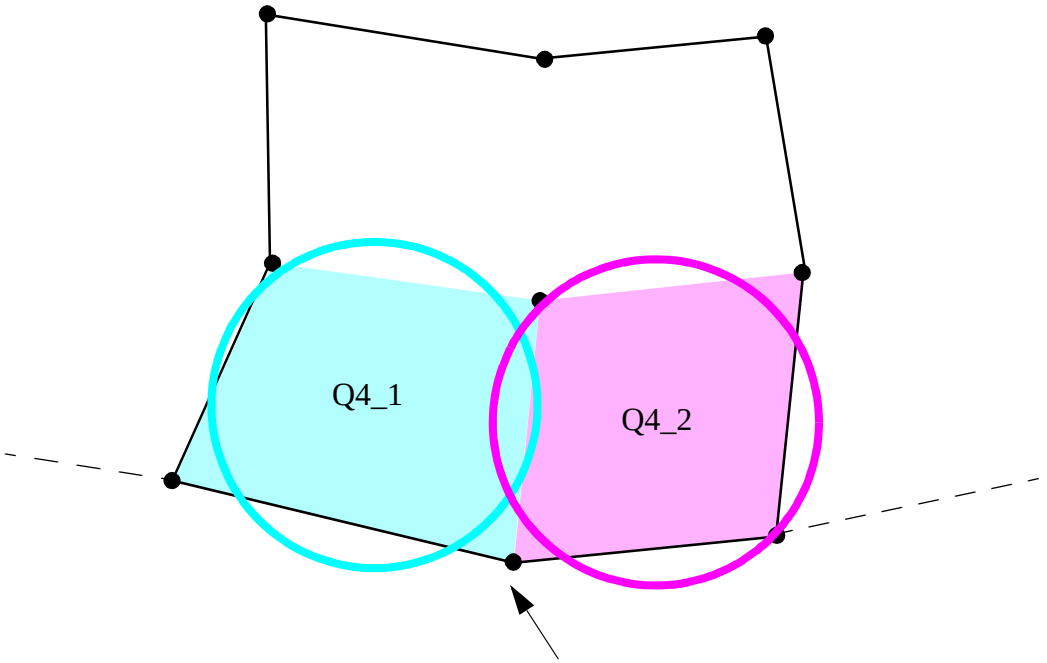
This calculation was considerably slower than the QUA401 calculation because, having replaced each QUA4 by a QUA9, the number of nodes and of Gauss points has more than doubled, and the stability step has halved.

The same minimum pinball diameter (`DMIN 0.1`) as in the QUA401 calculation has been kept, while it would have been probably more appropriate to halve it.

The additional option `EQVF` is an attempt to reduce the onset of spurious contacts between neighboring elements. The `CNOR` option should help reduce the redundancy of contact constraints, and use “smoother” normal approximations for the contact normal directions.

Figure 54 shows the progressive crushing of the structure until 9.1 s of physical time. Figure 55 shows the plastic strain distribution at 9.1 s. Note that, as indicated by the red arrow, some apparently parasitic plasticization takes place in the zone contained in the red circle (actually, in a single element). This element is subjected to strange vibrations during the test and plasticization occurs very early during the crushing process, and seems therefore completely non-physical. This phenomenon is currently under investigation, but see Section 4 for a possible explanation.

Figure 56 shows the final contacts at 9.1 s. Again, many spurious contacts occur, as highlighted in the zoom on the same Figure. This seems to be due to too large diameter of the pinballs. As anticipated, it would have been better to use `DMIN 0.05` instead of `DMIN 0.1`).



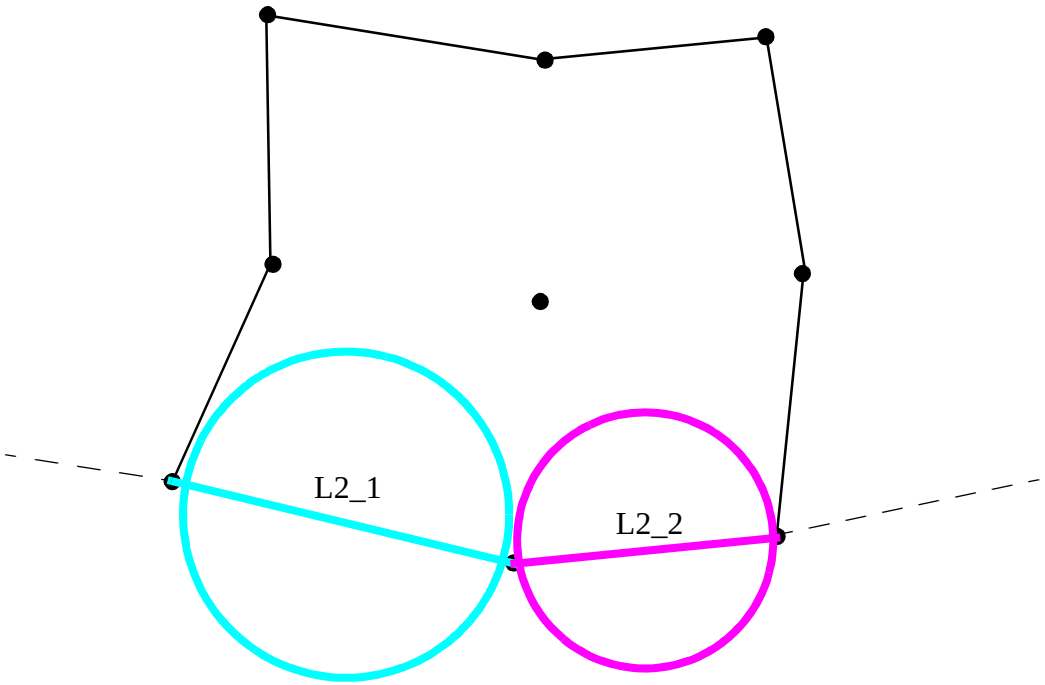
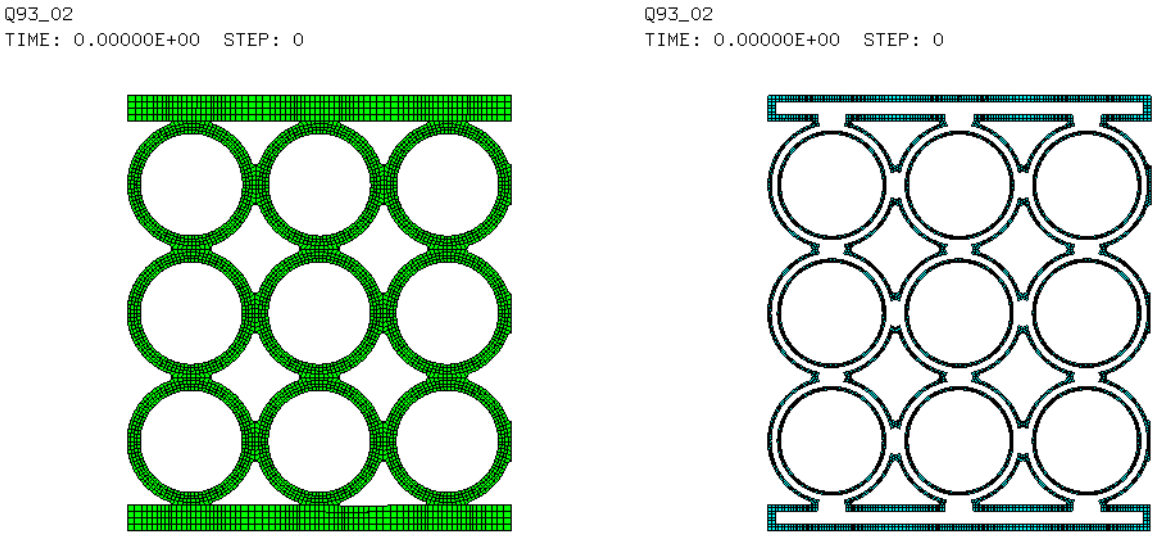
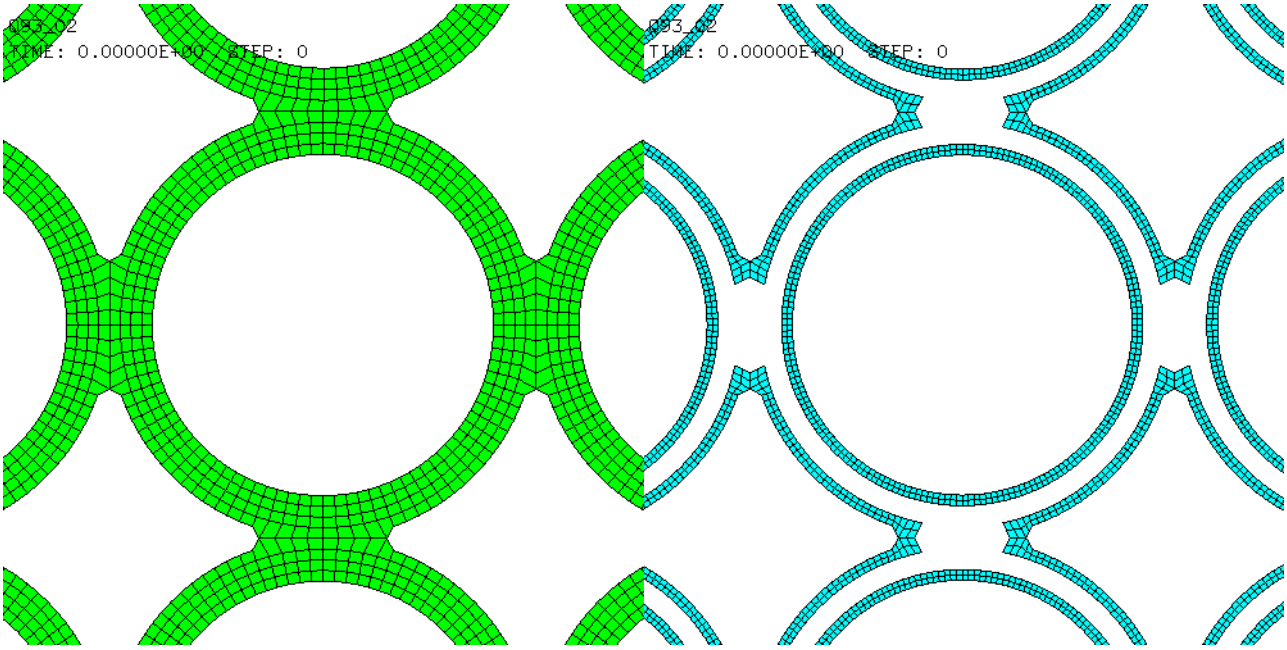


Figure 51 - Ghost mesh techniques to compute contact on parabolic elements



QUA9 mesh

QUA4 mesh (ghost)



zoom of the QUA9 and QUA4 meshes

Figure 52 - Structure and ghost meshes for case Q93_02

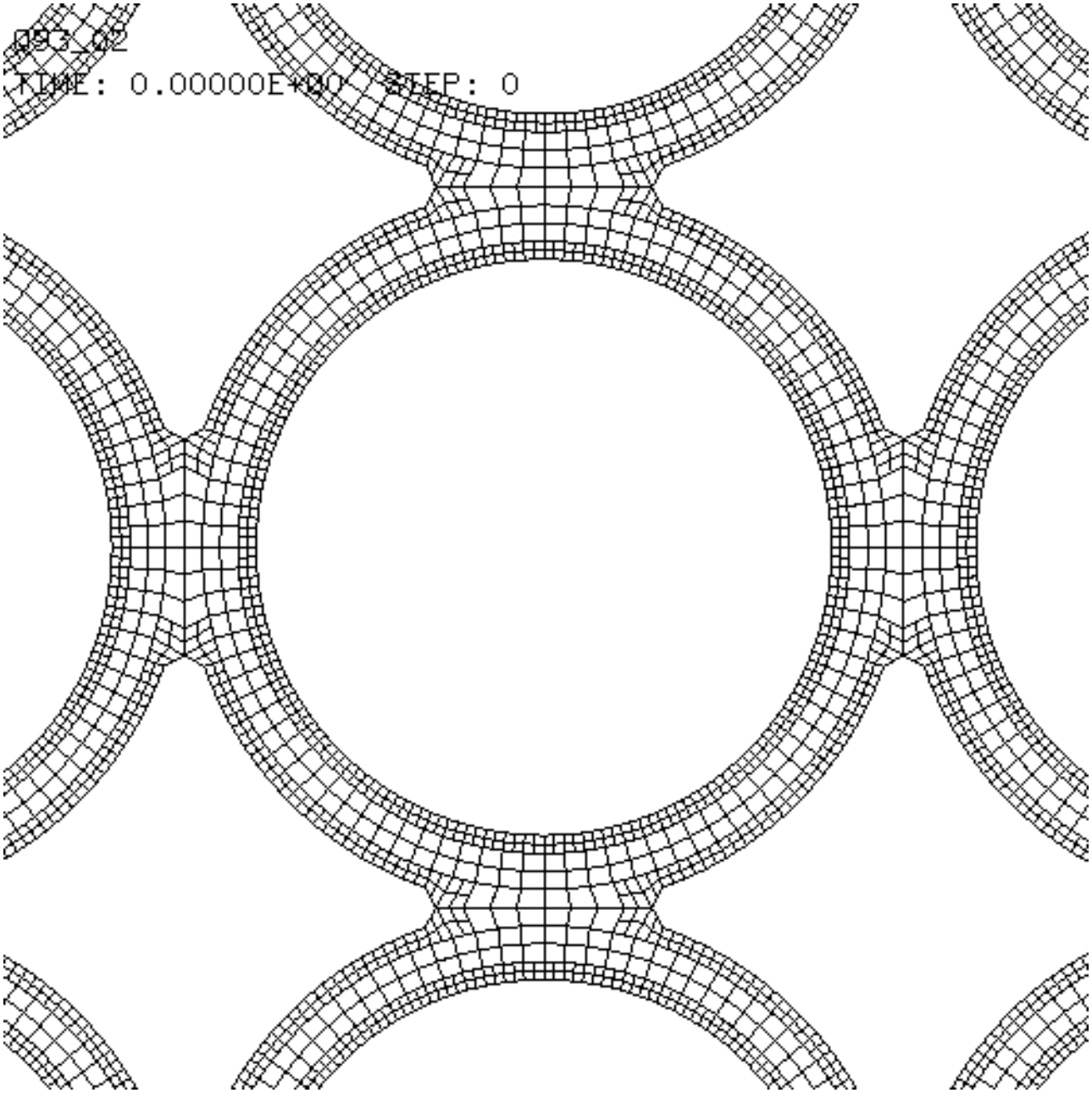


Figure 53 - Structure and ghost meshes superposed for test Q93_02

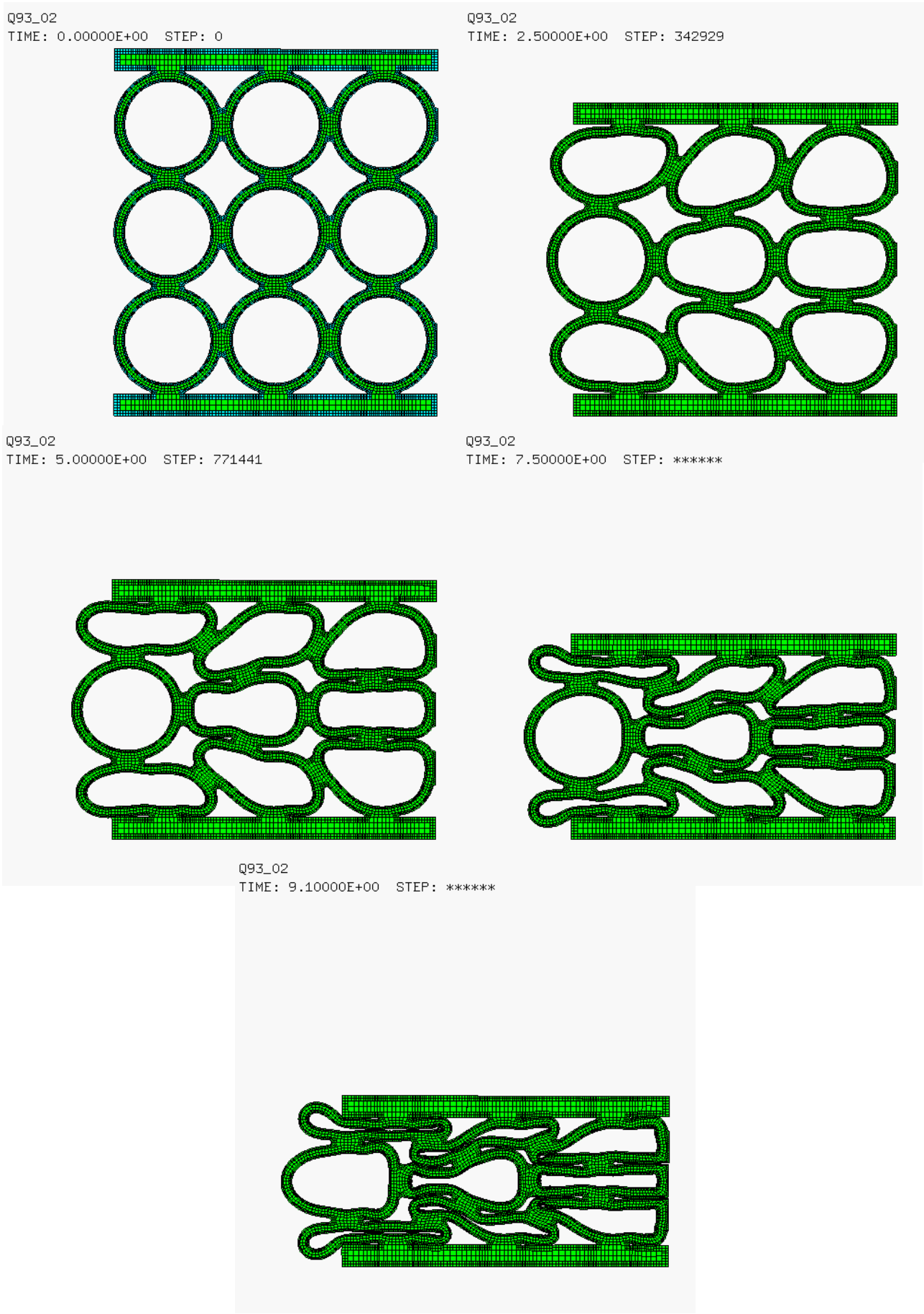


Figure 54 - Structure crushing in case Q93_02

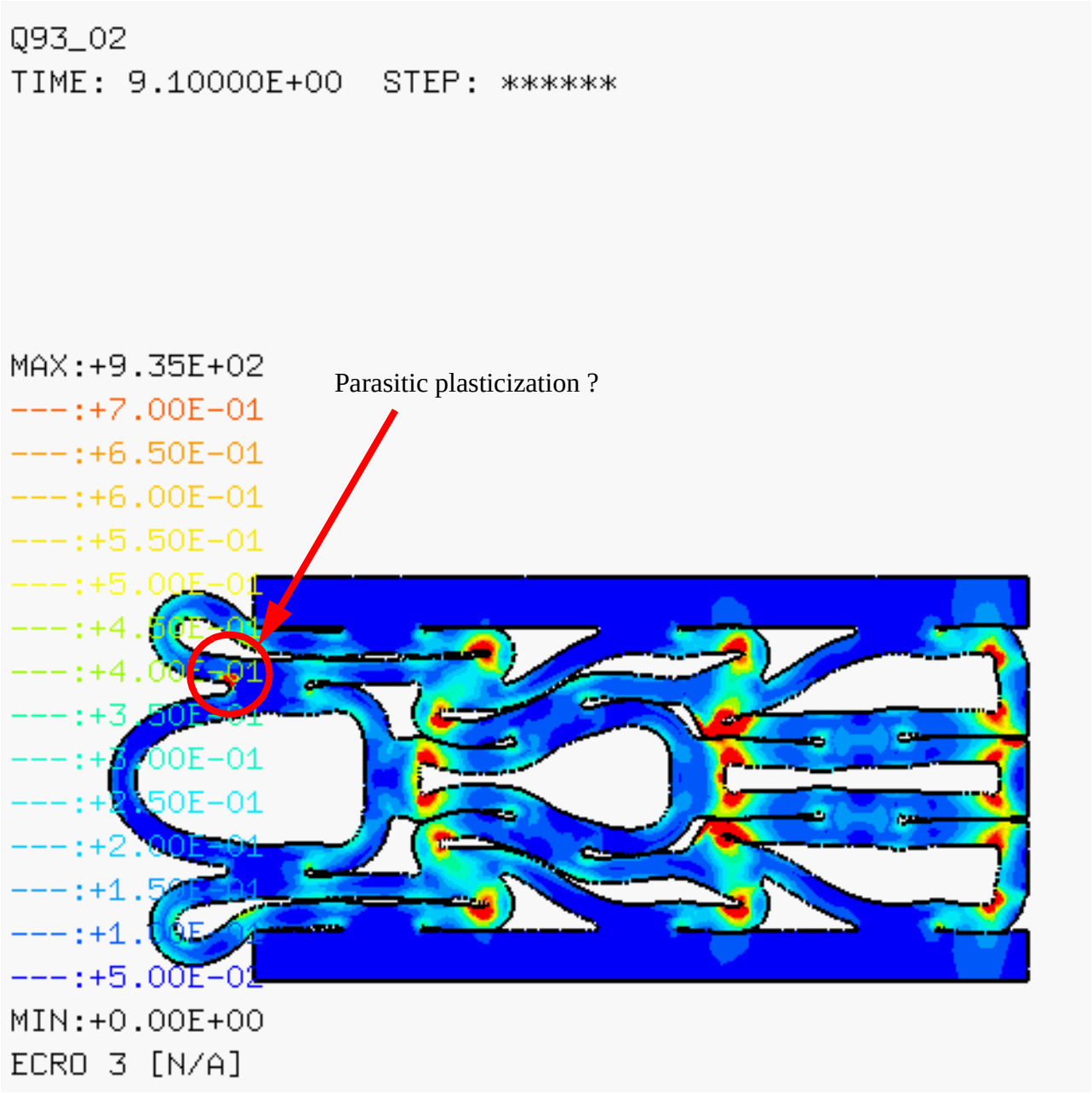


Figure 55 - Final plastic strain (at 9.1 s) in case Q93_02

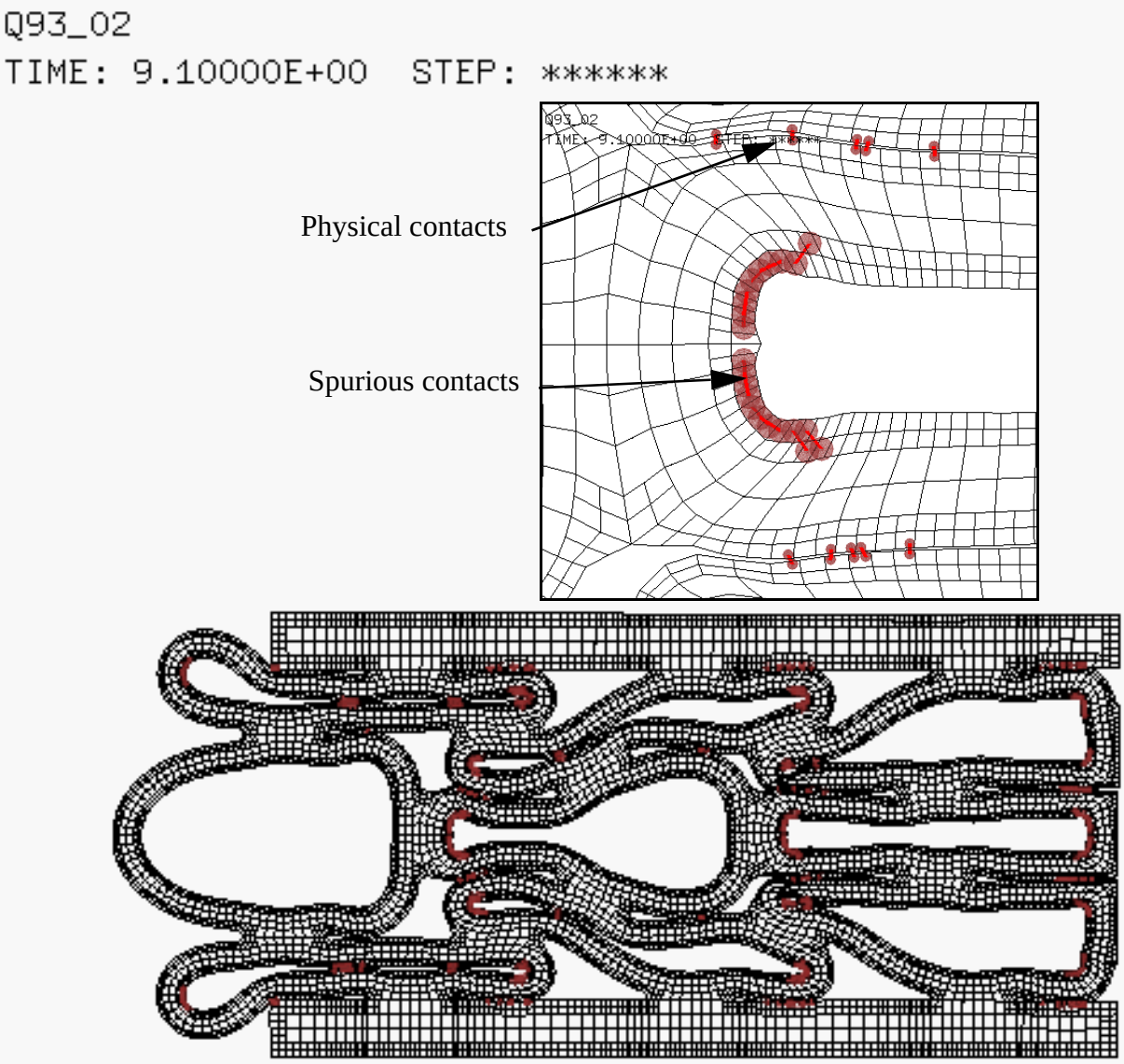


Figure 56 - Final contacts (at 9.1 s) in case Q93_02

Finally, Figure 57 compares the crushing force of case Q93_02 with the result of case QUA401. The Q9 solution exhibits some strong oscillations towards the end of the transient. These are possibly due to the parasitic contacts and will have to be analyzed. In any case, the force intensity is much lower than in the QUA4 case and in better accordance with experimentally observed values.

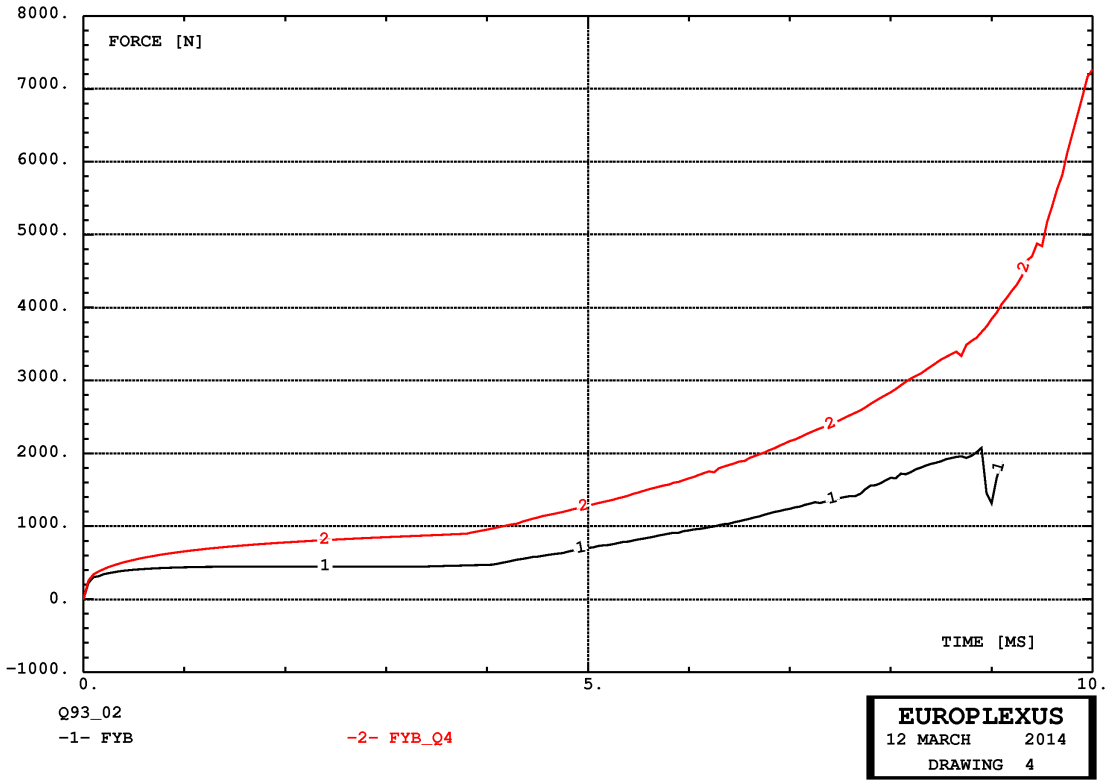


Figure 57 - Crushing force vs. imposed displacement in cases CAR401 and Q93_02

3. Pinball formulation for parabolic elements

We present now the native pinball formulation for parabolic elements. In 2D, the Q9 (continuum) element shape, i.e. the 9-node quadrilateral, will be considered. In 3D, the C27 (continuum) element shape, i.e. the 27-node hexahedron, will be considered, see [19] for details.

The pinballs construction for such elements is standard (see e.g. reference [13]), but we need to develop inverse mapping routines for such elements, in analogy with what had been done for the simpler (linear-displacement) element shapes, see references [17-18].

3.1 Inverse mapping for the parabolic 9-node quadrilateral in 2D space

The bi-parabolic quadrilateral in 2D space is shown in Figure 58. The element is one of the first implemented in EUROPLEXUS and dates back to the eighties, having been first implemented in the EURDYN-2 code at JRC Ispra [20-22]. The element formulation is summarized in reference [19]. However, the actual local numbering of the element nodes implemented in EUROPLEXUS is *not* the one mentioned in [19] (first the corner nodes, then the mid-sides and finally the central node), but the one shown in Figure 58, i.e. *circular* numbering (in order to make it compatible with the QUA9 element shape of the Cast3m pre-processor). With the numbering of Figure 58 the shape functions are:

$$
\begin{aligned}
N_1(\xi,\eta) &= \frac{1}{4}\xi\eta(\xi-1)(\eta-1) & N_5(\xi,\eta) &= \frac{1}{4}\xi\eta(\xi+1)(\eta+1)\\
N_2(\xi,\eta) &= \frac{1}{2}\eta(1-\xi^2)(\eta-1) & N_6(\xi,\eta) &= \frac{1}{2}\eta(1-\xi^2)(\eta+1)\\
N_3(\xi,\eta) &= \frac{1}{4}\xi\eta(\xi+1)(\eta-1) & N_7(\xi,\eta) &= \frac{1}{4}\xi\eta(\xi-1)(\eta+1)\\
N_4(\xi,\eta) &= \frac{1}{2}\xi(\xi+1)(1-\eta^2) & N_8(\xi,\eta) &= \frac{1}{2}\xi(\xi-1)(1-\eta^2)
\end{aligned}
\qquad (1)
$$

$$
N_9(\xi,\eta) = (1-\xi^2)(1-\eta^2)
$$

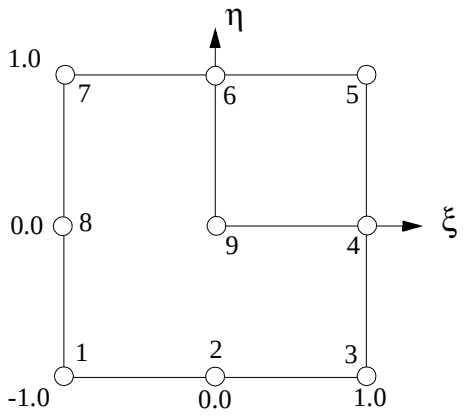


Figure 58 - The bi-parabolic 9-node 2D quadrilateral

and direct coordinate mapping is:

$$x = \sum_{I=1}^{9} N_I x_I \qquad ; \qquad y = \sum_{I=1}^{9} N_I y_I \tag{2}$$

By developing (2) with (1) we get:

$$\begin{aligned} F_1(\xi,\eta) &= a_1\xi^2\eta^2 + b_1\xi^2\eta + c_1\xi\eta^2 + d_1\xi\eta + e_1\xi^2 + f_1\eta^2 + g_1\xi + h_1\eta + i_1 - 4x = 0 \\ F_2(\xi,\eta) &= a_2\xi^2\eta^2 + b_2\xi^2\eta + c_2\xi\eta^2 + d_2\xi\eta + e_2\xi^2 + f_2\eta^2 + g_2\xi + h_2\eta + i_2 - 4y = 0 \end{aligned} \tag{3}$$

with:

$$\begin{aligned} a_1 &= x_1 - 2x_2 + x_3 - 2x_4 + x_5 - 2x_6 + x_7 - 2x_8 + 4x_9 & a_2 &= y_1 - 2y_2 + y_3 - 2y_4 + y_5 - 2y_6 + y_7 - 2y_8 + 4y_9 \\ b_1 &= -x_1 + 2x_2 - x_3 + x_5 - 2x_6 + x_7 & b_2 &= -y_1 + 2y_2 - y_3 + y_5 - 2y_6 + y_7 \\ c_1 &= -x_1 + x_3 - 2x_4 + x_5 - x_7 + 2x_8 & c_2 &= -y_1 + y_3 - 2y_4 + y_5 - y_7 + 2y_8 \\ d_1 &= x_1 - x_3 + x_5 - x_7 & d_2 &= y_1 - y_3 + y_5 - y_7 \\ e_1 &= 2x_4 + 2x_8 - 4x_9 & e_2 &= 2y_4 + 2y_8 - 4y_9 \\ f_1 &= 2x_2 + 2x_6 - 4x_9 & f_2 &= 2y_2 + 2y_6 - 4y_9 \\ g_1 &= 2x_4 - 2x_8 & g_2 &= 2y_4 - 2y_8 \\ h_1 &= -2x_2 + 2x_6 & h_2 &= -2y_2 + 2y_6 \\ i_1 &= 4x_9 & i_2 &= 4y_9 \end{aligned} \tag{4}$$

The system (3) being non-linear, it is not easy to be solved analytically. We prefer to resort to a numerical solution, obtained by the well-known Newton-Raphson iterative method. To this end, we re-formulate the problem by posing:

$$\underline{\chi} = \begin{bmatrix} \xi \\ \eta \end{bmatrix} \qquad ; \qquad \underline{F}(\underline{\chi}) = \begin{bmatrix} F_1(\xi,\eta) \\ F_2(\xi,\eta) \end{bmatrix} = \begin{bmatrix} F_1(\underline{\chi}) \\ F_2(\underline{\chi}) \end{bmatrix} \tag{5}$$

We search the value $\underline{\chi}^*$ of the independent variable for which we have $\underline{F}(\underline{\chi}^*) = \underline{0}$.

The Newton-Raphson method poses:

$$\underline{F}(\underline{\chi}) = \underline{F}(\underline{\chi}_0) + \left.\frac{\partial \underline{F}}{\partial \underline{\chi}}\right|_{\underline{\chi}_0} (\underline{\chi} - \underline{\chi}_0) \tag{6}$$

By imposing that $\underline{F}(\underline{\chi}) = \underline{0}$ we obtain:

$$\Delta\underline{\chi} = \underline{\chi} - \underline{\chi}_0 = \left[\left.\frac{\partial \underline{F}}{\partial \underline{\chi}}\right|_{\underline{\chi}_0}\right]^{-1} [\underline{0} - \underline{F}(\underline{\chi}_0)] . \tag{7}$$

The problem is solved iteratively:

1. Initialization: set $\xi_0 = 0$, $\eta_0 = 0$ (the centroid of the quadrilateral) so that $\underline{\chi}_0 = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$, and pose $\underline{\chi}^* = \underline{\chi}_0$.

2. Compute $\underline{F}(\underline{\chi}^*)$ and $\left.\dfrac{\partial \underline{F}}{\partial \underline{\chi}}\right|_{\underline{\chi}^*}$.

3. Compute $\Delta\underline{\chi} = \underline{\chi} - \underline{\chi}^* = \left[\left.\dfrac{\partial \underline{F}}{\partial \underline{\chi}}\right|_{\underline{\chi}^*}\right]^{-1} (\underline{0} - \underline{F}(\underline{\chi}^*))$.

4. Pose $\underline{\chi}^* \leftarrow \underline{\chi}^* + \Delta\underline{\chi}$.

5. Check for convergence: if $|\Delta\underline{\chi}| > \varepsilon$, then `goto 2`.

A graphical interpretation of this procedure for a function of only one variable is given in Figure 59.

From (5) and (3) we may write:

$$\frac{\partial \underline{F}}{\partial \underline{\chi}} = \begin{bmatrix} \dfrac{\partial F_1}{\partial \xi} & \dfrac{\partial F_1}{\partial \eta} \\ \dfrac{\partial F_2}{\partial \xi} & \dfrac{\partial F_2}{\partial \eta} \end{bmatrix} \tag{8}$$

or, equivalently:

$$\frac{\partial \underline{F}}{\partial \underline{\chi}} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \tag{9}$$

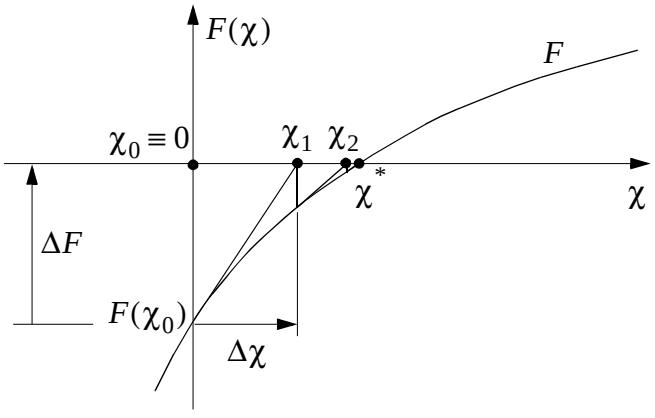


Figure 59 - The Newton-Raphson method for a function of one variable

having posed:

$$\begin{aligned}
\partial F_1/\partial\xi &= A = 2a_1\xi\eta^2 + 2b_1\xi\eta + c_1\eta^2 + d_1\eta + 2e_1\xi + g_1 \\
\partial F_1/\partial\eta &= B = 2a_1\xi^2\eta + b_1\xi^2 + 2c_1\xi\eta + d_1\xi + 2f_1\eta + h_1 \\
\partial F_2/\partial\xi &= C = 2a_2\xi\eta^2 + 2b_2\xi\eta + c_2\eta^2 + d_2\eta + 2e_2\xi + g_2 \\
\partial F_2/\partial\eta &= D = 2a_2\xi^2\eta + b_2\xi^2 + 2c_2\xi\eta + d_2\xi + 2f_2\eta + h_2
\end{aligned} \tag{10}$$

We obtain therefore:

$$\left[\frac{\partial F}{\partial \underline{\chi}}\right]^{-1} = \begin{bmatrix} \dfrac{\alpha_{11}}{\bar{D}} & \dfrac{\alpha_{21}}{\bar{D}} \\ \dfrac{\alpha_{12}}{\bar{D}} & \dfrac{\alpha_{22}}{\bar{D}} \end{bmatrix} \tag{11}$$

where:

$$\bar{D} = \det\begin{bmatrix} A & B \\ C & D \end{bmatrix} = AD - BC \qquad (\text{must be} \quad \neq 0\,!) \tag{12}$$

and:

$$\begin{aligned}
\alpha_{11} &= (-1)^{1+1}\cdot \text{cofactor}_{11} = D \\
\alpha_{12} &= (-1)^{1+2}\cdot \text{cofactor}_{12} = -C \\
\alpha_{21} &= (-1)^{2+1}\cdot \text{cofactor}_{21} = -B \\
\alpha_{22} &= (-1)^{2+2}\cdot \text{cofactor}_{22} = A
\end{aligned} \tag{13}$$

With (12) and (13), Eq. (11) becomes:

$$\left[\frac{\partial F}{\partial \underline{\chi}}\right]^{-1} = \frac{1}{AD - BC}\begin{bmatrix} D & -B \\ -C & A \end{bmatrix} \tag{14}$$

Then we may write:

$$\Delta\underline{\chi} = \underline{\chi} - \underline{\chi}^* = \begin{bmatrix} \xi \\ \eta \end{bmatrix} - \begin{bmatrix} \xi^* \\ \eta^* \end{bmatrix} = \begin{bmatrix} \xi - \xi^* \\ \eta - \eta^* \end{bmatrix} = -\frac{1}{AD - BC}\begin{bmatrix} D & -B \\ -C & A \end{bmatrix}\begin{bmatrix} F_1(\underline{\chi}^*) \\ F_2(\underline{\chi}^*) \end{bmatrix} \tag{15}$$

and finally:

$$\begin{aligned}
\xi - \xi^* = \Delta\xi &= -\frac{1}{AD - BC}[DF_1(\underline{\chi}^*) - BF_2(\underline{\chi}^*)] \\
\eta - \eta^* = \Delta\eta &= -\frac{1}{AD - BC}[-CF_1(\underline{\chi}^*) + AF_2(\underline{\chi}^*)]
\end{aligned} \tag{16}$$

3.2 Inverse mapping for the parabolic 27-node hexahedron in 3D space

The 27-node Lagrange parabolic element (C27) for 3D analysis in fast transient dynamics is shown in Figure 60 in the so-called parent element configuration, i.e. for normalized coordinates $-1 \le \xi \le 1$, $-1 \le \eta \le 1$, $-1 \le \zeta \le 1$. The local element numbering is as follows [19]: first the 8 vertex nodes, then the 6 (mid-)face nodes, then the 12 (mid-)corner nodes, and finally the central node.

The nodal shape functions $N_I(\xi, \eta, \zeta)$, $I = 1, \ldots, 27$ are obtained by blending of the 1-D parabolic shape functions $L_K(\delta)$, $K = 1, \ldots, 3$ given by (17):

$$\begin{aligned} L_1(\delta) &= \frac{1}{2}\delta(\delta - 1) = \frac{\delta^2}{2} - \frac{\delta}{2} \\ L_2(\delta) &= (1 + \delta)(1 - \delta) = 1 - \delta^2, \\ L_3(\delta) &= \frac{1}{2}\delta(\delta + 1) = \frac{\delta^2}{2} + \frac{\delta}{2} \end{aligned} \tag{17}$$

and result in the following expressions. For the 8 vertex nodes:

$$\begin{aligned} N_1(\xi, \eta, \zeta) &= L_1(\xi)L_1(\eta)L_1(\zeta) & N_5(\xi, \eta, \zeta) &= L_1(\xi)L_1(\eta)L_3(\zeta) \\ N_2(\xi, \eta, \zeta) &= L_3(\xi)L_1(\eta)L_1(\zeta) & N_6(\xi, \eta, \zeta) &= L_3(\xi)L_1(\eta)L_3(\zeta) \\ N_3(\xi, \eta, \zeta) &= L_3(\xi)L_3(\eta)L_1(\zeta) & N_7(\xi, \eta, \zeta) &= L_3(\xi)L_3(\eta)L_3(\zeta) \\ N_4(\xi, \eta, \zeta) &= L_1(\xi)L_3(\eta)L_1(\zeta) & N_8(\xi, \eta, \zeta) &= L_1(\xi)L_3(\eta)L_3(\zeta) \end{aligned} \tag{18}$$

For the 6 face nodes:

$$\begin{aligned} N_9(\xi, \eta, \zeta) &= L_2(\xi)L_2(\eta)L_1(\zeta) & N_{12}(\xi, \eta, \zeta) &= L_2(\xi)L_3(\eta)L_2(\zeta) \\ N_{10}(\xi, \eta, \zeta) &= L_2(\xi)L_1(\eta)L_2(\zeta) & N_{13}(\xi, \eta, \zeta) &= L_1(\xi)L_2(\eta)L_2(\zeta) \\ N_{11}(\xi, \eta, \zeta) &= L_3(\xi)L_2(\eta)L_2(\zeta) & N_{14}(\xi, \eta, \zeta) &= L_2(\xi)L_2(\eta)L_3(\zeta) \end{aligned} \tag{19}$$

For the 12 corner nodes:

$$\begin{aligned} N_{15}(\xi, \eta, \zeta) &= L_2(\xi)L_1(\eta)L_1(\zeta) & N_{21}(\xi, \eta, \zeta) &= L_3(\xi)L_3(\eta)L_2(\zeta) \\ N_{16}(\xi, \eta, \zeta) &= L_3(\xi)L_2(\eta)L_1(\zeta) & N_{22}(\xi, \eta, \zeta) &= L_1(\xi)L_3(\eta)L_2(\zeta) \\ N_{17}(\xi, \eta, \zeta) &= L_2(\xi)L_3(\eta)L_1(\zeta) & N_{23}(\xi, \eta, \zeta) &= L_2(\xi)L_1(\eta)L_3(\zeta) \\ N_{18}(\xi, \eta, \zeta) &= L_1(\xi)L_2(\eta)L_1(\zeta) & N_{24}(\xi, \eta, \zeta) &= L_3(\xi)L_2(\eta)L_3(\zeta) \\ N_{19}(\xi, \eta, \zeta) &= L_1(\xi)L_1(\eta)L_2(\zeta) & N_{25}(\xi, \eta, \zeta) &= L_2(\xi)L_3(\eta)L_3(\zeta) \\ N_{20}(\xi, \eta, \zeta) &= L_3(\xi)L_1(\eta)L_2(\zeta) & N_{26}(\xi, \eta, \zeta) &= L_1(\xi)L_2(\eta)L_3(\zeta) \end{aligned} \tag{20}$$

Finally, for the central node:

$$N_{27}(\xi, \eta, \zeta) = L_2(\xi)L_2(\eta)L_2(\zeta). \tag{21}$$

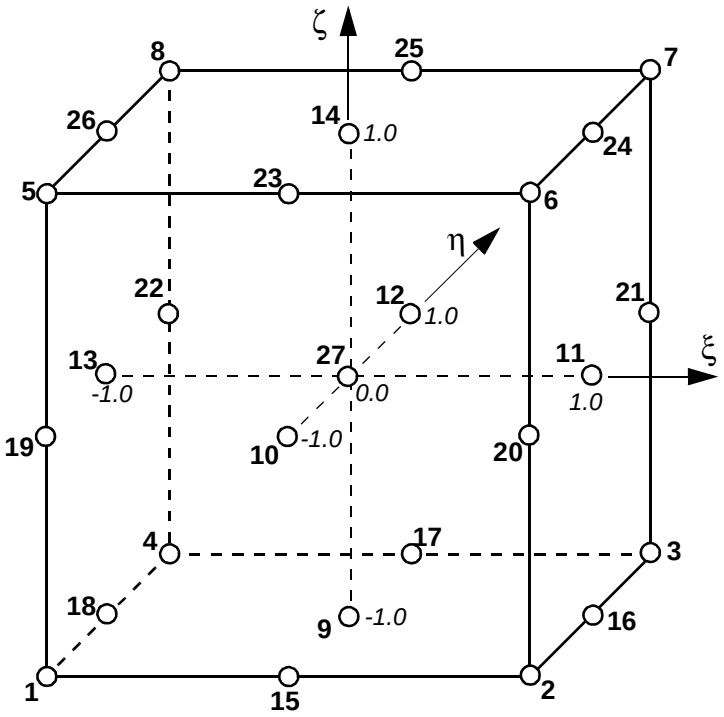


Figure 60 - The 27-node Lagrange parabolic element in 3D (C27)

The coordinate mapping is:

$$x = \sum_{I=1}^{27} N_I x_I \qquad ; \qquad y = \sum_{I=1}^{27} N_I y_I \qquad ; \qquad z = \sum_{I=1}^{27} N_I z_I \tag{22}$$

By developing (22) with (18-21) we get:

$$\begin{aligned}
F_1(\xi,\eta,\zeta) &= a_1\xi^2\eta^2\zeta^2 + b_1\xi^2\eta^2\zeta + c_1\xi^2\eta\zeta^2 + d_1\xi\eta^2\zeta^2 + e_1\xi^2\eta\zeta + f_1\xi\eta^2\zeta + g_1\xi\eta\zeta^2 + \\
&+ h_1\xi^2\eta^2 + i_1\xi^2\zeta^2 + j_1\eta^2\zeta^2 + k_1\xi\eta\zeta + l_1\xi^2\eta + m_1\xi^2\zeta + n_1\xi\eta^2 + o_1\xi\zeta^2 + \\
&+ p_1\eta^2\zeta + q_1\eta\zeta^2 + r_1\xi\eta + s_1\xi\zeta + t_1\eta\zeta + u_1\xi^2 + v_1\eta^2 + w_1\zeta^2 + X_1\xi + Y_1\eta + Z_1\zeta + A_1 - 8x = 0 \\
F_2(\xi,\eta,\zeta) &= a_2\xi^2\eta^2\zeta^2 + b_2\xi^2\eta^2\zeta + c_2\xi^2\eta\zeta^2 + d_2\xi\eta^2\zeta^2 + e_2\xi^2\eta\zeta + f_2\xi\eta^2\zeta + g_2\xi\eta\zeta^2 + \\
&+ h_2\xi^2\eta^2 + i_2\xi^2\zeta^2 + j_2\eta^2\zeta^2 + k_2\xi\eta\zeta + l_2\xi^2\eta + m_2\xi^2\zeta + n_2\xi\eta^2 + o_2\xi\zeta^2 + \\
&+ p_2\eta^2\zeta + q_2\eta\zeta^2 + r_2\xi\eta + s_2\xi\zeta + t_2\eta\zeta + u_2\xi^2 + v_2\eta^2 + w_2\zeta^2 + X_2\xi + Y_2\eta + Z_2\zeta + A_2 - 8y = 0 \\
F_3(\xi,\eta,\zeta) &= a_3\xi^2\eta^2\zeta^2 + b_3\xi^2\eta^2\zeta + c_3\xi^2\eta\zeta^2 + d_3\xi\eta^2\zeta^2 + e_3\xi^2\eta\zeta + f_3\xi\eta^2\zeta + g_3\xi\eta\zeta^2 + \\
&+ h_3\xi^2\eta^2 + i_3\xi^2\zeta^2 + j_3\eta^2\zeta^2 + k_3\xi\eta\zeta + l_3\xi^2\eta + m_3\xi^2\zeta + n_3\xi\eta^2 + o_3\xi\zeta^2 + \\
&+ p_3\eta^2\zeta + q_3\eta\zeta^2 + r_3\xi\eta + s_3\xi\zeta + t_3\eta\zeta + u_3\xi^2 + v_3\eta^2 + w_3\zeta^2 + X_3\xi + Y_3\eta + Z_3\zeta + A_3 - 8z = 0
\end{aligned} \tag{23}$$

where capital letters for the coefficients X_i, Y_i, Z_i $(i = 1, 2, 3)$ have been used in order to avoid confusion with the nodal coordinates x_I, y_I, z_I $(I = 1, \ldots, 27)$.

The 27 coefficients $a_1, \ldots, A_1$ are given by:

$$
\begin{aligned}
a_1 &= 4x_9 + x_8 + x_7 + x_6 + x_5 + x_4 + x_3 - 8x_{27} - 2x_{26} - 2x_{25} - 2x_{24} - 2x_{23} - 2x_{22} - 2x_{21} - 2x_{20} + x_2 - 2x_{19} - 2x_{18} - 2x_{17} - \\
&\quad 2x_{16} - 2x_{15} + 4x_{14} + 4x_{13} + 4x_{12} + 4x_{11} + 4x_{10} + x_1 \\
b_1 &= -4x_9 + x_8 + x_7 + x_6 + x_5 - x_4 - x_3 - 2x_{26} - 2x_{25} - 2x_{24} - 2x_{23} - x_2 + 2x_{18} + 2x_{17} + 2x_{16} + 2x_{15} + 4x_{14} - x_1 \\
c_1 &= x_8 + x_7 - x_6 - x_5 + x_4 + x_3 - 2x_{25} + 2x_{23} - 2x_{22} - 2x_{21} + 2x_{20} - x_2 + 2x_{19} - 2x_{17} + 2x_{15} + 4x_{12} - 4x_{10} - x_1 \\
d_1 &= -x_8 + x_7 + x_6 - x_5 - x_4 + x_3 + 2x_{26} - 2x_{24} + 2x_{22} - 2x_{21} - 2x_{20} + x_2 + 2x_{19} + 2x_{18} - 2x_{16} - 4x_{13} + 4x_{11} - x_1 \\
e_1 &= x_8 + x_7 - x_6 - x_5 - x_4 - x_3 - 2x_{25} + 2x_{23} + x_2 + 2x_{17} - 2x_{15} + x_1 \\
f_1 &= -x_8 + x_7 + x_6 - x_5 + x_4 - x_3 + 2x_{26} - 2x_{24} - x_2 - 2x_{18} + 2x_{16} + x_1 \\
g_1 &= -x_8 + x_7 - x_6 + x_5 - x_4 + x_3 + 2x_{22} - 2x_{21} + 2x_{20} - x_2 - 2x_{19} + x_1 \\
h_1 &= 8x_{27} + 2x_{22} + 2x_{21} + 2x_{20} + 2x_{19} - 4x_{13} - 4x_{12} - 4x_{11} - 4x_{10} \\
i_1 &= -4x_9 + 8x_{27} + 2x_{26} + 2x_{24} + 2x_{18} + 2x_{16} - 4x_{14} - 4x_{13} - 4x_{11} \\
j_1 &= -4x_9 + 8x_{27} + 2x_{25} + 2x_{23} + 2x_{17} + 2x_{15} - 4x_{14} - 4x_{12} - 4x_{10} \\
k_1 &= -x_8 + x_7 - x_6 + x_5 + x_4 - x_3 + x_2 - x_1 \\
l_1 &= 2x_{22} + 2x_{21} - 2x_{20} - 2x_{19} - 4x_{12} + 4x_{10} \\
m_1 &= 4x_9 + 2x_{26} + 2x_{24} - 2x_{16} - 4x_{14} - 2x_{18} \\
n_1 &= -2x_{22} + 2x_{21} + 2x_{20} - 2x_{19} + 4x_{13} - 4x_{11} \\
o_1 &= -2x_{26} + 2x_{24} - 2x_{18} + 2x_{16} + 4x_{13} - 4x_{11} \\
p_1 &= 4x_9 + 2x_{25} + 2x_{23} - 2x_{17} - 2x_{15} - 4x_{14} \\
q_1 &= 2x_{25} - 2x_{23} + 2x_{17} - 2x_{15} - 4x_{12} + 4x_{10} \\
r_1 &= -2x_{22} + 2x_{21} - 2x_{20} + 2x_{19} \\
s_1 &= -2x_{26} + 2x_{24} + 2x_{18} - 2x_{16} \\
t_1 &= 2x_{25} - 2x_{23} - 2x_{17} + 2x_{15} \\
u_1 &= -8x_{27} + 4x_{13} + 4x_{11} \\
v_1 &= -8x_{27} + 4x_{12} + 4x_{10} \\
w_1 &= 4x_9 - 8x_{27} + 4x_{14} \\
X_1 &= -4x_{13} + 4x_{11} \\
Y_1 &= 4x_{12} - 4x_{10} \\
Z_1 &= -4x_9 + 4x_{14} \\
A_1 &= 8x_{27}
\end{aligned}
\tag{24}
$$

The coefficients $a_2, \ldots, A_2$ and $a_3, \ldots, A_3$ are given by the same expressions (4) but with y_I or, respectively, z_I in place of x_I.

The system (23) being <u>non-linear</u>, it is not easy to be solved analytically. We prefer to resort to a numerical solution, obtained by the well-known Newton-Raphson iterative method. To this end, we re-formulate the problem by posing:

$$
\underline{\chi} = \begin{bmatrix} \xi \\ \eta \\ \zeta \end{bmatrix} \qquad ; \qquad \underline{F}(\underline{\chi}) = \begin{bmatrix} F_1(\xi, \eta, \zeta) \\ F_2(\xi, \eta, \zeta) \\ F_3(\xi, \eta, \zeta) \end{bmatrix} = \begin{bmatrix} F_1(\underline{\chi}) \\ F_2(\underline{\chi}) \\ F_3(\underline{\chi}) \end{bmatrix} \tag{25}
$$

We search the value $\underline{\chi}^*$ of the independent variable for which we have $\underline{F}(\underline{\chi}^*) = \underline{0}$.

The Newton-Raphson method poses:

$$\underline{F}(\underline{\chi}) = \underline{F}(\underline{\chi}_0) + \left.\frac{\partial \underline{F}}{\partial \underline{\chi}}\right|_{\underline{\chi}_0} (\underline{\chi} - \underline{\chi}_0) \tag{26}$$

By imposing that $\underline{F}(\underline{\chi}) = \underline{0}$ we obtain:

$$\Delta\underline{\chi} = \underline{\chi} - \underline{\chi}_0 = \left[\left.\frac{\partial \underline{F}}{\partial \underline{\chi}}\right|_{\underline{\chi}_0}\right]^{-1} [\underline{0} - \underline{F}(\underline{\chi}_0)] . \tag{27}$$

The problem is solved iteratively:

1. Initialization: set $\xi_0 = 0$, $\eta_0 = 0$, $\zeta = 0$ (the centroid of the hexahedron) so that $\underline{\chi}_0 = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$, and pose $\underline{\chi}^* = \underline{\chi}_0$.

2. Compute $\underline{F}(\underline{\chi}^*)$ and $\left.\frac{\partial \underline{F}}{\partial \underline{\chi}}\right|_{\underline{\chi}^*}$.

3. Compute $\Delta\underline{\chi} = \underline{\chi} - \underline{\chi}^* = \left[\left.\frac{\partial \underline{F}}{\partial \underline{\chi}}\right|_{\underline{\chi}^*}\right]^{-1} (\underline{0} - \underline{F}(\underline{\chi}^*))$.

4. Pose $\underline{\chi}^* \leftarrow \underline{\chi}^* + \Delta\underline{\chi}$.

5. Check for convergence: if $|\Delta\underline{\chi}| > \varepsilon$, then `goto` 2.

A graphical interpretation of this procedure for a function of only one variable is given in Figure 61.

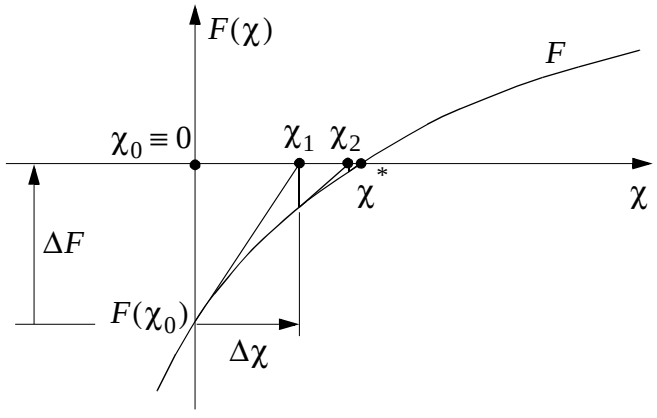


Figure 61 - The Newton-Raphson method for a function of one variable

From (25) and (23) we may write:

$$\frac{\partial \underline{\underline{F}}}{\partial \underline{\underline{\chi}}} = \begin{bmatrix} \frac{\partial F_1}{\partial \xi} & \frac{\partial F_1}{\partial \eta} & \frac{\partial F_1}{\partial \zeta} \\ \frac{\partial F_2}{\partial \xi} & \frac{\partial F_2}{\partial \eta} & \frac{\partial F_2}{\partial \zeta} \\ \frac{\partial F_3}{\partial \xi} & \frac{\partial F_3}{\partial \eta} & \frac{\partial F_3}{\partial \zeta} \end{bmatrix} \tag{28}$$

or, equivalently:

$$\frac{\partial \underline{\underline{F}}}{\partial \underline{\underline{\chi}}} = \begin{bmatrix} A & B & C \\ D & E & F \\ G & H & I \end{bmatrix} \tag{29}$$

having posed:

$$\begin{aligned}
\partial F_1/\partial\xi = A &= 2a_1\xi\eta^2\zeta^2 + 2b_1\xi\eta^2\zeta + 2c_1\xi\eta\zeta^2 + d_1\eta^2\zeta^2 + 2e_1\xi\eta\zeta + f_1\eta^2\zeta + g_1\eta\zeta^2 + \\
&+ 2h_1\xi\eta^2 + 2i_1\xi\zeta^2 + k_1\eta\zeta + 2l_1\xi\eta + 2m_1\xi\zeta + n_1\eta^2 + o_1\zeta^2 + r_1\eta + s_1\zeta + 2u_1\xi + X_1 \\
\partial F_1/\partial\eta = B &= 2a_1\xi^2\eta\zeta^2 + 2b_1\xi^2\eta\zeta + c_1\xi^2\zeta^2 + 2d_1\xi\eta\zeta^2 + e_1\xi^2\zeta + 2f_1\xi\eta\zeta + g_1\xi\zeta^2 + \\
&+ 2h_1\xi^2\eta + 2j_1\eta\zeta^2 + k_1\xi\zeta + l_1\xi^2 + 2n_1\xi\eta + 2p_1\eta\zeta + q_1\zeta^2 + r_1\xi + t_1\zeta + 2v_1\eta + Y_1 \\
\partial F_1/\partial\zeta = C &= 2a_1\xi^2\eta^2\zeta + b_1\xi^2\eta^2 + 2c_1\xi^2\eta\zeta + 2d_1\xi\eta^2\zeta + e_1\xi^2\eta + f_1\xi\eta^2 + 2g_1\xi\eta\zeta + \\
&+ 2i_1\xi^2\zeta + 2j_1\eta^2\zeta + k_1\xi\eta + m_1\xi^2 + 2o_1\xi\zeta + p_1\eta^2 + 2q_1\eta\zeta + s_1\xi + t_1\eta + 2w_1\zeta + Z_1 \\
\partial F_2/\partial\xi = D &= 2a_2\xi\eta^2\zeta^2 + 2b_2\xi\eta^2\zeta + 2c_2\xi\eta\zeta^2 + d_2\eta^2\zeta^2 + 2e_2\xi\eta\zeta + f_2\eta^2\zeta + g_2\eta\zeta^2 + \\
&+ 2h_2\xi\eta^2 + 2i_2\xi\zeta^2 + k_2\eta\zeta + 2l_2\xi\eta + 2m_2\xi\zeta + n_2\eta^2 + o_2\zeta^2 + r_2\eta + s_2\zeta + 2u_2\xi + X_2 \\
\partial F_2/\partial\eta = E &= 2a_2\xi^2\eta\zeta^2 + 2b_2\xi^2\eta\zeta + c_2\xi^2\zeta^2 + 2d_2\xi\eta\zeta^2 + e_2\xi^2\zeta + 2f_2\xi\eta\zeta + g_2\xi\zeta^2 + \\
&+ 2h_2\xi^2\eta + 2j_2\eta\zeta^2 + k_2\xi\zeta + l_2\xi^2 + 2n_2\xi\eta + 2p_2\eta\zeta + q_2\zeta^2 + r_2\xi + t_2\zeta + 2v_2\eta + Y_2 \\
\partial F_2/\partial\zeta = F &= 2a_2\xi^2\eta^2\zeta + b_2\xi^2\eta^2 + 2c_2\xi^2\eta\zeta + 2d_2\xi\eta^2\zeta + e_2\xi^2\eta + f_2\xi\eta^2 + 2g_2\xi\eta\zeta + \\
&+ 2i_2\xi^2\zeta + 2j_2\eta^2\zeta + k_2\xi\eta + m_2\xi^2 + 2o_2\xi\zeta + p_2\eta^2 + 2q_2\eta\zeta + s_2\xi + t_2\eta + 2w_2\zeta + Z_2 \\
\partial F_3/\partial\xi = G &= 2a_3\xi\eta^2\zeta^2 + 2b_3\xi\eta^2\zeta + 2c_3\xi\eta\zeta^2 + d_3\eta^2\zeta^2 + 2e_3\xi\eta\zeta + f_3\eta^2\zeta + g_3\eta\zeta^2 + \\
&+ 2h_3\xi\eta^2 + 2i_3\xi\zeta^2 + k_3\eta\zeta + 2l_3\xi\eta + 2m_3\xi\zeta + n_3\eta^2 + o_3\zeta^2 + r_3\eta + s_3\zeta + 2u_3\xi + X_3 \\
\partial F_3/\partial\eta = H &= 2a_3\xi^2\eta\zeta^2 + 2b_3\xi^2\eta\zeta + c_3\xi^2\zeta^2 + 2d_3\xi\eta\zeta^2 + e_3\xi^2\zeta + 2f_3\xi\eta\zeta + g_3\xi\zeta^2 + \\
&+ 2h_3\xi^2\eta + 2j_3\eta\zeta^2 + k_3\xi\zeta + l_3\xi^2 + 2n_3\xi\eta + 2p_3\eta\zeta + q_3\zeta^2 + r_3\xi + t_3\zeta + 2v_3\eta + Y_3 \\
\partial F_3/\partial\zeta = I &= 2a_3\xi^2\eta^2\zeta + b_3\xi^2\eta^2 + 2c_3\xi^2\eta\zeta + 2d_3\xi\eta^2\zeta + e_3\xi^2\eta + f_3\xi\eta^2 + 2g_3\xi\eta\zeta + \\
&+ 2i_3\xi^2\zeta + 2j_3\eta^2\zeta + k_3\xi\eta + m_3\xi^2 + 2o_3\xi\zeta + p_3\eta^2 + 2q_3\eta\zeta + s_3\xi + t_3\eta + 2w_3\zeta + Z_3
\end{aligned} \tag{30}$$

We obtain therefore:

$$\left[\frac{\partial F}{\partial \underline{\chi}}\right]^{-1} = \begin{bmatrix} \frac{\alpha_{11}}{\bar{D}} & \frac{\alpha_{21}}{\bar{D}} & \frac{\alpha_{31}}{\bar{D}} \\ \frac{\alpha_{12}}{\bar{D}} & \frac{\alpha_{22}}{\bar{D}} & \frac{\alpha_{32}}{\bar{D}} \\ \frac{\alpha_{13}}{\bar{D}} & \frac{\alpha_{23}}{\bar{D}} & \frac{\alpha_{33}}{\bar{D}} \end{bmatrix} \tag{31}$$

where:

$$\bar{D} = \det \begin{bmatrix} A & B & C \\ D & E & F \\ G & H & I \end{bmatrix} = A(EI - FH) - B(DI - FG) + C(DH - EG) \qquad \text{(must be } \neq 0\text{!)} \tag{32}$$

and:

$$\begin{aligned} \alpha_{11} &= (-1)^{1+1} \cdot \text{cofactor}_{11} = EI - FH \\ \alpha_{12} &= (-1)^{1+2} \cdot \text{cofactor}_{12} = -(DI - FG) \\ \alpha_{13} &= (-1)^{1+3} \cdot \text{cofactor}_{13} = DH - EG \\ \alpha_{21} &= (-1)^{2+1} \cdot \text{cofactor}_{21} = -(BI - CH) \\ \alpha_{22} &= (-1)^{2+2} \cdot \text{cofactor}_{22} = AI - CG \quad . \\ \alpha_{23} &= (-1)^{2+3} \cdot \text{cofactor}_{23} = -(AH - BG) \\ \alpha_{31} &= (-1)^{3+1} \cdot \text{cofactor}_{31} = BF - CE \\ \alpha_{32} &= (-1)^{3+2} \cdot \text{cofactor}_{32} = -(AF - CD) \\ \alpha_{33} &= (-1)^{3+3} \cdot \text{cofactor}_{33} = AE - BD \end{aligned} \tag{33}$$

With (32) and (33), Eq. (31) becomes:

$$\left[\frac{\partial F}{\partial \underline{\chi}}\right]^{-1} = \frac{1}{A(EI - FH) - B(DI - FG) + C(DH - EG)} \begin{bmatrix} (EI - FH) & -(BI - CH) & (BF - CE) \\ -(DI - FG) & (AI - CG) & -(AF - CD) \\ (DH - EG) & -(AH - BG) & (AE - BD) \end{bmatrix} \tag{34}$$

Then we may write:

$$\Delta\underline{\chi} = \underline{\chi} - \underline{\chi}^* = \begin{bmatrix}\xi\\ \eta\\ \zeta\end{bmatrix} - \begin{bmatrix}\xi^*\\ \eta^*\\ \zeta^*\end{bmatrix} = \begin{bmatrix}\xi-\xi^*\\ \eta-\eta^*\\ \zeta-\zeta^*\end{bmatrix} = \\ -\frac{1}{A(EI-FH)-B(DI-FG)+C(DH-EG)}\begin{bmatrix}(EI-FH) & -(BI-CH) & (BF-CE)\\ -(DI-FG) & (AI-CG) & -(AF-CD)\\ (DH-EG) & -(AH-BG) & (AE-BD)\end{bmatrix}\begin{bmatrix}F_1(\underline{\chi}^*)\\ F_2(\underline{\chi}^*)\\ F_3(\underline{\chi}^*)\end{bmatrix} \tag{35}$$

and finally:

$$\begin{aligned}
\xi-\xi^* &= \Delta\xi = -\frac{[(EI-FH)F_1(\underline{\chi}^*)-(BI-CH)F_2(\underline{\chi}^*)+(BF-CE)F_3(\underline{\chi}^*)]}{A(EI-FH)-B(DI-FG)+C(DH-EG)}\\
\eta-\eta^* &= \Delta\eta = -\frac{[-(DI-FG)F_1(\underline{\chi}^*)+(AI-CG)F_2(\underline{\chi}^*)-(AF-CD)F_3(\underline{\chi}^*)]}{A(EI-FH)-B(DI-FG)+C(DH-EG)}.\\
\zeta-\zeta^* &= \Delta\zeta = -\frac{[(DH-EG)F_1(\underline{\chi}^*)-(AH-BG)F_2(\underline{\chi}^*)+(AE-BD)F_3(\underline{\chi}^*)]}{A(EI-FH)-B(DI-FG)+C(DH-EG)}
\end{aligned} \tag{36}$$

The algebraic manipulations to obtain the coefficients (24) are tedious and error-prone. Therefore, use has been made of the free software Maxima in order to do part of the work. The input for the Maxima code is listed in the appendix (see file `test03.wxm`) and an example of printed output from Maxima is shown in Figure 62.

```
(%i43) expand(Sx8);
(%o43) 4 a9 x^2 y^2 z^2+a8 x^2 y^2 z^2+a7 x^2 y^2 z^2+a6 x^2 y^2 z^2+a5 x^2 y^2 z^2+a4 x^2 y^2
z^2+a3 x^2 y^2 z^2-8 a27 x^2 y^2 z^2-2 a26 x^2 y^2 z^2-2 a25 x^2 y^2 z^2-2 a24 x^2 y^2 z^2-2
a23 x^2 y^2 z^2-2 a22 x^2 y^2 z^2-2 a21 x^2 y^2 z^2-2 a20 x^2 y^2 z^2+a2 x^2 y^2 z^2-2 a19 x^2
y^2 z^2-2 a18 x^2 y^2 z^2-2 a17 x^2 y^2 z^2-2 a16 x^2 y^2 z^2-2 a15 x^2 y^2 z^2+4 a14 x^2 y^2
z^2+4 a13 x^2 y^2 z^2+4 a12 x^2 y^2 z^2+4 a11 x^2 y^2 z^2+4 a10 x^2 y^2 z^2+a1 x^2 y^2 z^2-a8
x y^2 z^2+a7 x y^2 z^2+a6 x y^2 z^2-a5 x y^2 z^2-a4 x y^2 z^2+a3 x y^2 z^2+2 a26 x y^2 z^2-
2 a24 x y^2 z^2+2 a22 x y^2 z^2-2 a21 x y^2 z^2-2 a20 x y^2 z^2+a2 x y^2 z^2+2 a19 x y^2
z^2+2 a18 x y^2 z^2-2 a16 x y^2 z^2-4 a13 x y^2 z^2+4 a11 x y^2 z^2-a1 x y^2 z^2-4 a9 y^2
z^2+8 a27 y^2 z^2+2 a25 y^2 z^2+2 a23 y^2 z^2+2 a17 y^2 z^2+2 a15 y^2 z^2-4 a14 y^2 z^2-4
a12 y^2 z^2-4 a10 y^2 z^2+a8 x^2 y z^2+a7 x^2 y z^2-a6 x^2 y z^2-a5 x^2 y z^2+a4 x^2 y z^2+
a3 x^2 y z^2-2 a25 x^2 y z^2+2 a23 x^2 y z^2-2 a22 x^2 y z^2-2 a21 x^2 y z^2+2 a20 x^2 y
z^2-a2 x^2 y z^2+2 a19 x^2 y z^2-2 a17 x^2 y z^2+2 a15 x^2 y z^2+4 a12 x^2 y z^2-4 a10 x^2
y z^2-a1 x^2 y z^2-a8 x y z^2+a7 x y z^2-a6 x y z^2+a5 x y z^2-a4 x y z^2+a3 x y z^2+2
a22 x y z^2-2 a21 x y z^2+2 a20 x y z^2-a2 x y z^2-2 a19 x y z^2+a1 x y z^2+2 a25 y
z^2-2 a23 y z^2+2 a17 y z^2-2 a15 y z^2-4 a12 y z^2+4 a10 y z^2-4 a9 x^2 z^2+8 a27 x^2
z^2+2 a26 x^2 z^2+2 a24 x^2 z^2+2 a18 x^2 z^2+2 a16 x^2 z^2-4 a14 x^2 z^2-4 a13 x^2 z^2-4
a11 x^2 z^2-2 a26 x z^2+2 a24 x z^2-2 a18 x z^2+2 a16 x z^2+4 a13 x z^2-4 a11 x z^2+4
a9 z^2-8 a27 z^2+4 a14 z^2-4 a9 x^2 y^2 z+a8 x^2 y^2 z+a7 x^2 y^2 z+a6 x^2 y^2 z+a5 x^2
y^2 z-a4 x^2 y^2 z-a3 x^2 y^2 z-2 a26 x^2 y^2 z-2 a25 x^2 y^2 z-2 a24 x^2 y^2 z-2 a23 x^2
y^2 z-a2 x^2 y^2 z+2 a18 x^2 y^2 z+2 a17 x^2 y^2 z+2 a16 x^2 y^2 z+2 a15 x^2 y^2 z+4 a14
x^2 y^2 z-a1 x^2 y^2 z-a8 x y^2 z+a7 x y^2 z+a6 x y^2 z-a5 x y^2 z+a4 x y^2 z-a3 x y^2 z
+2 a26 x y^2 z-2 a24 x y^2 z-a2 x y^2 z-2 a18 x y^2 z+2 a16 x y^2 z+a1 x y^2 z+4 a9
y^2 z+2 a25 y^2 z+2 a23 y^2 z-2 a17 y^2 z-2 a15 y^2 z-4 a14 y^2 z+a8 x^2 y z+a7 x^2 y
z-a6 x^2 y z-a5 x^2 y z-a4 x^2 y z-a3 x^2 y z-2 a25 x^2 y z+2 a23 x^2 y z+a2 x^2 y z+
2 a17 x^2 y z-2 a15 x^2 y z+a1 x^2 y z-a8 x y z+a7 x y z-a6 x y z+a5 x y z+a4 x y
z-a3 x y z+a2 x y z-a1 x y z+2 a25 y z-2 a23 y z-2 a17 y z+2 a15 y z+4 a9 x^2 z
+2 a26 x^2 z+2 a24 x^2 z-2 a18 x^2 z-2 a16 x^2 z-4 a14 x^2 z-2 a26 x z+2 a24 x z+2
a18 x z-2 a16 x z-4 a9 z+4 a14 z+8 a27 x^2 y^2+2 a22 x^2 y^2+2 a21 x^2 y^2+2 a20 x^2
y^2+2 a19 x^2 y^2-4 a13 x^2 y^2-4 a12 x^2 y^2-4 a11 x^2 y^2-4 a10 x^2 y^2-2 a22 x y^2+2
a21 x y^2+2 a20 x y^2-2 a19 x y^2+4 a13 x y^2-4 a11 x y^2-8 a27 y^2+4 a12 y^2+4 a10
y^2+2 a22 x^2 y+2 a21 x^2 y-2 a20 x^2 y-2 a19 x^2 y-4 a12 x^2 y+4 a10 x^2 y-2 a22 x
y+2 a21 x y-2 a20 x y+2 a19 x y+4 a12 y-4 a10 y-8 a27 x^2+4 a13 x^2+4 a11 x^2-
4 a13 x+4 a11 x+8 a27
```

Figure 62 - Output from the Maxima symbolic calculation package

3.3 Simple numerical examples

The “native” pinball formulation for parabolic elements introduced above is now tested on some simple numerical examples.

We start from 2D and consider the “perfect” impact of two quadrilaterals, as shown in Figure 63. Each quadrilateral measures 2×2 m and has an initial velocity of 100 m/s in the vertical direction (with opposite signs as shown). The initial gap between the two quadrilaterals is zero, although in Figure 63 a certain gap is shown for clarity. A total of 100 time steps is performed.

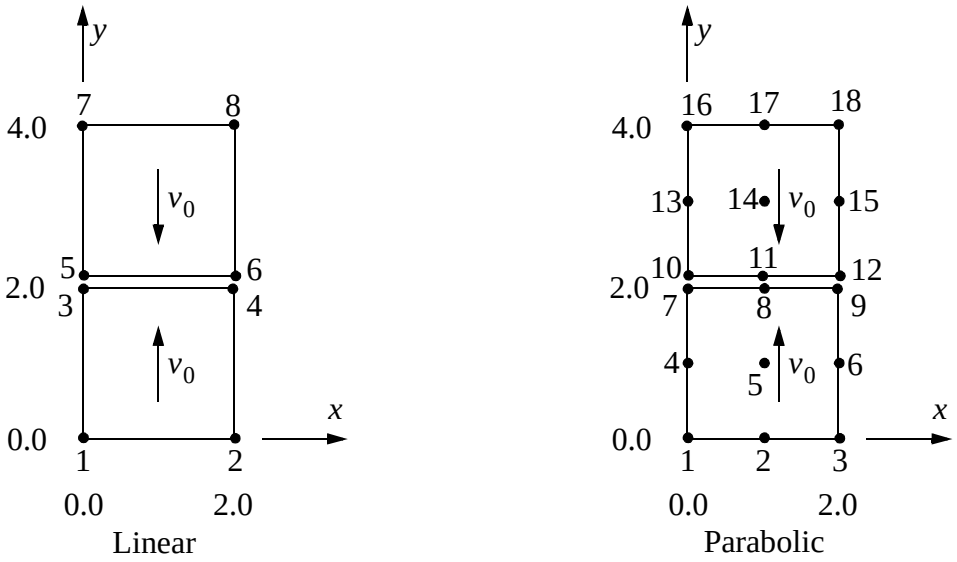


Figure 63 - Definition and initial mesh of the quadrilateral impact problem

First, a reference solution is obtained by means of linear elements (Q41L and Q42L), see left part of Figure 63. Then, the same problem is solved with quadratic elements (Q92 and Q93) using the native pinball formulation for such elements. All performed calculations are summarized in Table 4.

Case	Mesh	Notes	Steps	CPU [s]	Els*step
PBQ401	2 Q41L	0-level pinballs	100	0.55	202
PBQ402	2 Q41L	MLEV 1 EQVF	100	0.55	202
PBQ403	2 Q41L	MLEV 2 EQVF	100	0.55	202
PBQ404	2 Q41L	MLEV 3 EQVF	100	0.64	202
PBQ421	2 Q42L	0-level pinballs	100	0.58	202
PBQ422	2 Q42L	MLEV 1 EQVF	100	0.66	202
PBQ423	2 Q42L	MLEV 2 EQVF	100	0.58	202
PBQ424	2 Q42L	MLEV 3 EQVF	100	0.55	202

Table 4 - Calculations for the quadrilateral impact problem in 2D with linear elements

3.3.1 2D solutions with linear elements

PBQ401

This test uses 0-level (parent) pinballs. The vertical displacement of node 1 is plotted in Figure 64 for this test case and the following 7 cases (all solutions with linear elements). The initial and final configuration for this solution are shown in Figure 65. The solution is degenerated, in the sense that all nodes are instantaneously stopped at step 0, due to the fact that only one element is used on each side of the impact, and the contact points are at the centres of the parent pinballs, which coincide with the element centroids. Therefore, the contact force is equally distributed on all nodes and the effect is that the velocity becomes instantly zero at the initial step. No rebound occurs.

PBQ402

This test is similar to PBQ401 but uses level 1 pinballs (MLEV 1). Additionally, the `EQVF` option is activated, according to which the volume of the final (contacting) pinballs is equivalent to the volume of the corresponding parent element portion. The solution is shown in Figure 66. In this case some rebound occurs.

PBQ403

This test is similar to PBQ402 but uses MLEV 2. A solution is obtained despite the fact that some redundancies in the contact constraints can occur in this case, and is shown in Figure 67. In this case some rebound occurs.

PBQ404

This test is similar to PBQ403 but uses MLEV 3. A solution is obtained despite the fact that several redundancies in the contact constraints occur in this case, and is shown in Figure 68. In this case some rebound occurs.

PBQ421

This test is similar to PBQ401 but uses the fully integrated element Q42L instead of the reduced-integrated element Q41L. The solution is shown in Figure 69. Like in case PBQ401, no rebound occurs.

PBQ422

This test is similar to PBQ402 but uses the fully integrated element Q42L instead of the reduced-integrated element Q41L. The solution is shown in Figure 70.

PBQ423

This test is similar to PBQ403 but uses the fully integrated element Q42L instead of the reduced-integrated element Q41L. The solution is shown in Figure 71.

PBQ424

This test is similar to PBQ404 but uses the fully integrated element Q42L instead of the reduced-integrated element Q41L. The solution is shown in Figure 72.

We may conclude that in the case of linear elements, the solutions as far as contact is concerned are identical with the reduced integrated and with the fully integrated element.

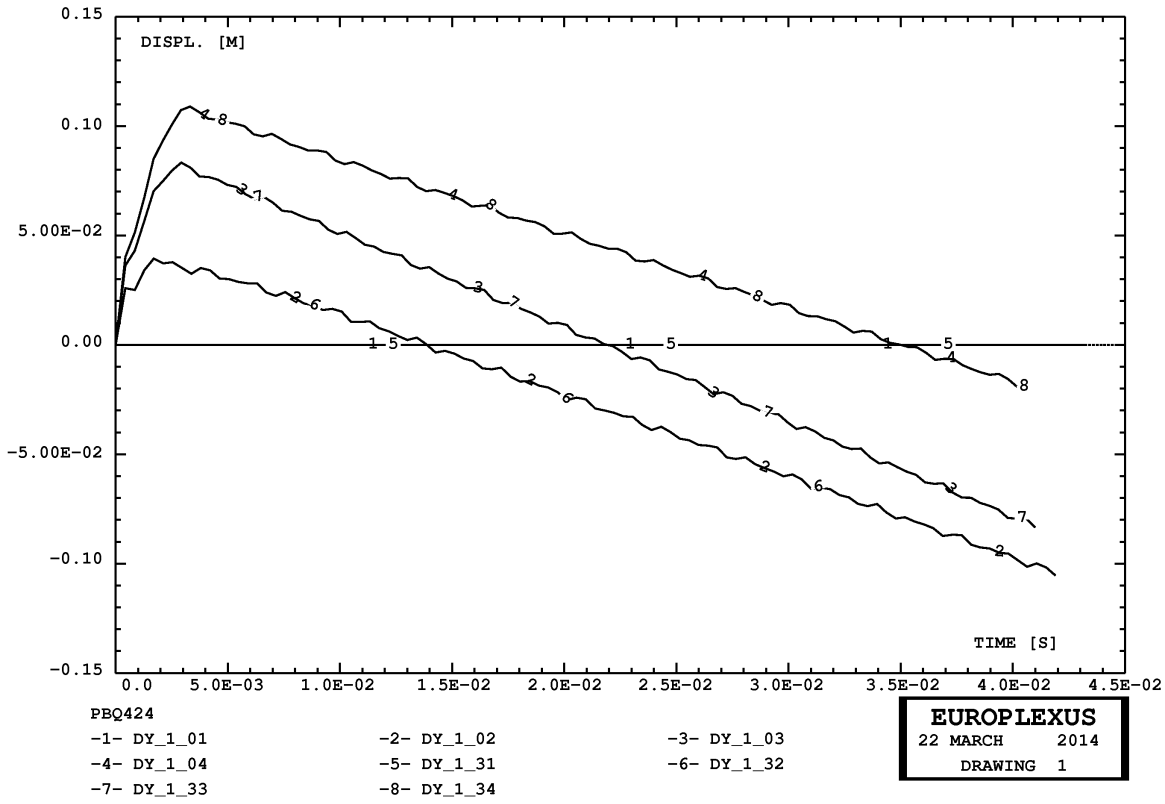


Figure 64 - Vertical displacement of node 1 in the 8 linear element solutions PBQXXX

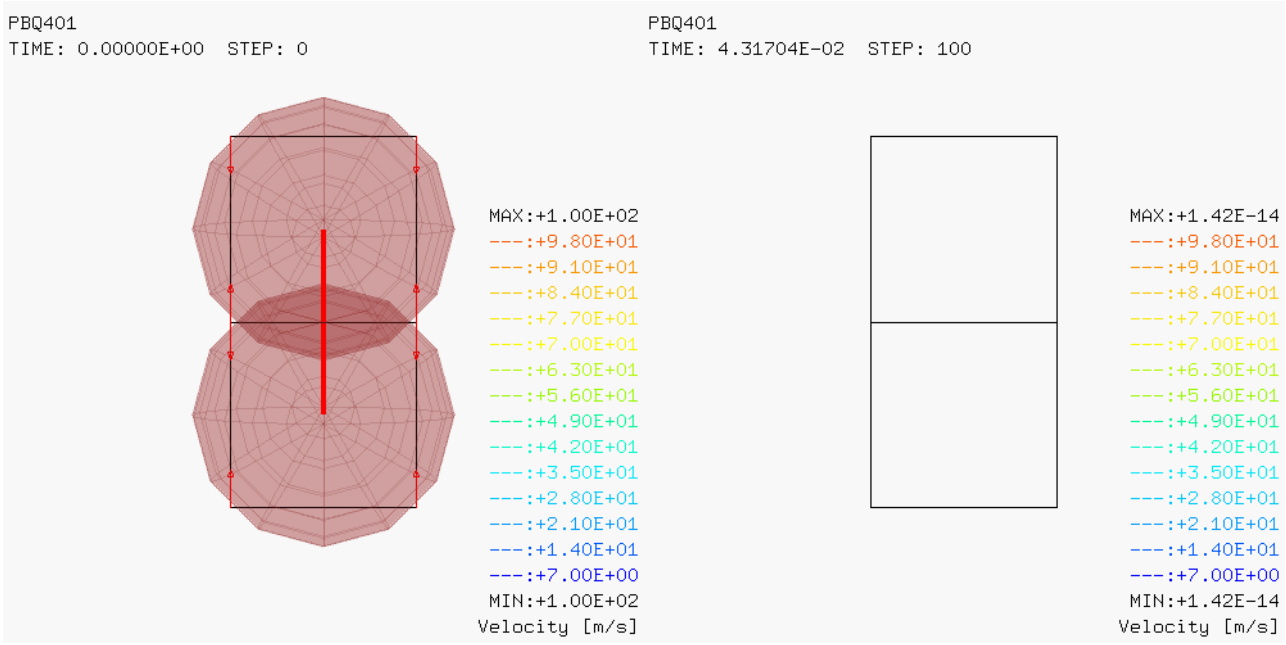


Figure 65 - Initial and final configurations for test PBQ401

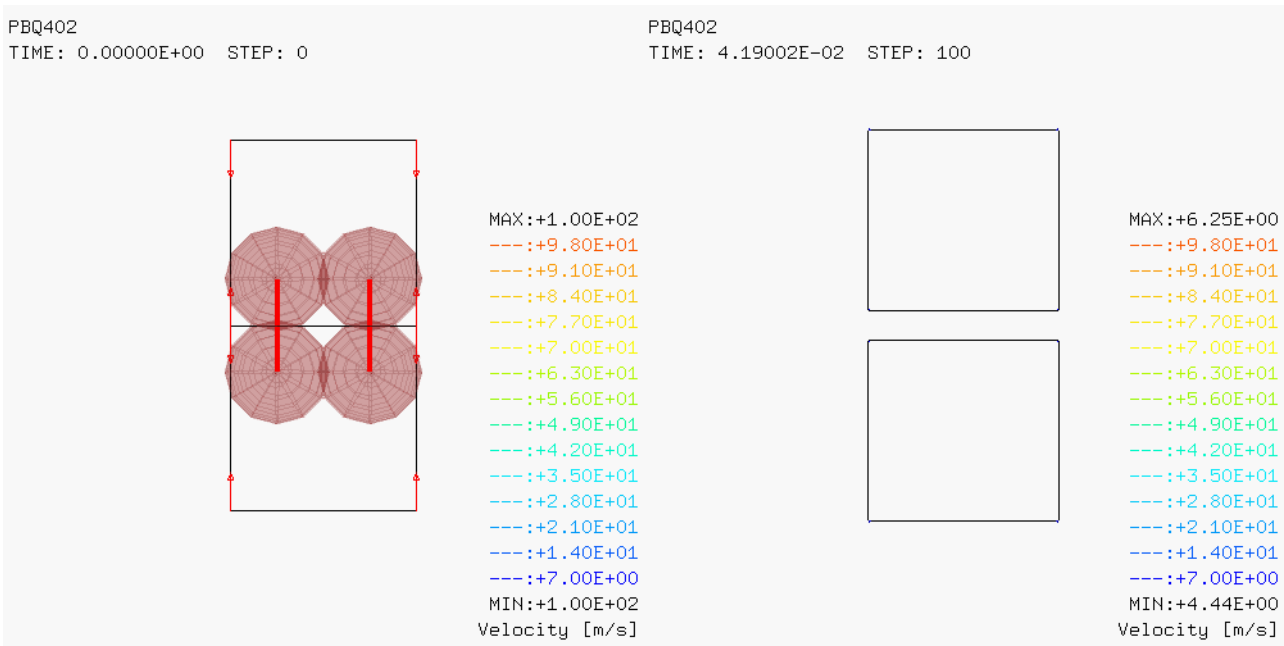


Figure 66 - Initial and final configurations for test PBQ402

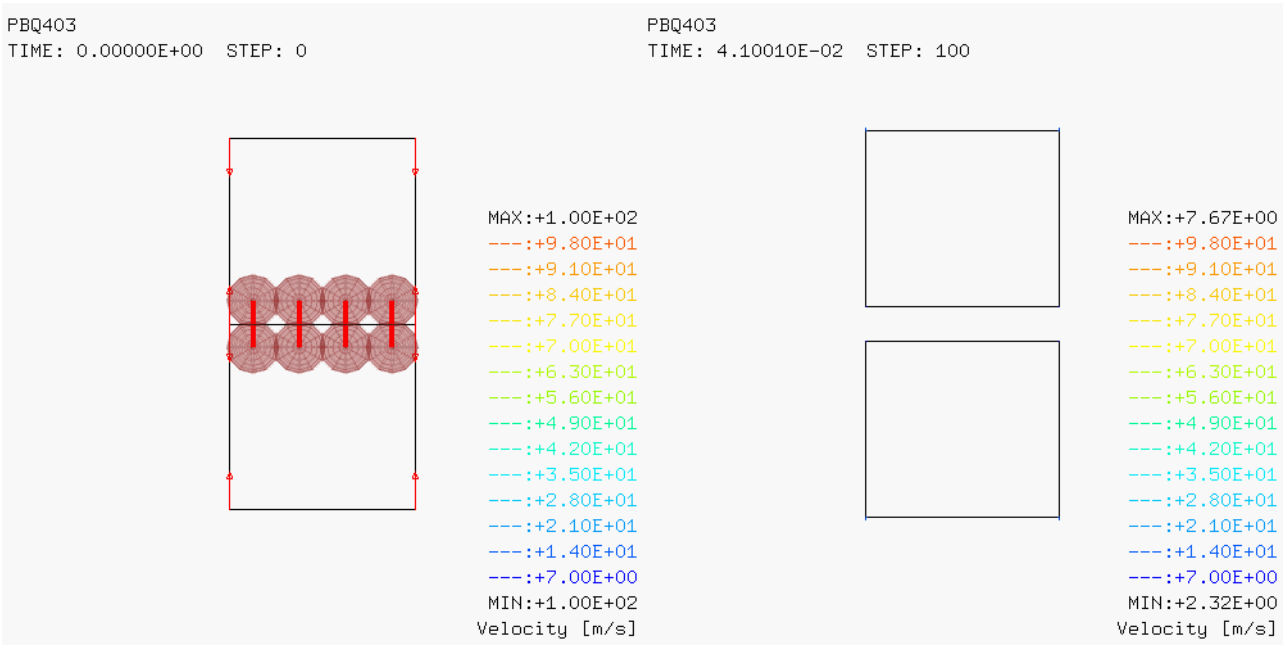


Figure 67 - Initial and final configurations for test PBQ403

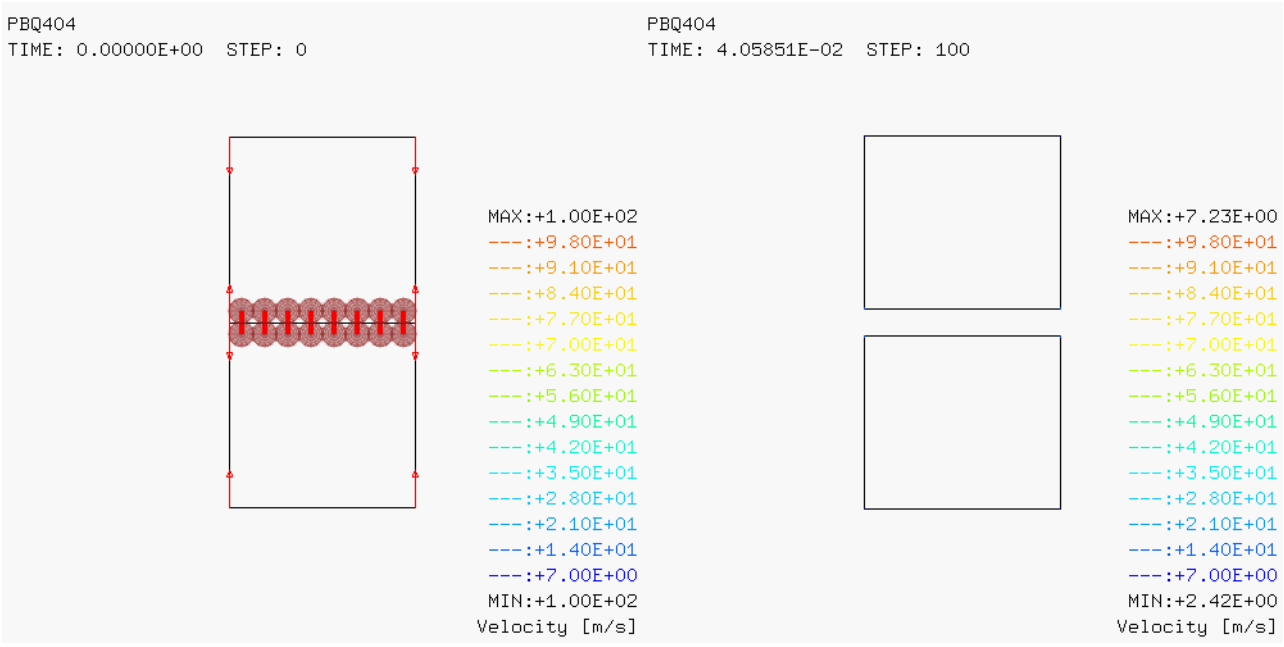


Figure 68 - Initial and final configurations for test PBQ404

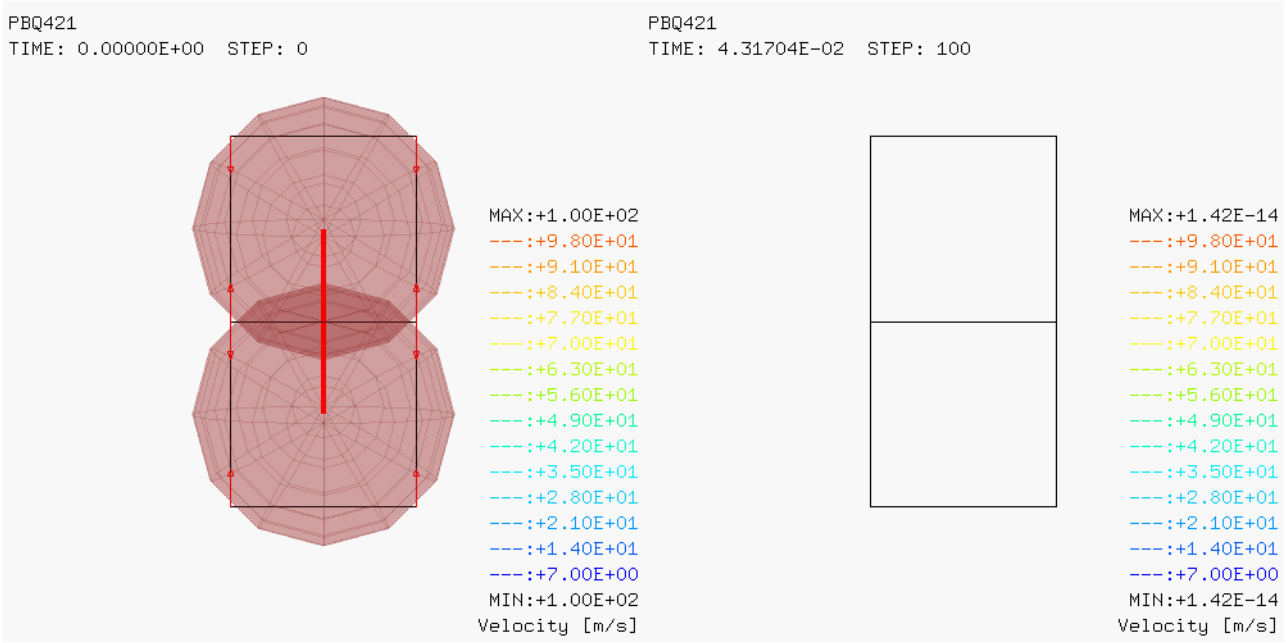


Figure 69 - Initial and final configurations for test PBQ421

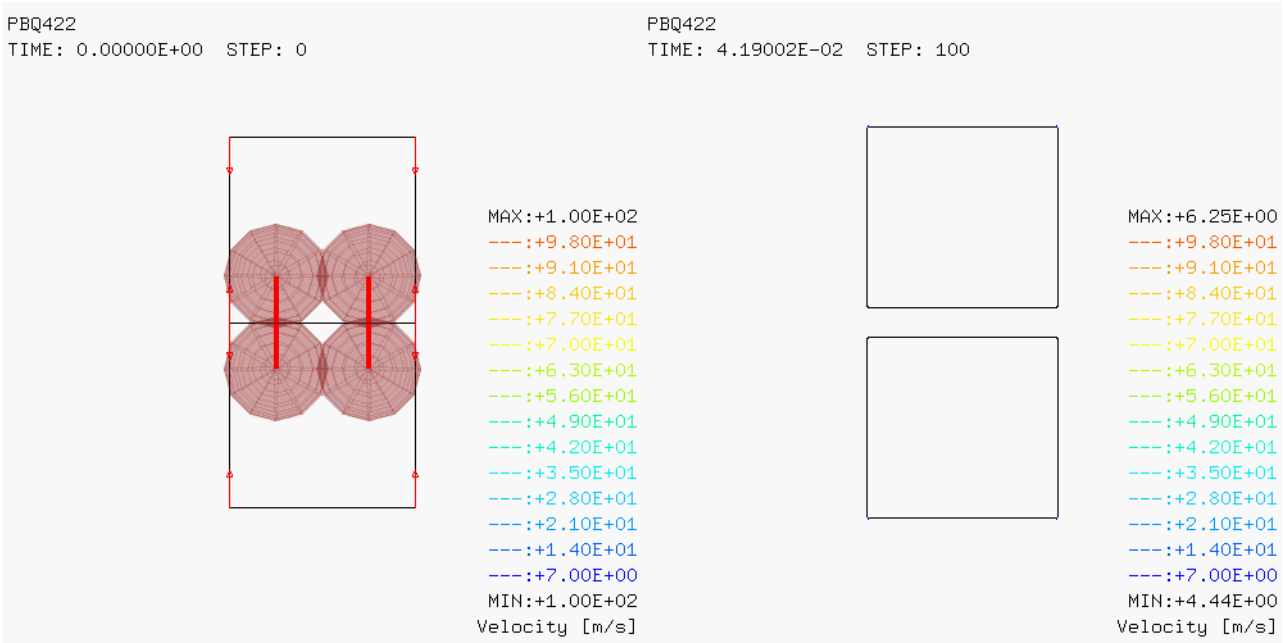


Figure 70 - Initial and final configurations for test PBQ422

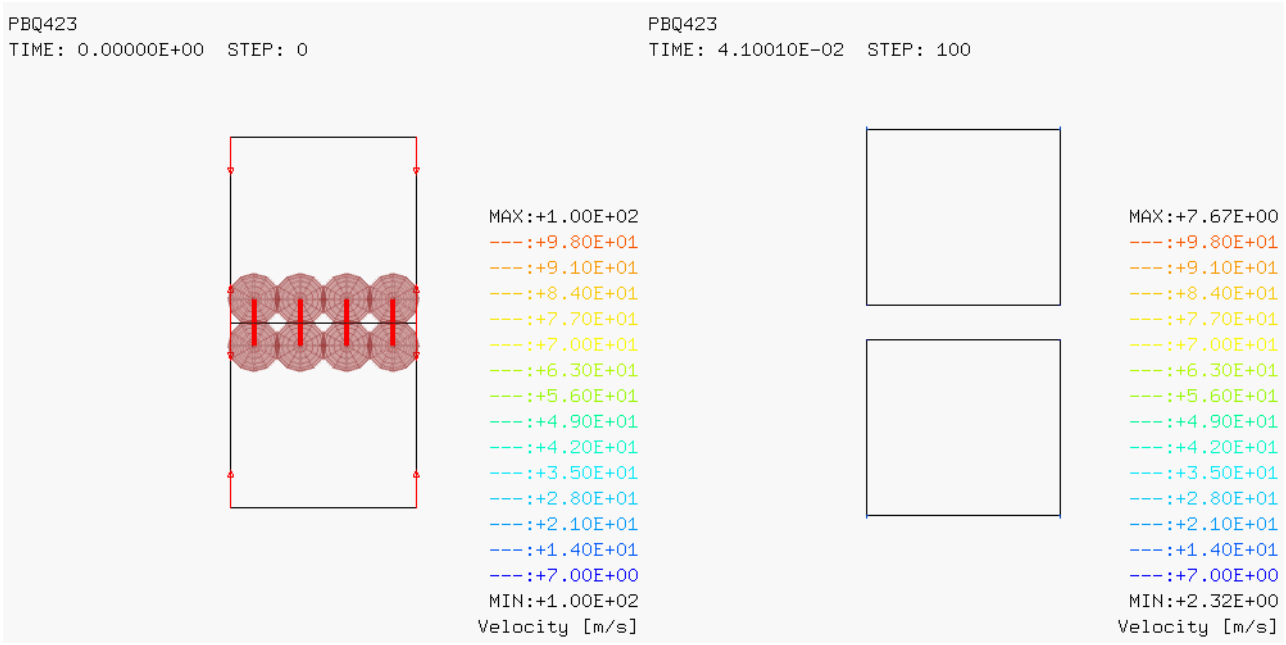


Figure 71 - Initial and final configurations for test PBQ423

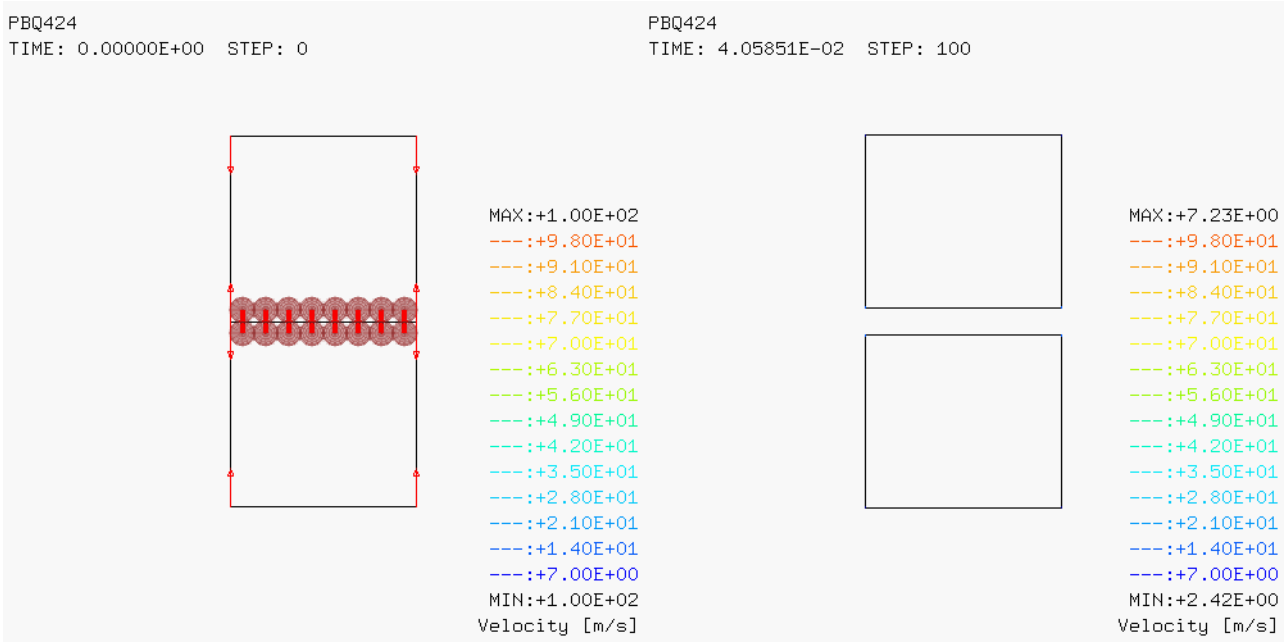


Figure 72 - Initial and final configurations for test PBQ424

3.3.2 2D solutions with parabolic elements

Next, we consider the same test cases but by using the parabolic elements Q92 (with reduced 2×2 integration) and Q93 (with full 3×3 integration). The initial configuration is the one shown in the right part of Figure 63. All performed calculations with the parabolic elements are summarized in Table 5 (square brackets indicate prematurely stopped calculations).

Case	Mesh	Notes	Steps	CPU [s]	Els*step
PBQ901	2 Q92	0-level pinballs	100	0.70	202
PBQ902	2 Q92	MLEV 1 EQVF	100	0.66	202
PBQ903	2 Q92	MLEV 2 EQVF	100	0.67	202
PBQ904	2 Q92	MLEV 3 EQVF	100	0.66	202
PBQ931	2 Q93	0-level pinballs	100	0.59	202
PBQ932	2 Q93	MLEV 1 EQVF	[93]	[0.64]	[188]
PBQ933	2 Q93	MLEV 2 EQVF	100	0.58	202
PBQ934	2 Q93	MLEV 3 EQVF	[44]	[0.36]	[90]

Table 5 - Calculations for the quadrilateral impact problem in 2D with parabolic elements

PBQ901

This test uses 0-level (parent) pinballs. The vertical displacement of node 5 is plotted in Figure 73 for this test case and the following 7 cases (all solutions with parabolic elements). The initial and final configuration for this solution are shown in Figure 74. The solution is subjected to strong mechanisms. Like in the PBQ401 case, the contact points in this case are the centers of the (parent) pinballs, i.e. the centroid of the two quadrilateral elements. However, unlike in the linear case, now a node (the ninth node of each element) is present at that point. Therefore, at step 0 only this node "feels" the contact force, while all other nodes continue undisturbed their motion. This seems to activate an hourglass mode of the parabolic element.

PBQ902

This test is similar to PBQ901 but uses level 1 pinballs (MLEV 1). Additionally, the `EQVF` option is activated, according to which the volume of the final (contacting) pinballs is equivalent to the volume of the corresponding parent element portion. Some hourglassing appears also in this case. The final configuration is shown in Figure 75.

PBQ903

This test is similar to PBQ902 but uses MLEV 2. A solution is obtained despite the fact that some redundancies in the contact constraints can occur in this case. No hourglassing occurs. The final configuration is plotted in Figure 76, showing some rebound.

PBQ904

This test is similar to PBQ903 but uses MLEV 3. A solution is obtained despite the fact that many redundancies in the contact constraints occur in this case, and is shown in Figure 77. Strangely, strong hourglassing occurs only in one of the elements.

PBQ931

This test is similar to PBQ901 but uses the fully integrated element Q93 instead of the reduced-integrated element Q92. The solution is shown in Figure 78. Like in case PBQ401, no rebound occurs.

PBQ932

This test is similar to PBQ902 but uses the fully integrated element Q93 instead of the reduced-integrated element Q92. The solution is shown in Figure 79. Strong hourglass occurs and the solution stops at step 93.

PBQ933

This test is similar to PBQ903 but uses the fully integrated element Q93 instead of the reduced-integrated element Q92. The solution is shown in Figure 80. No hourglass is developed and some rebound occurs.

PBQ934

This test is similar to PBQ904 but uses the fully integrated element Q93 instead of the reduced-integrated element Q92. The solution is shown in Figure 81 and is characterized by strong hourglassing, so that the solution stops at step 44.

We may conclude that in the case of parabolic elements, solutions of this simple problem seem to be very unstable and are characterized by strong hourglassing, except in the case MLEV 2. Furthermore, the hourglassing is even stronger in the case of fully integrated element (Q93) than in the case of reduced integrated element (Q92), which seems contrary to expectation.

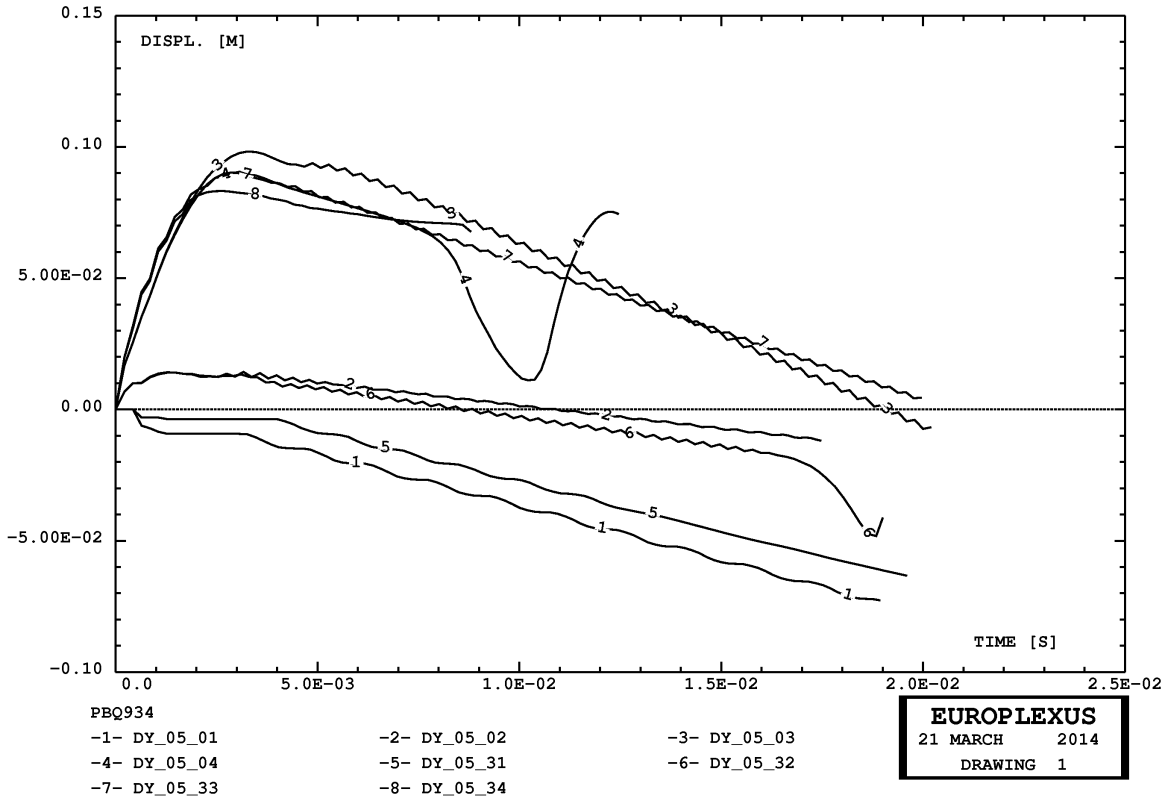


Figure 73 - Vertical displacement of node 1 in the 8 linear element solutions PBQXXX

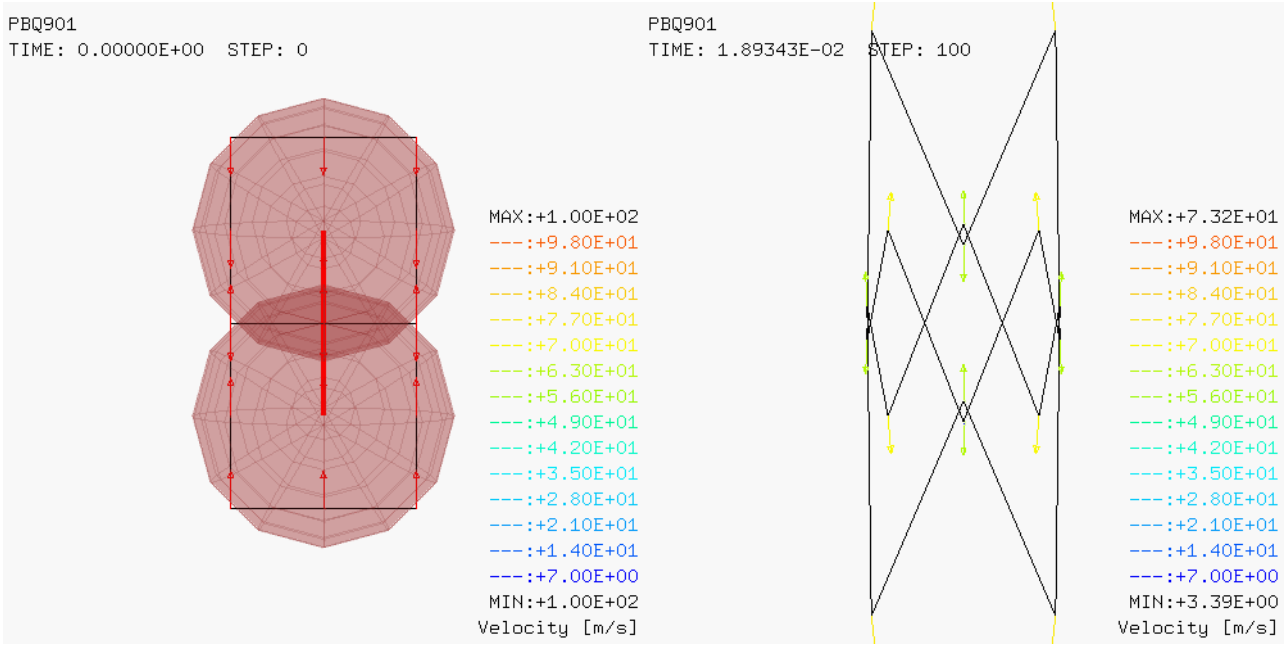


Figure 74 - Initial and final configurations for test PBQ901

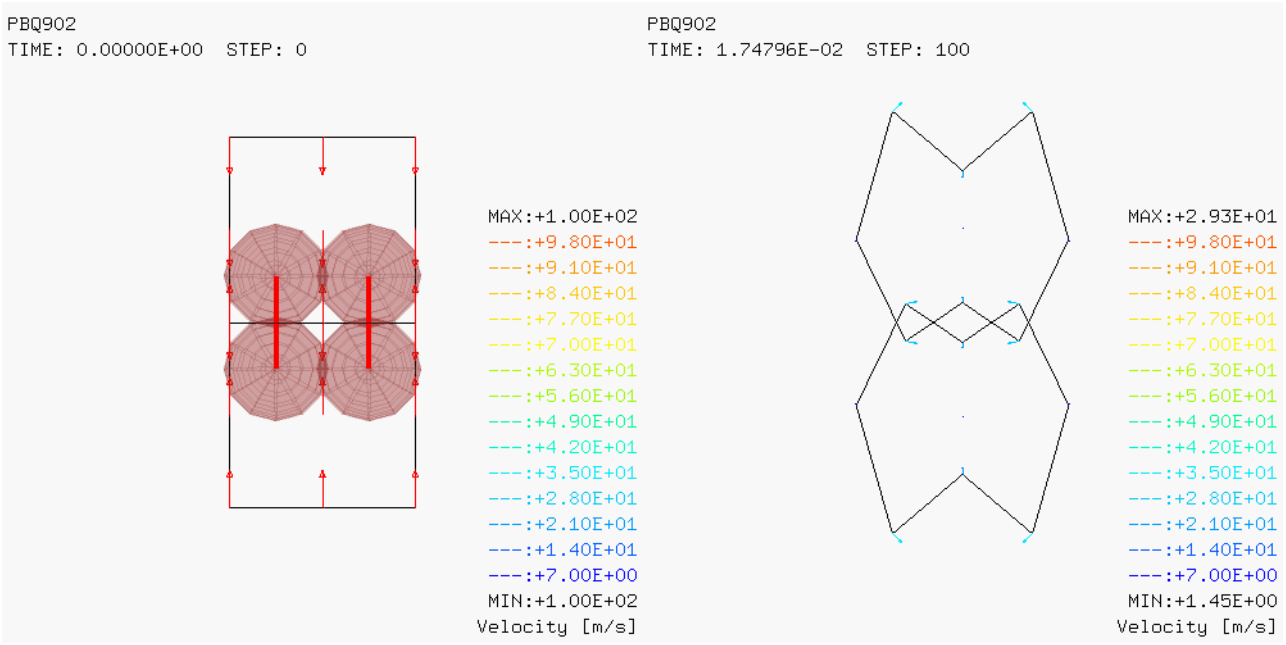


Figure 75 - Initial and final configurations for test PBQ902

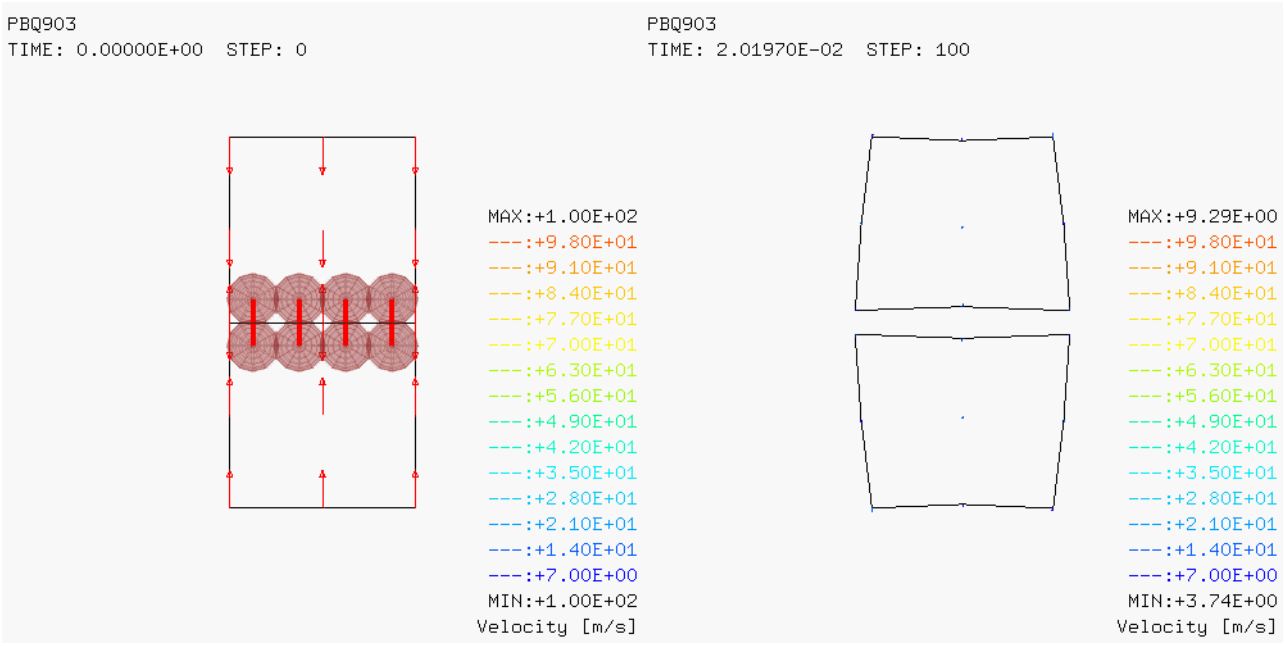


Figure 76 - Initial and final configurations for test PBQ903

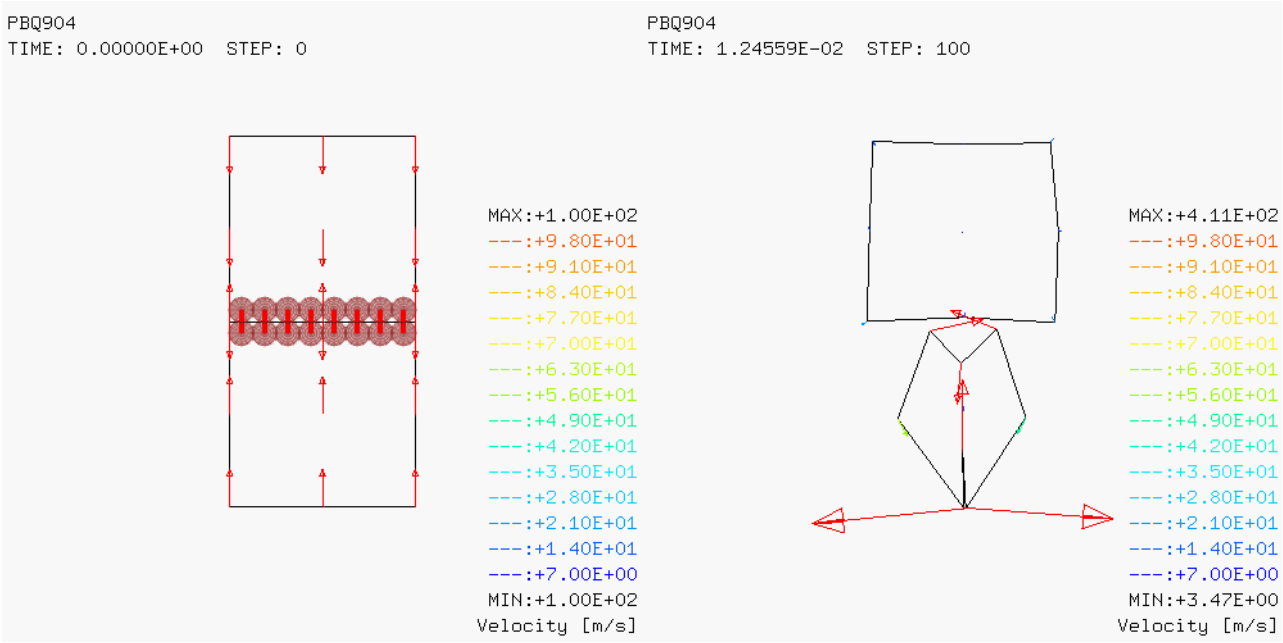


Figure 77 - Initial and final configurations for test PBQ904

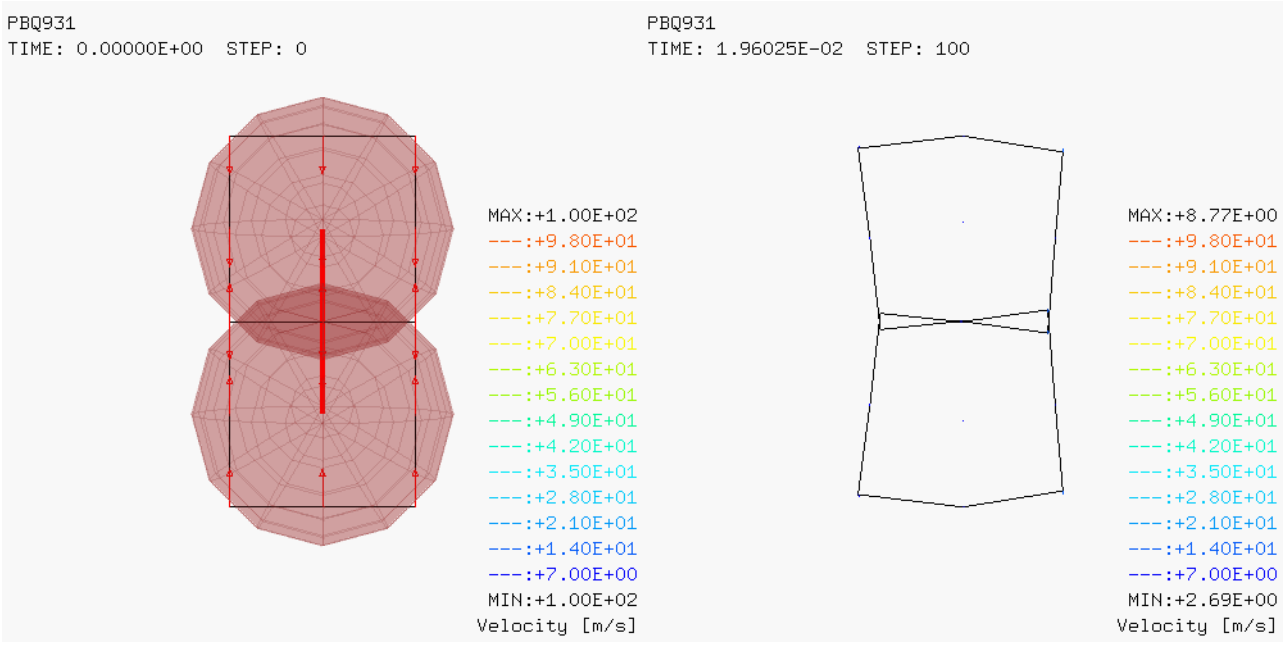


Figure 78 - Initial and final configurations for test PBQ931

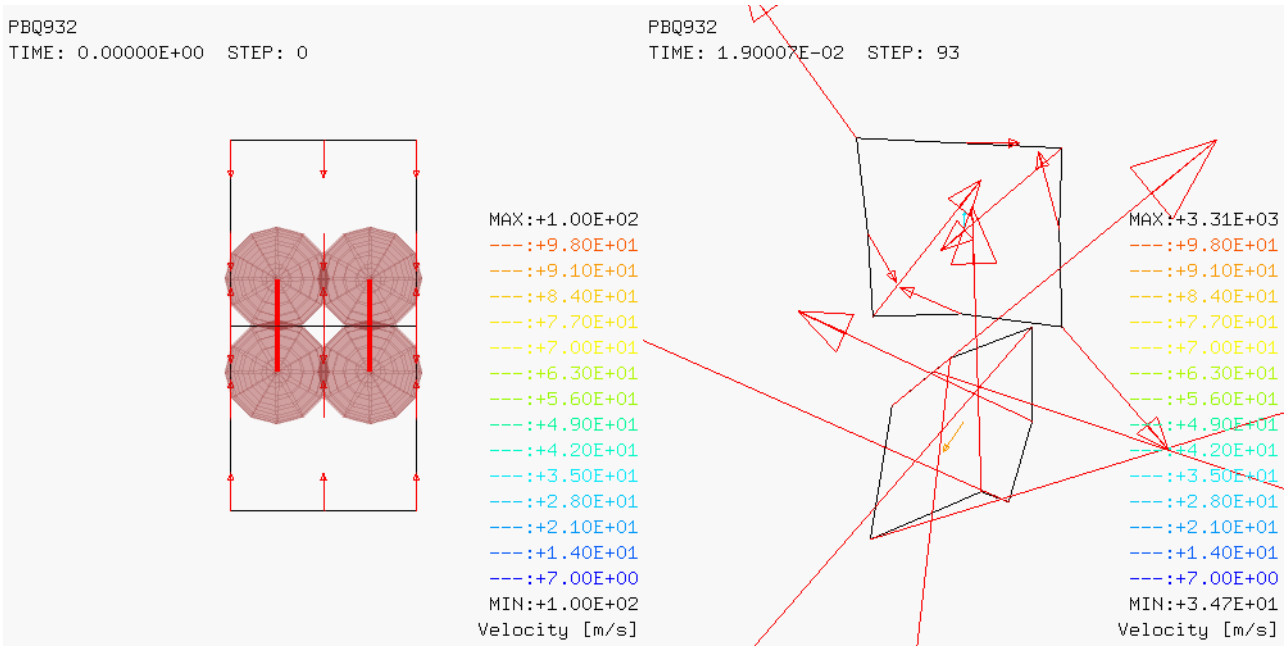


Figure 79 - Initial and final configurations for test PBQ932

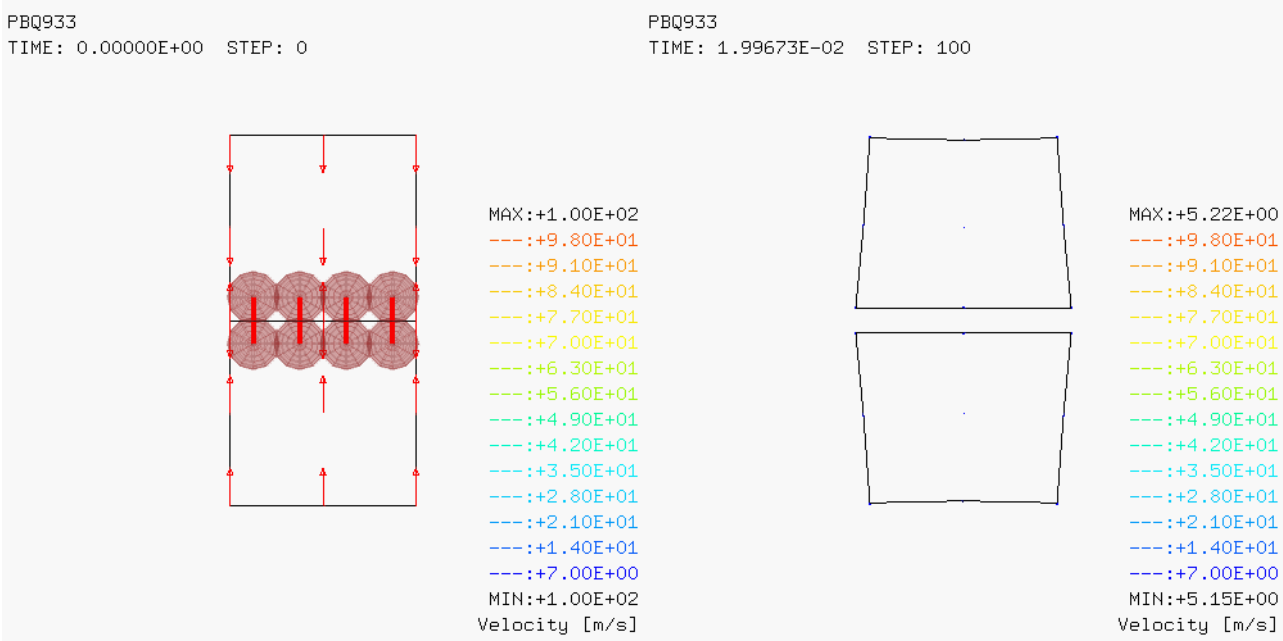


Figure 80 - Initial and final configurations for test PBQ933

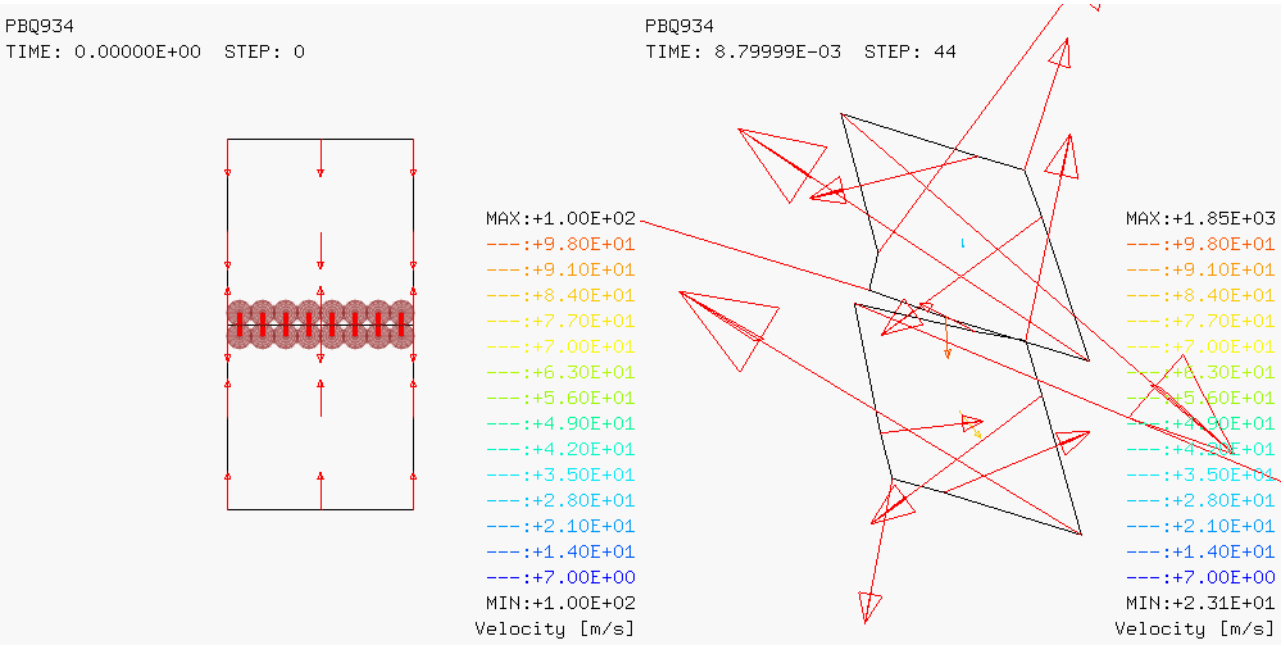


Figure 81 - Initial and final configurations for test PBQ934

3.3.3 3D solutions with linear elements

We consider now the 3D equivalent of the impact problem of Section 3.3 whereby, instead of two quadrilaterals, we have two hexahedra. Each hexahedron measures $2 \times 2 \times 2$ m and has an initial velocity of 100 m/s in the vertical (now z) direction (with opposite signs in the two elements). The initial gap between the two hexahedra is zero. A total of 100 time steps is performed.

First, a reference solution is obtained by means of linear elements (CUBE and CUB8). Then, the same problem is solved with quadratic elements (C272 and C273) using the native pinball formulation for such elements. All performed calculations with linear elements are summarized in Table 6.

Case	Mesh	Notes	Steps	CPU [s]	Els*step
PBCU01	2 CUBE	0-level pinballs	100	0.59	202
PBCU02	2 CUBE	MLEV 1 EQVF	100	0.61	202
PBCU03	2 CUBE	MLEV 2 EQVF	100	0.72	202
PBCU04	2 CUBE	MLEV 3 EQVF	[0]	[0]	[0]
PBC801	2 CUB8	0-level pinballs	100	0.55	202
PBC802	2 CUB8	MLEV 1 EQVF	[9]	[0.12]	[20]
PBC803	2 CUB8	MLEV 2 EQVF	[11]	[0.17]	[24]
PBC804	2 CUB8	MLEV 3 EQVF	[0]	[0]	[0]

Table 6 - Calculations for the hexahedral impact problem in 3D with linear elements

PBCU01

This test uses 0-level (parent) pinballs. The vertical displacement of node 1 is plotted in Figure 82 for this test case and the following 5 cases (all obtained solutions with linear elements). The initial and final configuration for this solution are shown in Figure 83. The solution is degenerated, in the sense that all nodes are instantaneously stopped at step 0, due to the fact that only one element is used on each side of the impact, and the contact points are at the centres of the parent pinballs, which coincide with the element centroids. Therefore, the contact force is equally distributed on all nodes and the effect is that the velocity becomes instantly zero at the initial step. No rebound occurs.

PBCU02

This test is similar to PBCU01 but uses level 1 pinballs (MLEV 1). Additionally, the `EQVF` option is activated, according to which the volume of the final (contacting) pinballs is equivalent to the volume of the corresponding parent element portion. The solution is shown in Figure 84. In this case some rebound occurs.

PBCU03

This test is similar to PBCU02 but uses MLEV 2. A solution is obtained despite the fact that some redundancies in the contact constraints can occur in this case, and is shown in Figure 85. In this case some rebound occurs.

PBCU04

This test is similar to PBCU03 but uses MLEV 3. No solution is obtained because there are too many redundant constraints and the system of constraints cannot be solved.

PBC801

This test is similar to PBCU01 but uses the fully integrated element CUB8 instead of the reduced-integrated element CUBE. The solution is shown in Figure 86. Like in case PBQ401, no rebound occurs.

PBC802

This test is similar to PBCU02 but uses the fully integrated element CUB8 instead of the reduced-integrated element CUBE. The solution stops at step 9 because of large instabilities. The last obtained configuration is shown in Figure 87.

PBC803

This test is similar to PBCU03 but uses the fully integrated element CUB8 instead of the reduced-integrated element CUBE. The solution stops at step 11 because of large instabilities. The last obtained configuration is shown in Figure 88.

PBC804

This test is similar to PBCU04 but uses the fully integrated element CUB8 instead of the reduced-integrated element CUBE. No solution is obtained because there are too many redundant constraints and the system of constraints cannot be solved.

We may conclude that in the case of linear elements, the 3D solutions as far as contact is concerned are similar to the 2D case, with the reduced integrated element. However, with the fully integrated element strong instabilities occur and no solution can be obtained.

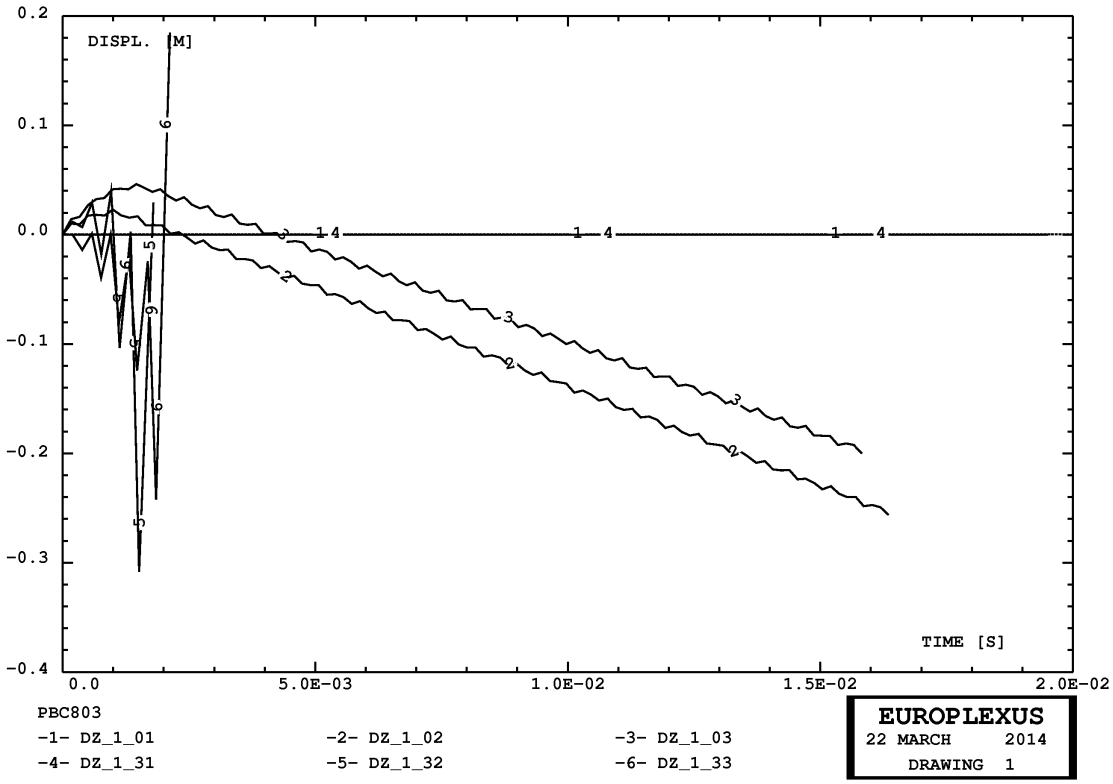


Figure 82 - Vertical displacement of node 1 in the 6 linear element solutions PBCXXX

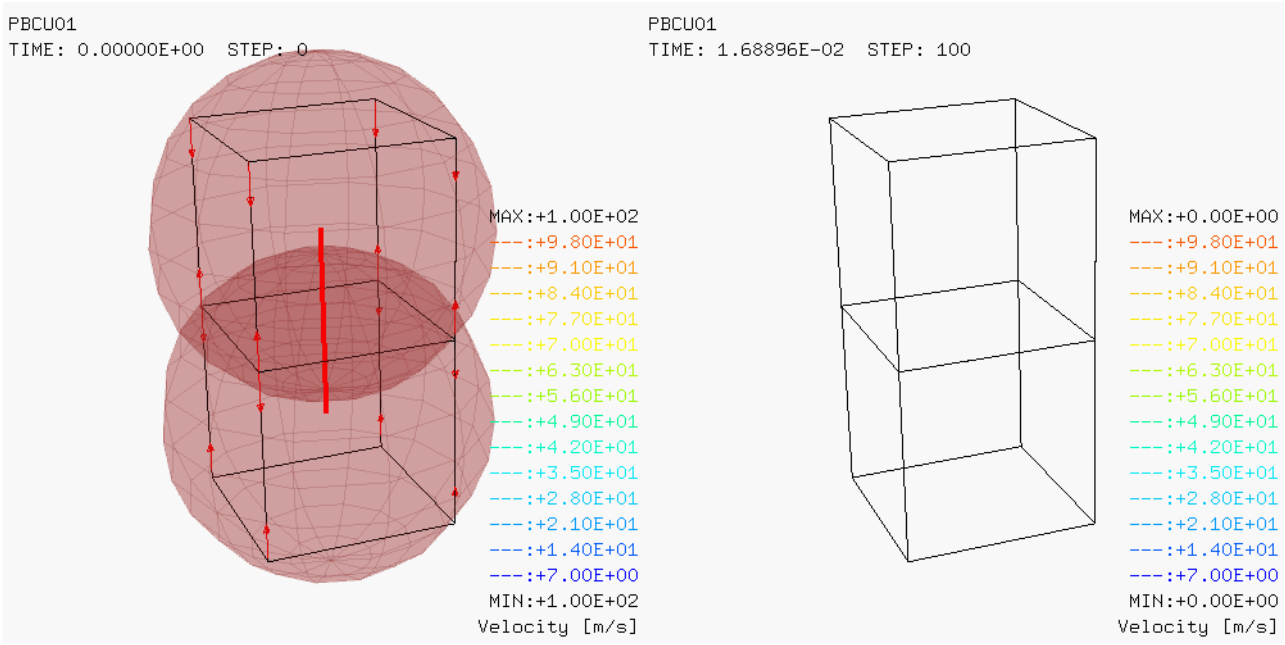


Figure 83 - Initial and final configurations for test PBCU01

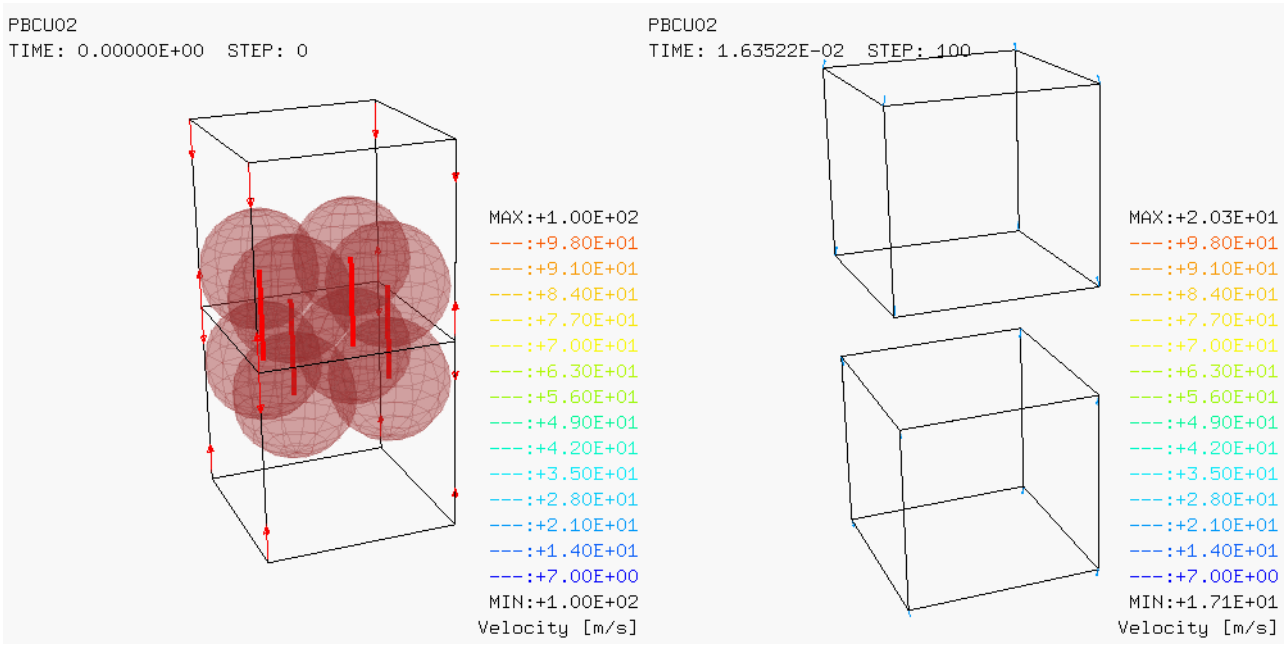


Figure 84 - Initial and final configurations for test PBCU02

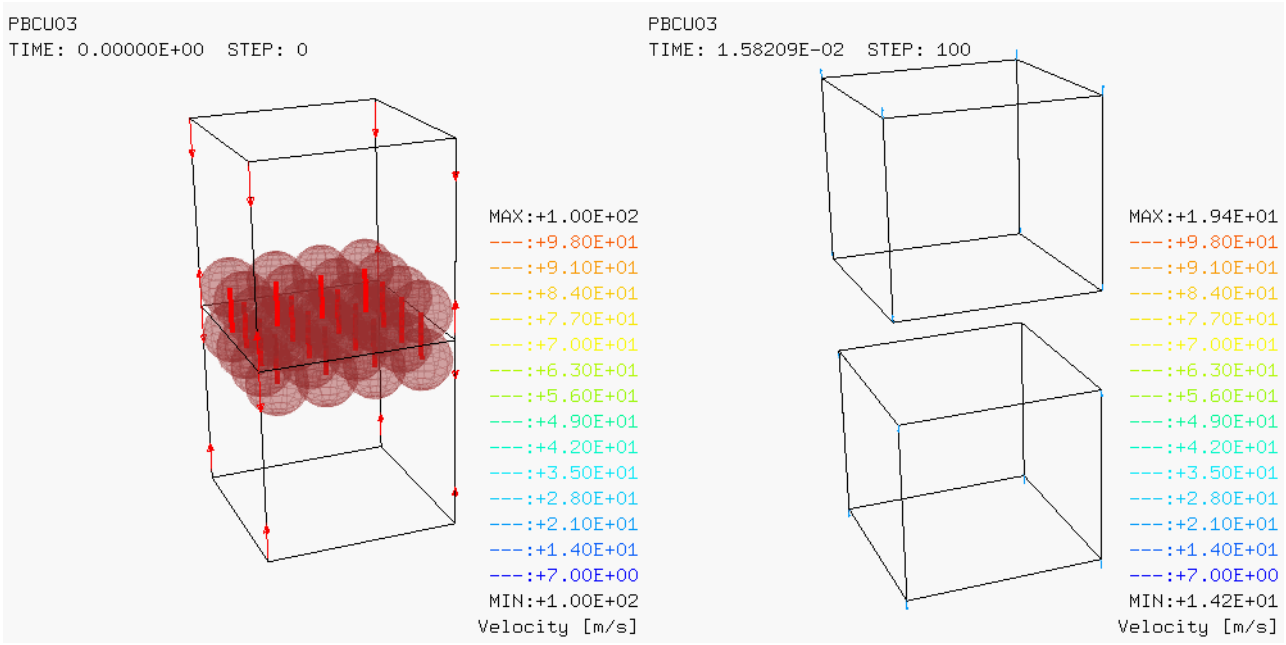


Figure 85 - Initial and final configurations for test PBCU03

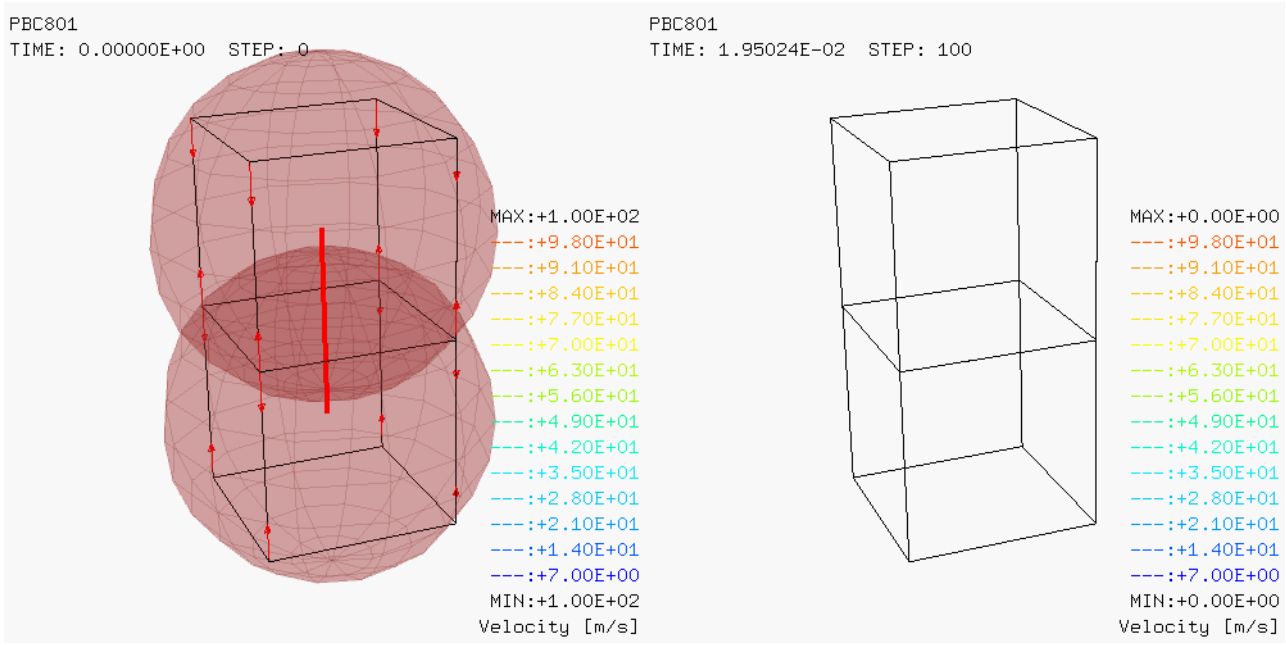


Figure 86 - Initial and final configurations for test PBC801

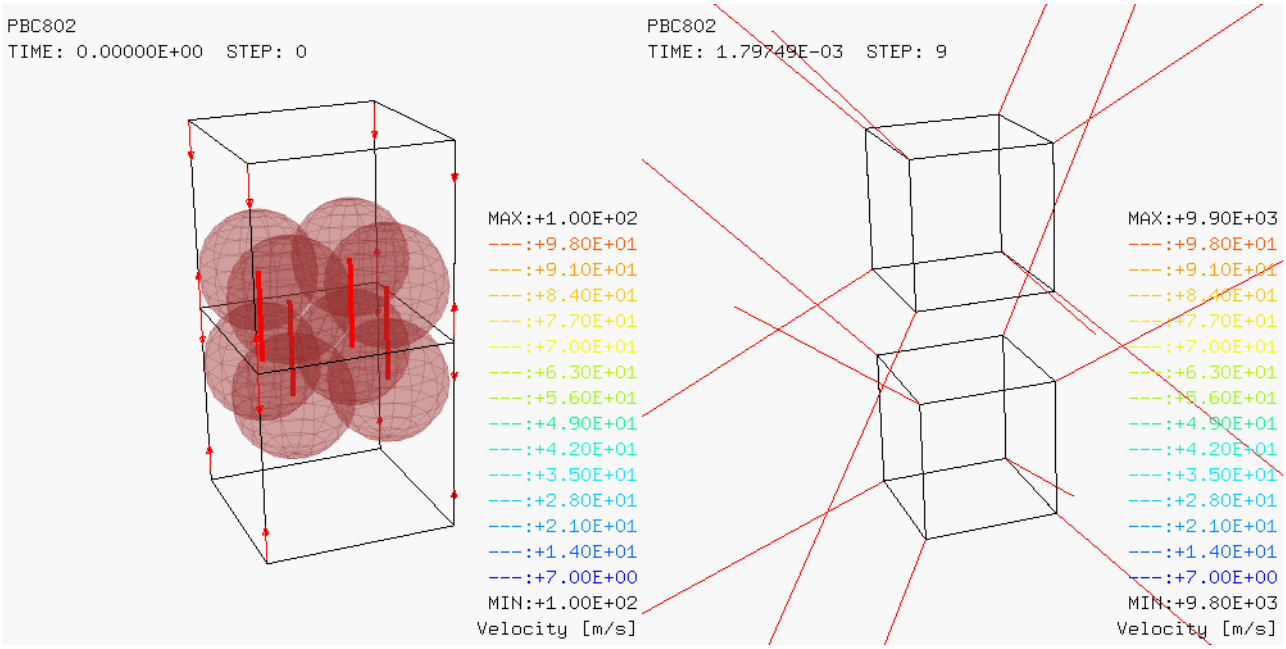


Figure 87 - Initial and final configurations for test PBC802

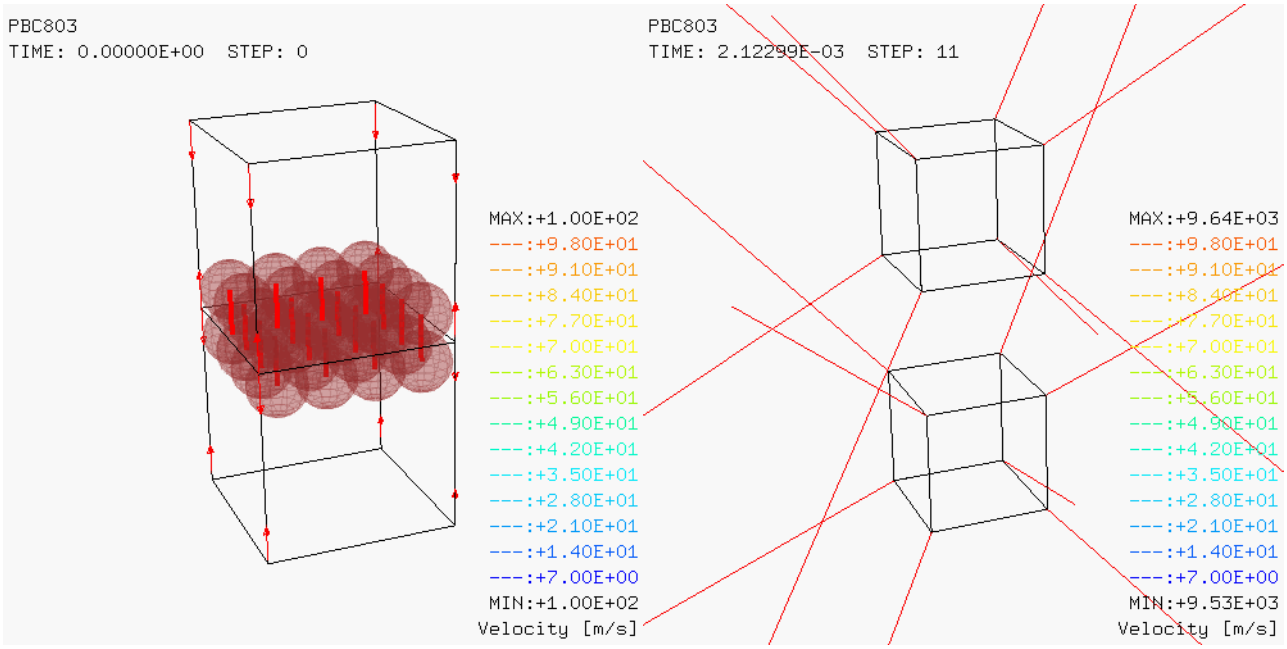


Figure 88 - Initial and final configurations for test PBC803

3.3.4 3D solutions with parabolic elements

Next, we consider the same test cases but by using the parabolic elements C272 (with reduced $2 \times 2 \times 2$ integration) and C273 (with full $3 \times 3 \times 3$ integration). All performed calculations with the parabolic elements are summarized in Table 7 (square brackets indicate prematurely stopped calculations).

Case	Mesh	Notes	Steps	CPU [s]	Els*step
PBC201	2 C272	0-level pinballs	100	1.00	202
PBC202	2 C272	MLEV 1 EQVF	[15]	[0.31]	[32]
PBC203	2 C272	MLEV 2 EQVF	[19]	[0.36]	[40]
PBC204	2 C272	MLEV 3 EQVF	[0]	[0]	[0]
PBC231	2 C273	0-level pinballs	[17]	[0.23]	[36]
PBC232	2 C273	MLEV 1 EQVF	[16]	[0.36]	[34]
PBC233	2 C273	MLEV 2 EQVF	[20]	[0.86]	[42]
PBC234	2 C273	MLEV 3 EQVF	[0]	[0]	[0]

Table 7 - Calculations for the hexahedral impact problem in 3D with parabolic elements

PBC201

This test uses 0-level (parent) pinballs. The vertical displacement of node 27 is plotted in Figure 89 for this test case and the following 5 cases (all solutions with parabolic elements). The initial and final configuration for this solution are shown in Figure 90. The solution arrives at step 100 but is subjected to strong mechanisms.

PBC202

This test is similar to PBC201 but uses level 1 pinballs (MLEV 1). Additionally, the `EQVF` option is activated, according to which the volume of the final (contacting) pinballs is equivalent to the volume of the corresponding parent element portion. Strong hourglassing appears in this case and the solution stops at step 15. The final configuration is shown in Figure 91.

PBC203

This test is similar to PBC202 but uses MLEV 2. Strong hourglassing appears in this case and the solution stops at step 19. The final configuration is shown in Figure 92.

PBC204

This test is similar to PBC203 but uses MLEV 3. No solution can be obtained because there are too many redundant constraints.

PBC231

This test is similar to PBC201 but uses the fully integrated element C273 instead of the reduced-integrated element C272. Strong hourglassing appears in this case and the solution stops at step 17. The solution is shown in Figure 93.

PBC232

This test is similar to PBC202 but uses the fully integrated element C273 instead of the reduced-integrated element C272. The solution is shown in Figure 94. Strong hourglass occurs and the solution stops at step 16.

PBC233

This test is similar to PBC203 but uses the fully integrated element C273 instead of the reduced-integrated element C272. The solution is shown in Figure 95. Strong hourglass occurs and the solution stops at step 20.

PBC234

This test is similar to PBC204 but uses the fully integrated element Q93 instead of the reduced-integrated element Q92. No solution can be obtained because there are too many redundant constraints.

We may conclude that in the case of 3D parabolic elements, solutions of this simple problem seem to be very unstable and are characterized by strong hourglassing. No valid solution can be obtained.

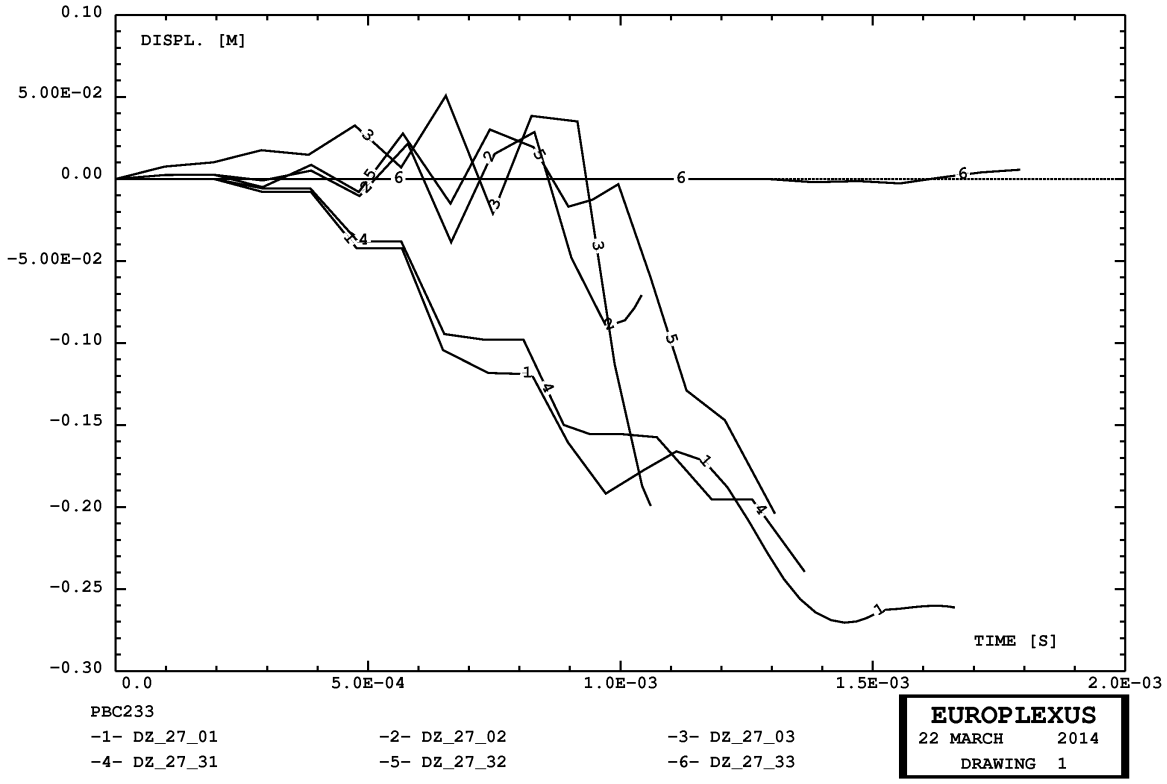


Figure 89 - Vertical displacement of node 27 in the 6 parabolic element solutions PBCXXX

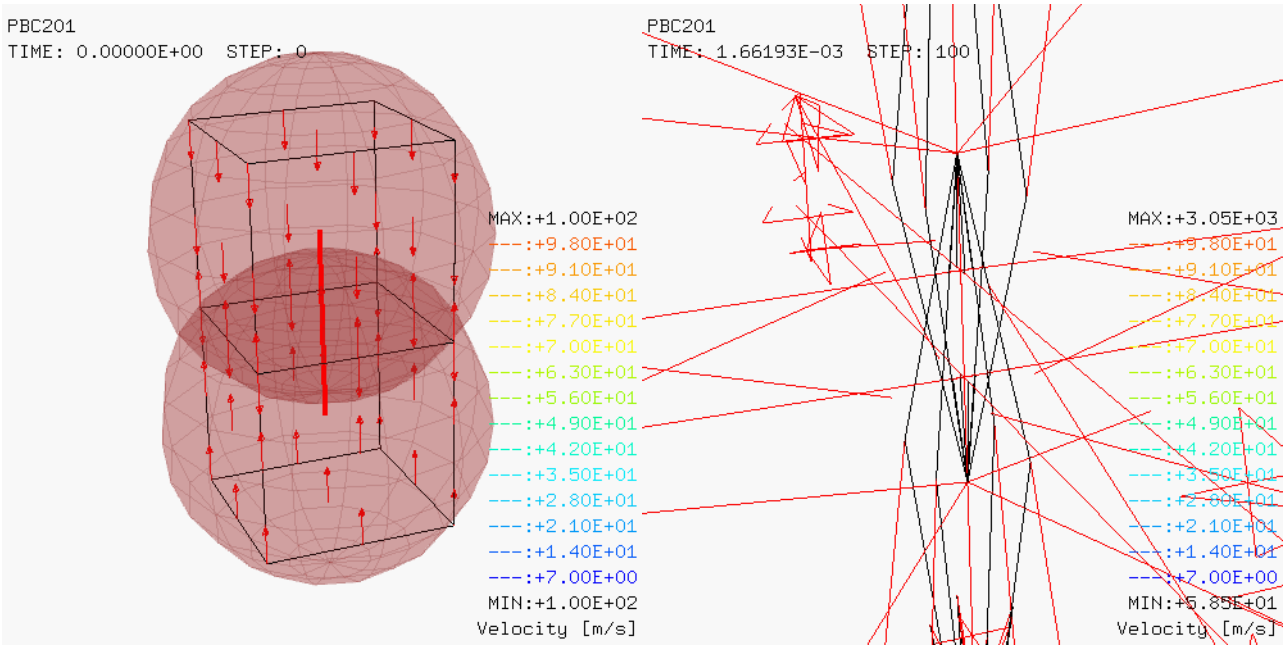


Figure 90 - Initial and final configurations for test PBC201

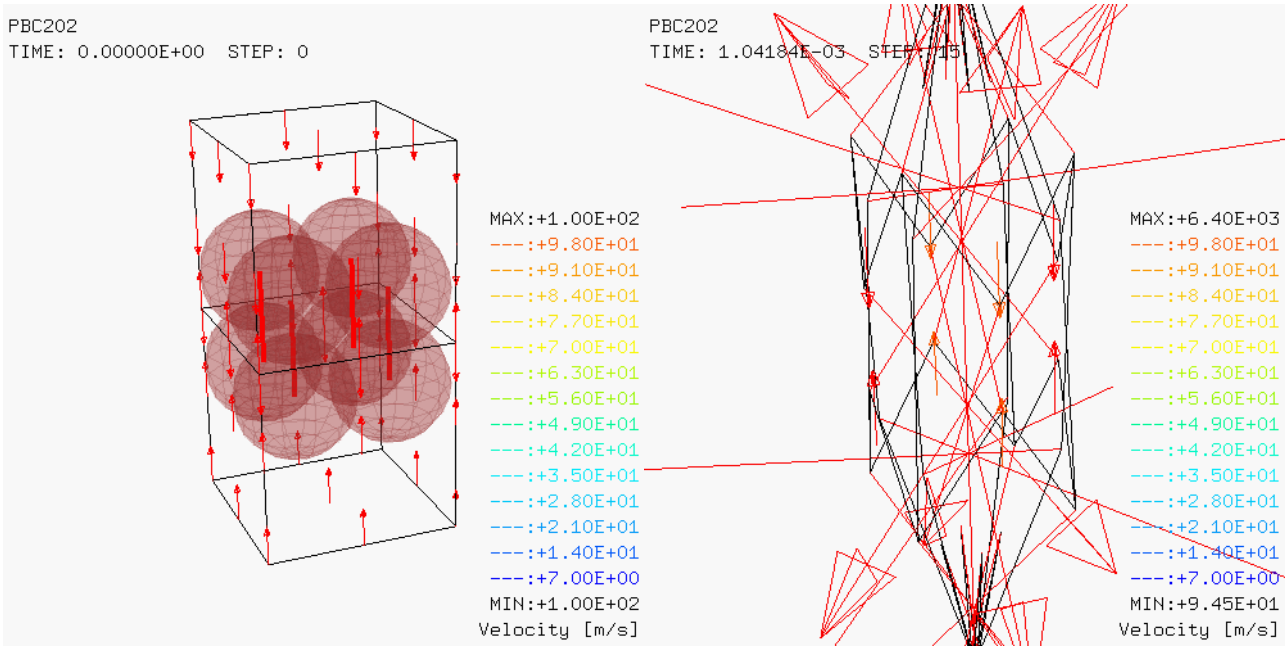


Figure 91 - Initial and final configurations for test PBC202

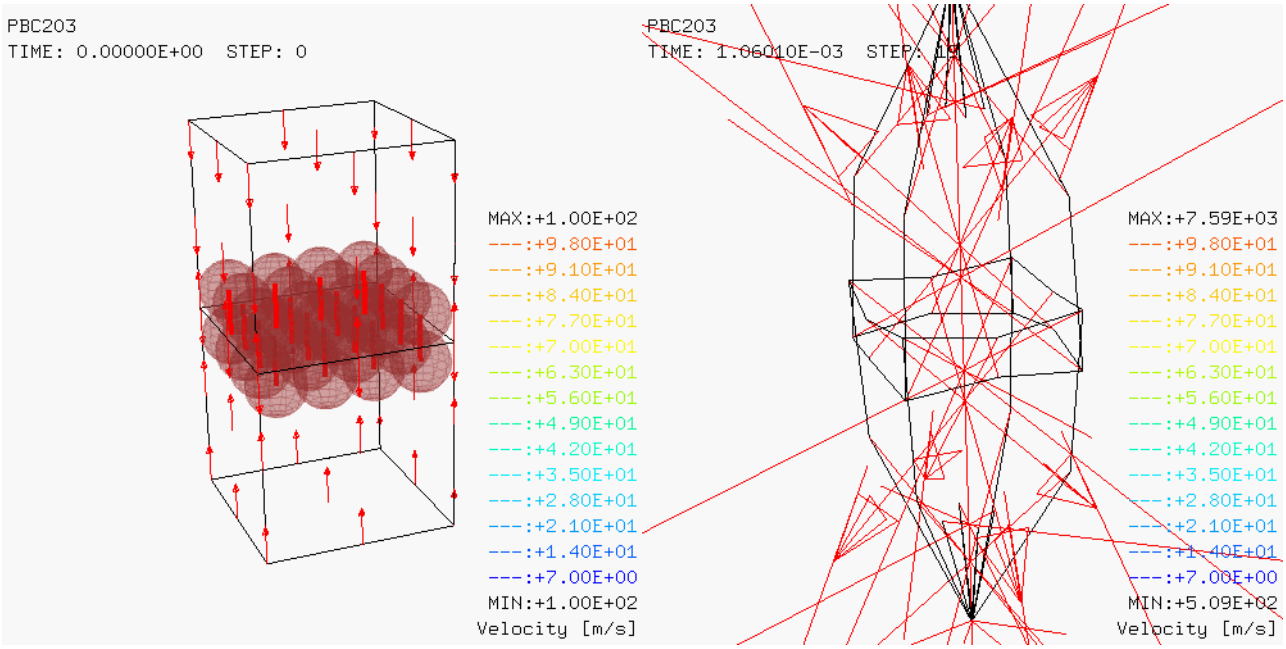


Figure 92 - Initial and final configurations for test PBC203

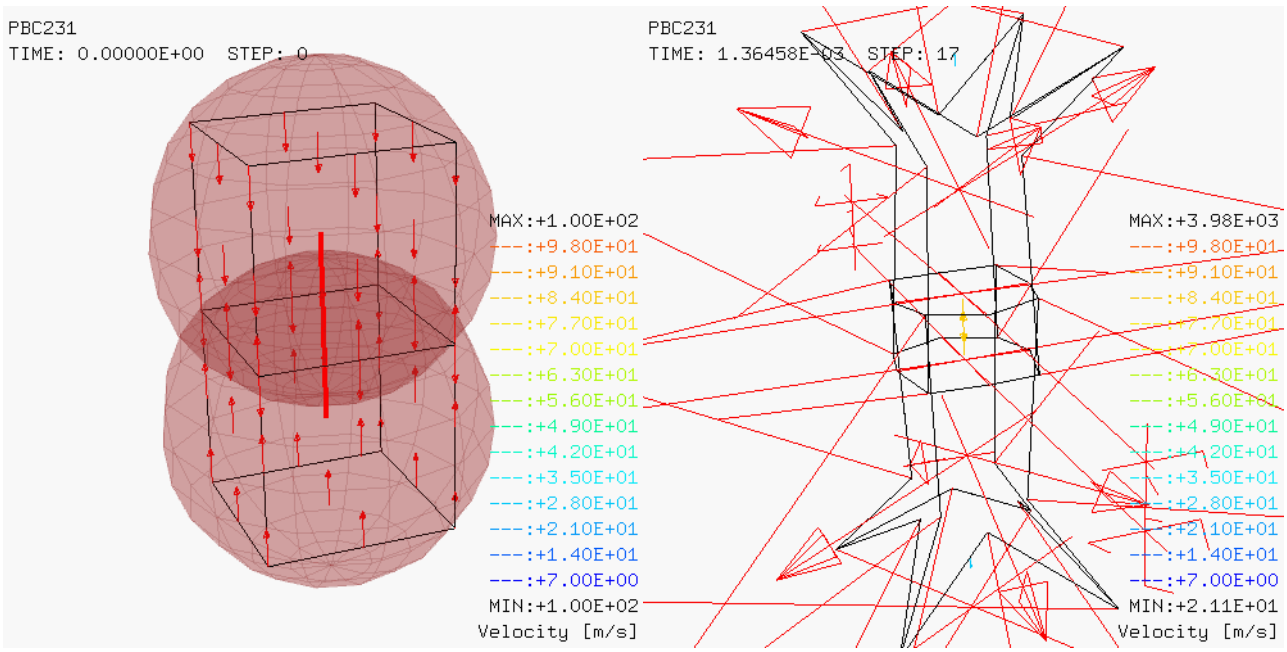


Figure 93 - Initial and final configurations for test PBC231

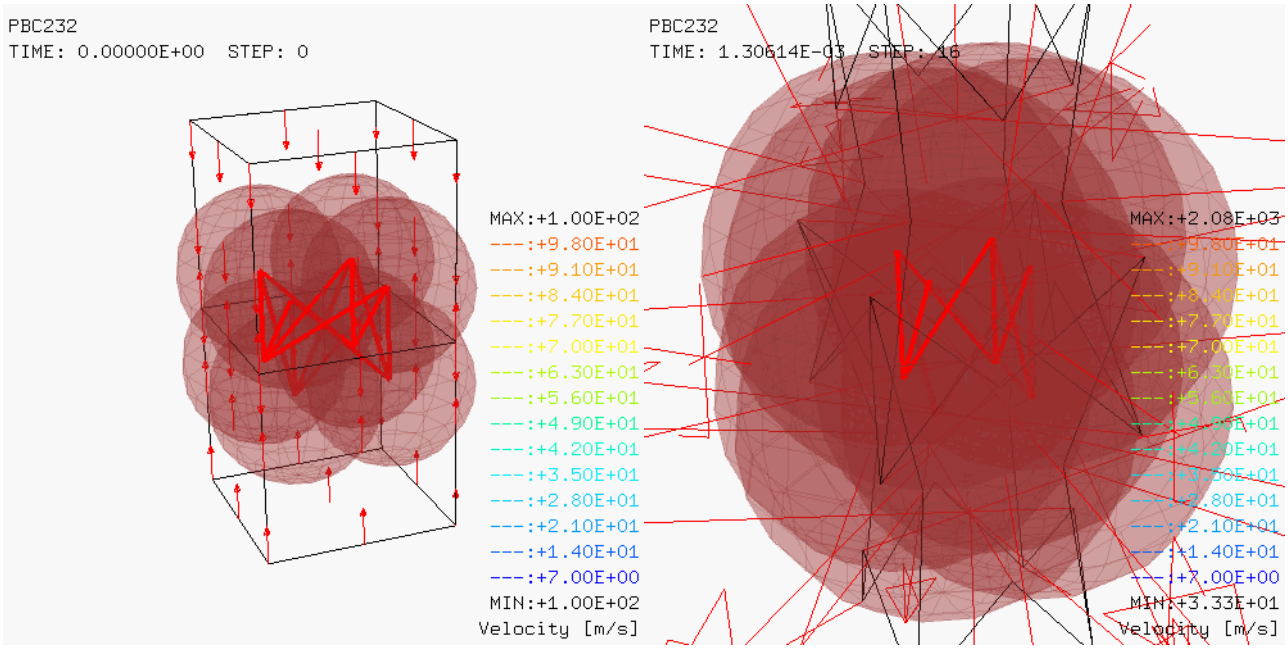


Figure 94 - Initial and final configurations for test PBC232

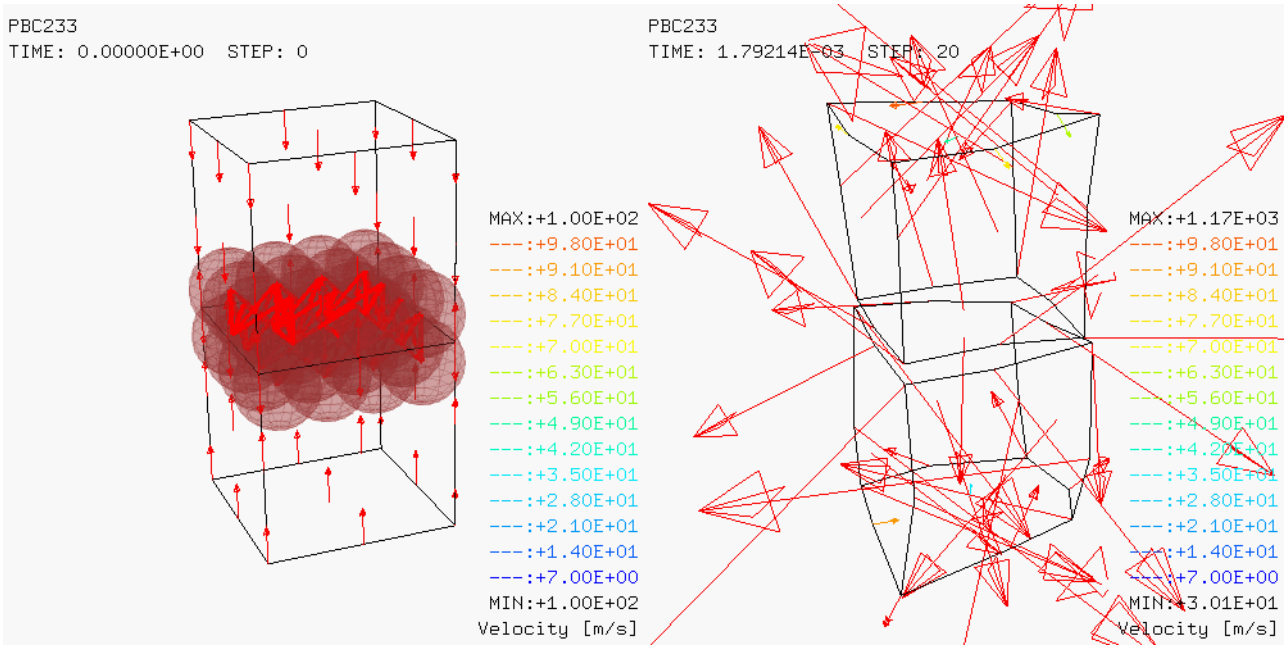


Figure 95 - Initial and final configurations for test PBC233

4. Contact problem with native parabolic pinballs

We return now to the structure crushing problem of Section 2 and attempt to solve it with the new "native" pinball formulations for parabolic elements, i.e. by using the Q93 fully-integrated 9-node quadrilateral. All performed calculations are summarized in Table 8.

Table 8 - Calculations of the structure crash problem by Q93 and native pinballs

Case	Mesh	Notes	Steps	CPU [s]	Els*step
Q93_03	4080 Q93	1 PINB SELF DMIN 0.1 EQVF	2,149,425	38,116	8.77×10^{9}
Q92_03	4080 Q92	1 PINB SELF DMIN 0.1 EQVF	[164,536]	[1,755]	[6.71×10^{8}]
Q9M_03[a]	3264 Q92 816 Q93	1 PINB SELF DMIN 0.1 EQVF	8,827,232	231,252	3.60×10^{10}
Q9M_04[a]	3264 Q92 816 Q93	1 PINB SELF DMIN 0.1 EQVF OPTI PART PLIN	[126,574] t = 2.26 s	[8,988]	[1.98×10^{9}]
Q9M_05[a]	3264 Q92 816 Q93	1 PINB SELF DMIN 0.1 EQVF OPTI PART PLIN CSTA 0.5	[535,675] t = 5.99 s	[43,815]	[8.09×10^{9}]
Q95_03	4080 Q95	1 PINB SELF DMIN 0.1 EQVF	[511,060]	[10,008]	[2.08×10^{9}]

a. These calculations were performed at JRC on \\sm02.

Q93_03

This calculation uses standard native pinballs in the Q93 elements. The mesh has been obtained by Cast3m from that of case QUA401 by transforming each QUA4 into a QUA9 via the `pxq42q92` Gibiane procedure already described in Section 2.3.

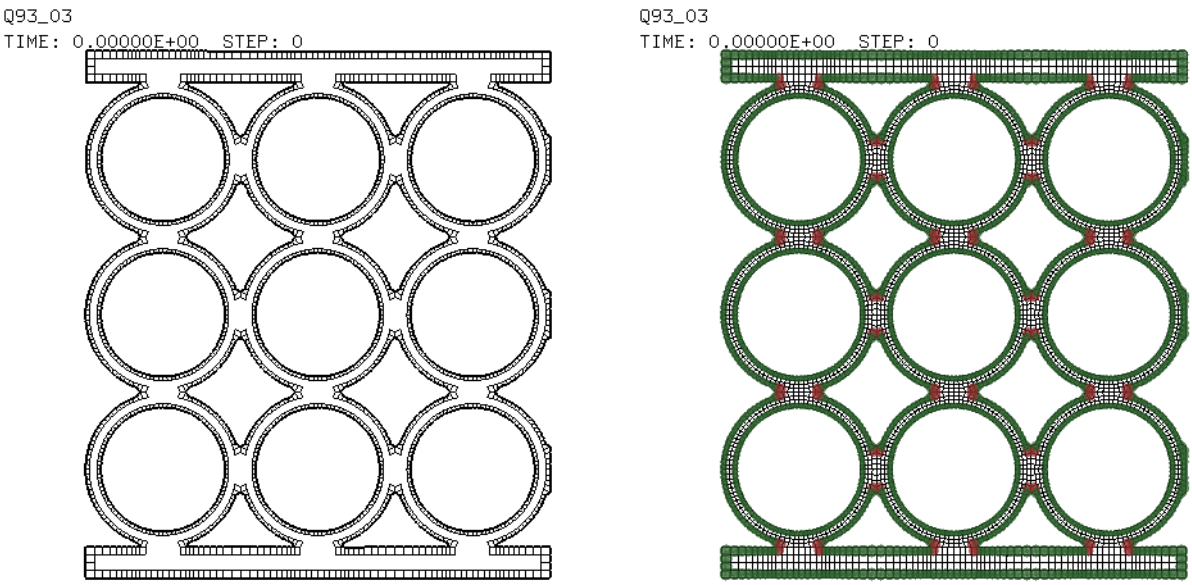


Figure 96 - Pinballs zone in case Q93_03

For simplicity (of the user, but not of the code) there is just one zone with embedded pinballs, which encompasses the whole external surface of the model, see Figure 96. The zone is declared as a self-contacting body (`PINB SELF`). Hierarchic pinballs are activated by specifying a minimum pinball diameter of 0.1 mm (`DMIN 0.1`). A fast search of pinball contacts is activated for efficiency of the computation by the option `OPTI PINS GRID`.

The progressive crushing of the structure (every 2.5 s) is illustrated in Figure 97. Figure 98 shows the final plastic strain. The first contacts appear at about 3.65 s. There remains, like in case Q93_02, a strange occurrence of large (non-physical) plastic strains localized in a couple of elements (see red circles in Figure 98. This spurious plasticization appears very early in the transient, starting from 0.1 s of physical time. It might be due to a meshing problem, or to a locally too distorted shape of the element in the initial configuration. The problem is under investigation.

Figure 99 shows the final contacts in the structure. All the contacts seem physical in this solution.

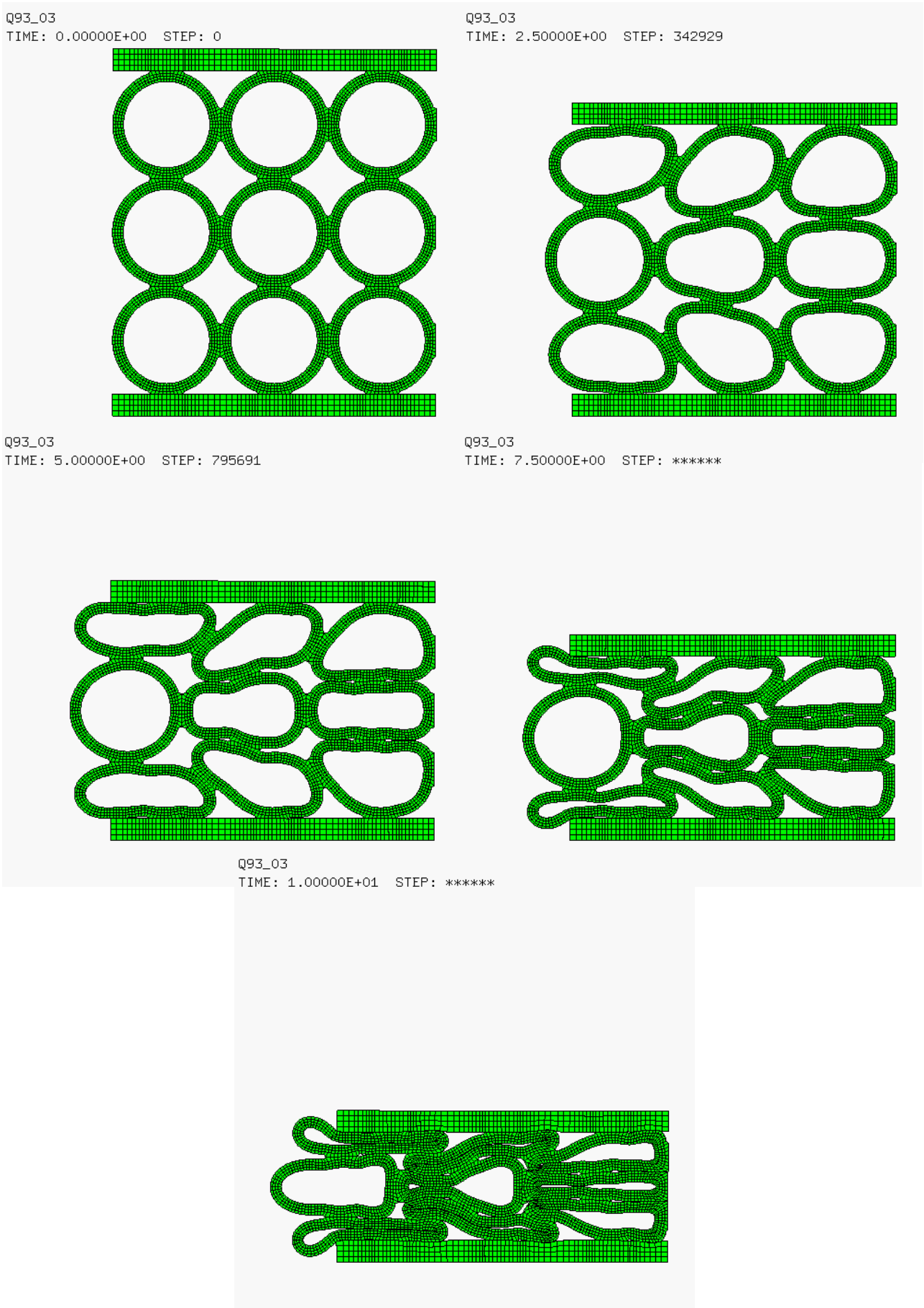
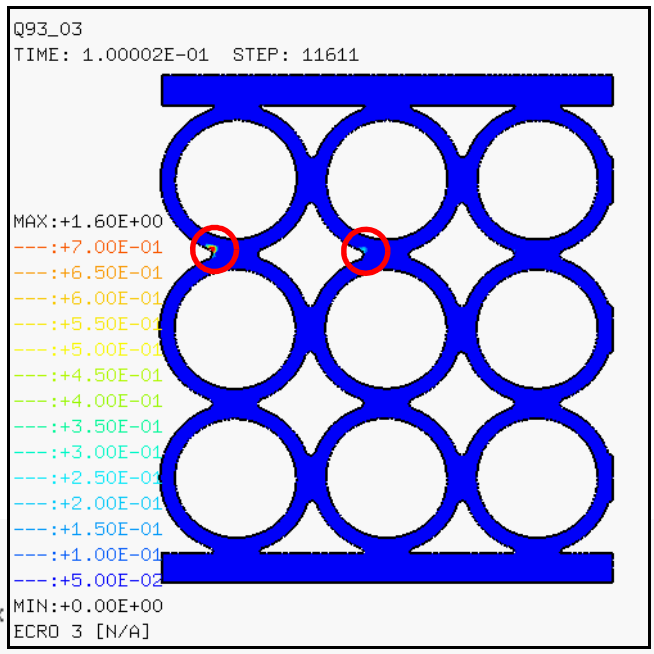


Figure 97 - Structure crushing in case Q93_03

spurious plasticization
from t = 0.1 s



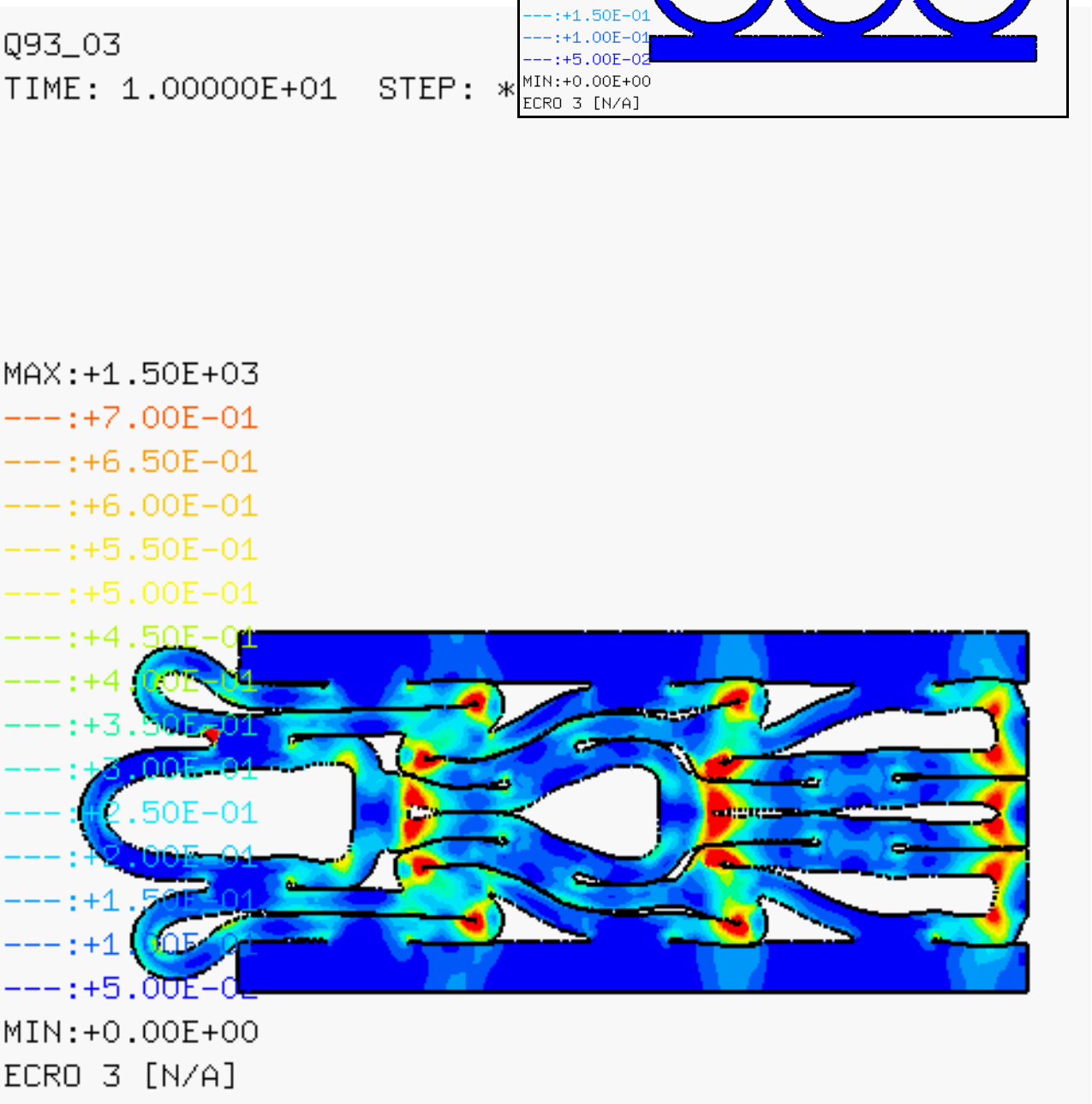


Figure 98 - Final plastic strain in case Q93_03

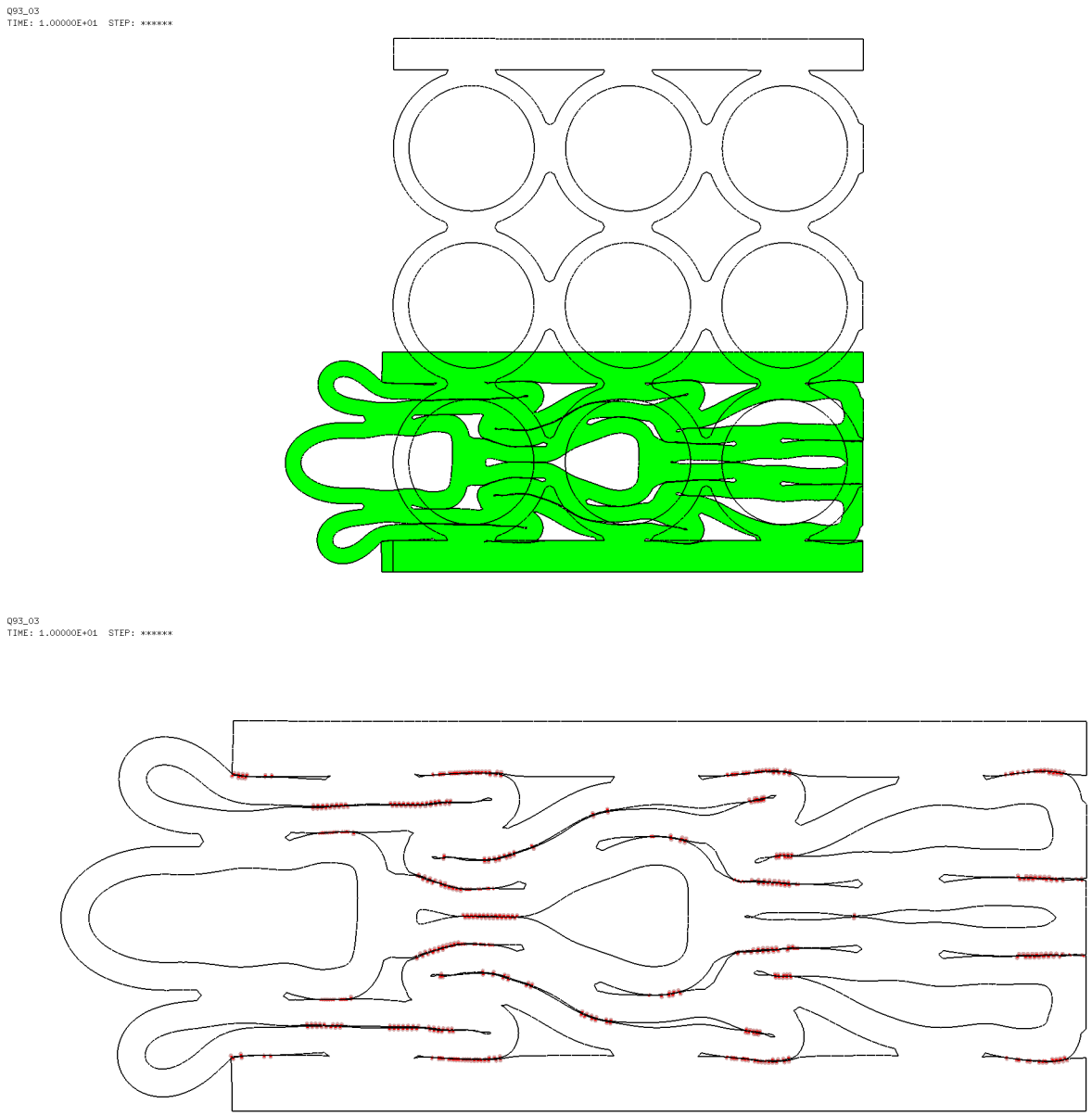


Figure 99 - Final contacts in case Q93_03

Figure 100 shows the resulting crushing force vs. displacement of the top plate. The force is obtained by adding all vertical nodal forces in the nodes on the upper part of the top plate.

Finally, Figure 101 compares the crushing force obtained in the three solutions:

- CAR401, with the CAR4 linear element, red curve, is too stiff
- Q93_02, with Q93 parabolic element and superposed ghost Q41L elements for the contact, green curve, is more ductile (in better accordance with the experiments), but presents some strong oscillations at about 9 s when the crushing is almost complete.

- Q93_03, with Q93 parabolic elements and “native” pinballs, black curve, is ductile and presents no oscillations.

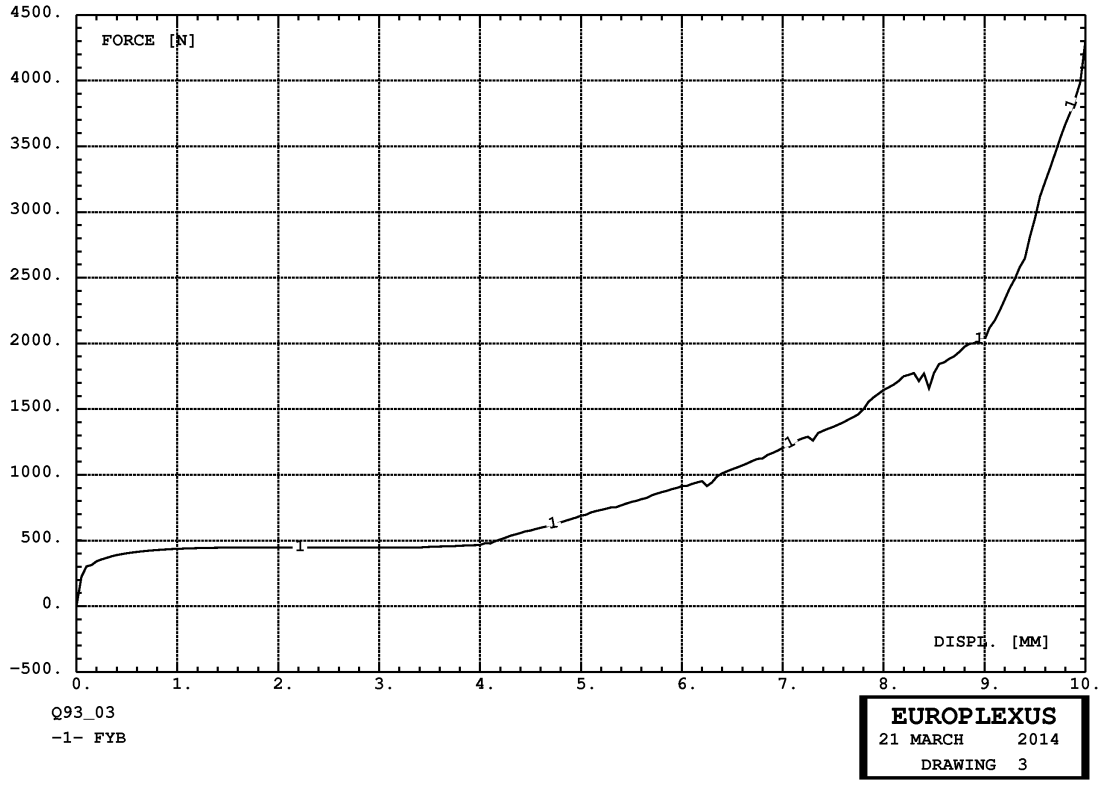


Figure 100 - Crushing force vs. imposed displacement in case Q93_03

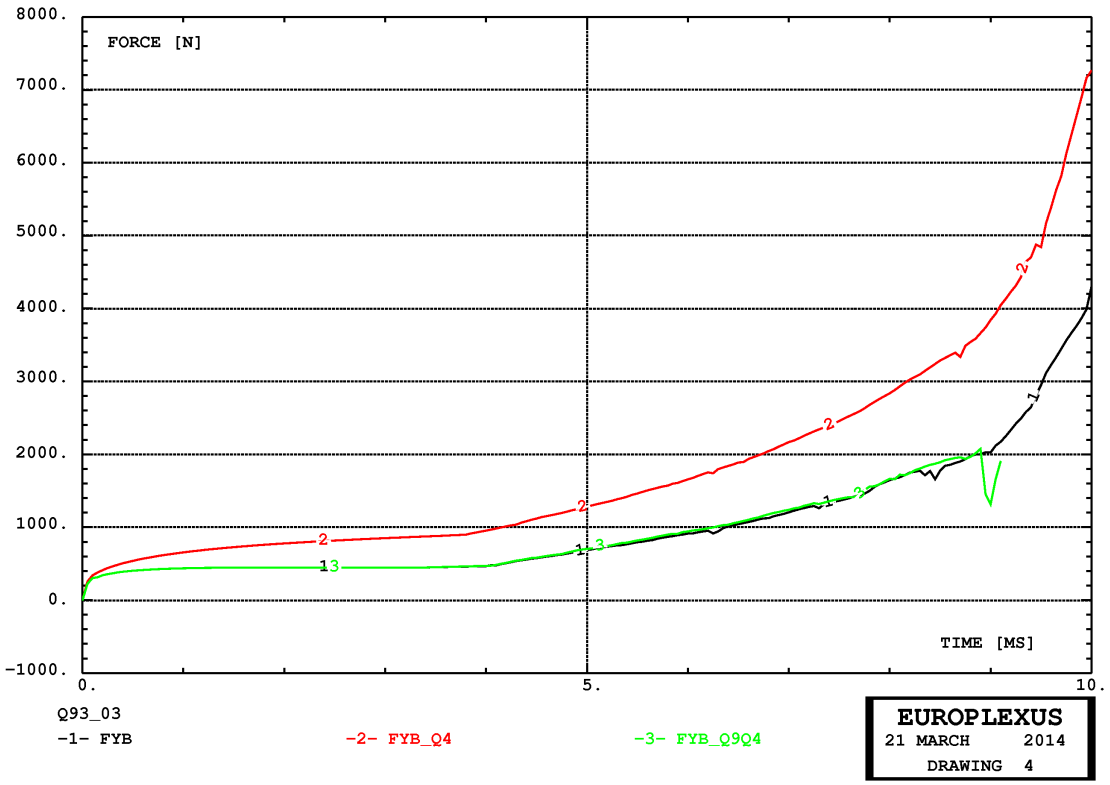


Figure 101 - Crushing force vs. imposed displacement in case Q93_03

Q92_03

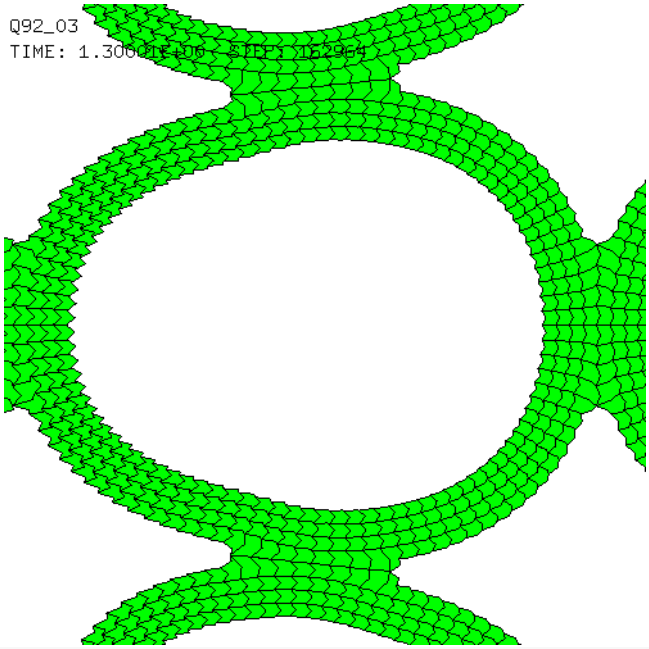
This calculation is identical to Q93_03 but uses the Q92 reduced-integrated element instead of the Q93 fully integrated element. The scope is to see whether the spurious early plastic deformation noted in the previous test depends on the type of numerical integration.

This calculation stopped at step 164,536 at a time of 1.31 s, because of “negative area” in one of the elements. No contact has occurred yet at this time. The failure is due to the onset of hourglass modes, which are known to affect the (under-integrated) Q92. However, the calculation is useful because:

- No early plasticization occurs, showing that this phenomenon is peculiar of the Q93 (fully integrated) element. Some analysis of the problem leads to think that the phenomenon is related to the heavily irregular initial shape of the element in which the phenomenon occurs. This element has an angle of about $130°$ in the initial configuration and this is by no means advisable. An element *can* undergo very large *distortions*, but its *initial* shape should be relatively regular (especially as angles are concerned). No attempt has been made to modify the mesh because this was not readily available, but a test in such sense would be quite interesting.
- Despite the hourglass, the Q92 solution remains *very precise* in terms of strains, stresses and crushing force until the end of the calculation. The calculation crash is due purely to a geometrical issue (a negative area) which, unfortunately, is fatal. This is very well known, and logical since hourglass modes are zero-energy modes by definition, so they produce no strains and no stresses.

Figure 102 shows the mesh at 1.3 s, with the typical hourglass modes. Figure 103 shows the equivalent plastic strain distribution at the same time. Finally, Figure 104 compares the crushing force (black curve) with the one obtained with the Q93 element (in cyan), the one obtained with the ghost mesh (in green) and the one obtained with the QUA4 element (in red). The agreement between the first three solution mentioned is remarkably good.

Zoom showing the hourglass modes



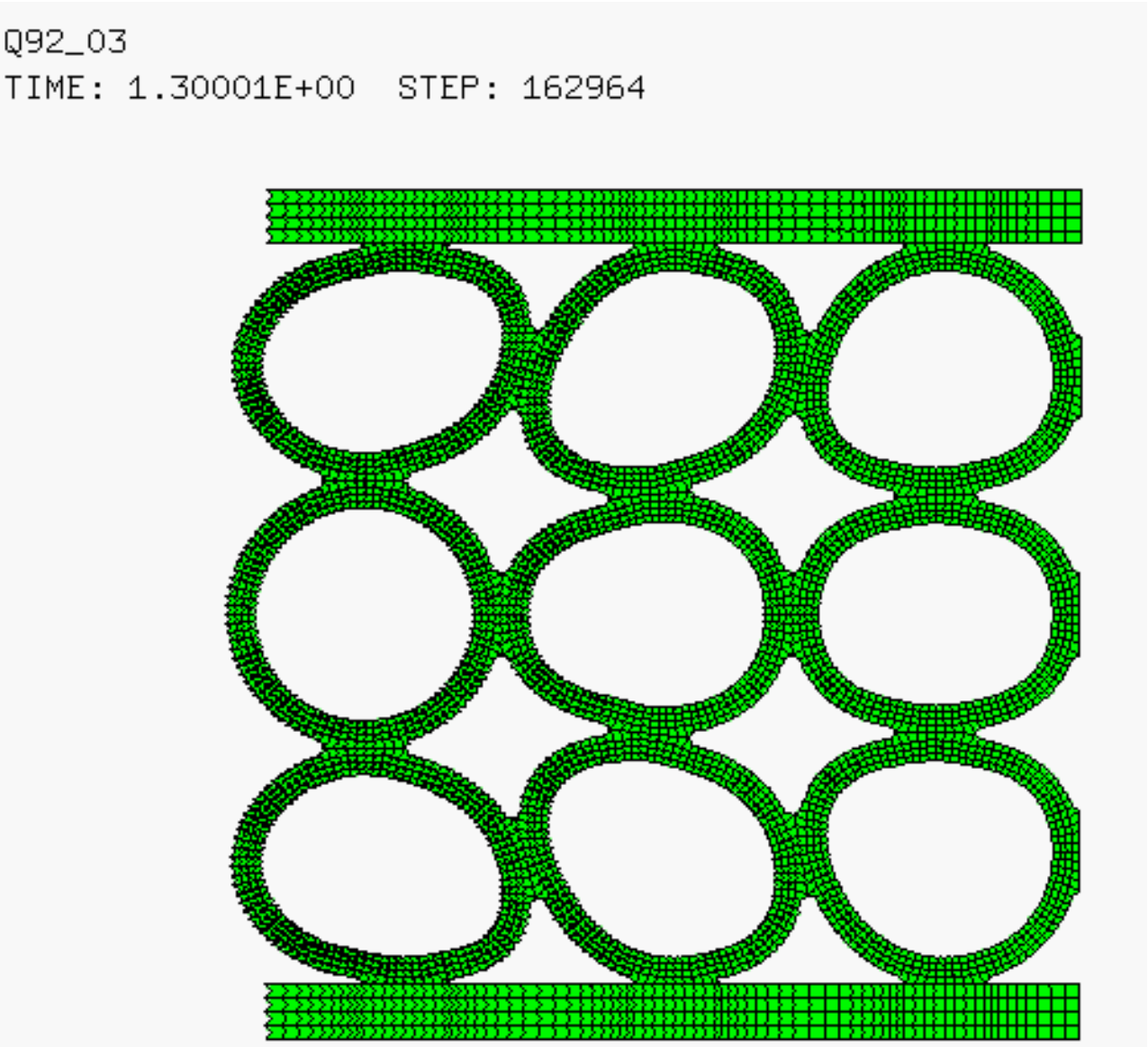


Figure 102 - Distorted mesh with hourglass modes in case Q92_03

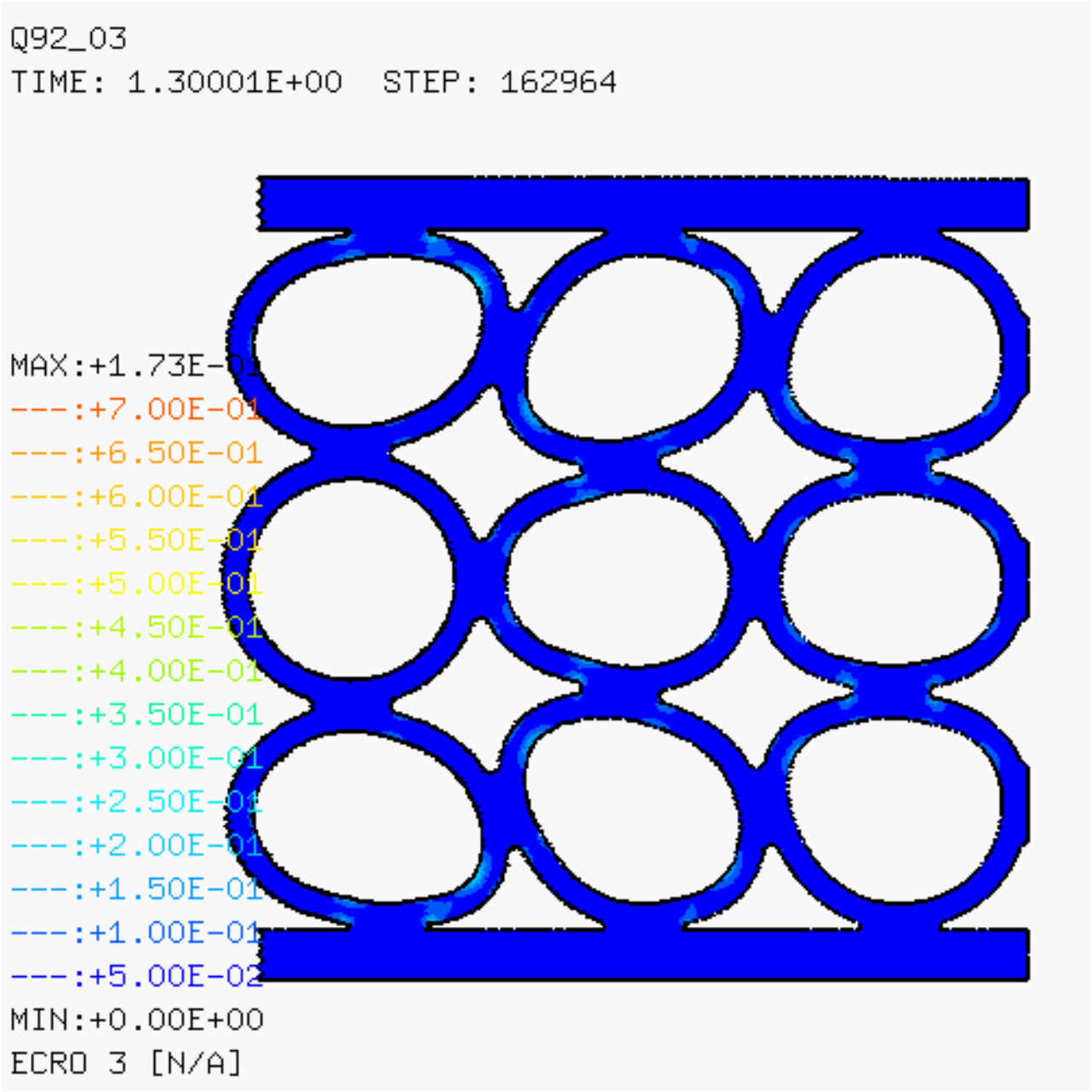


Figure 103 - Equivalent plastic strain in case Q92_03

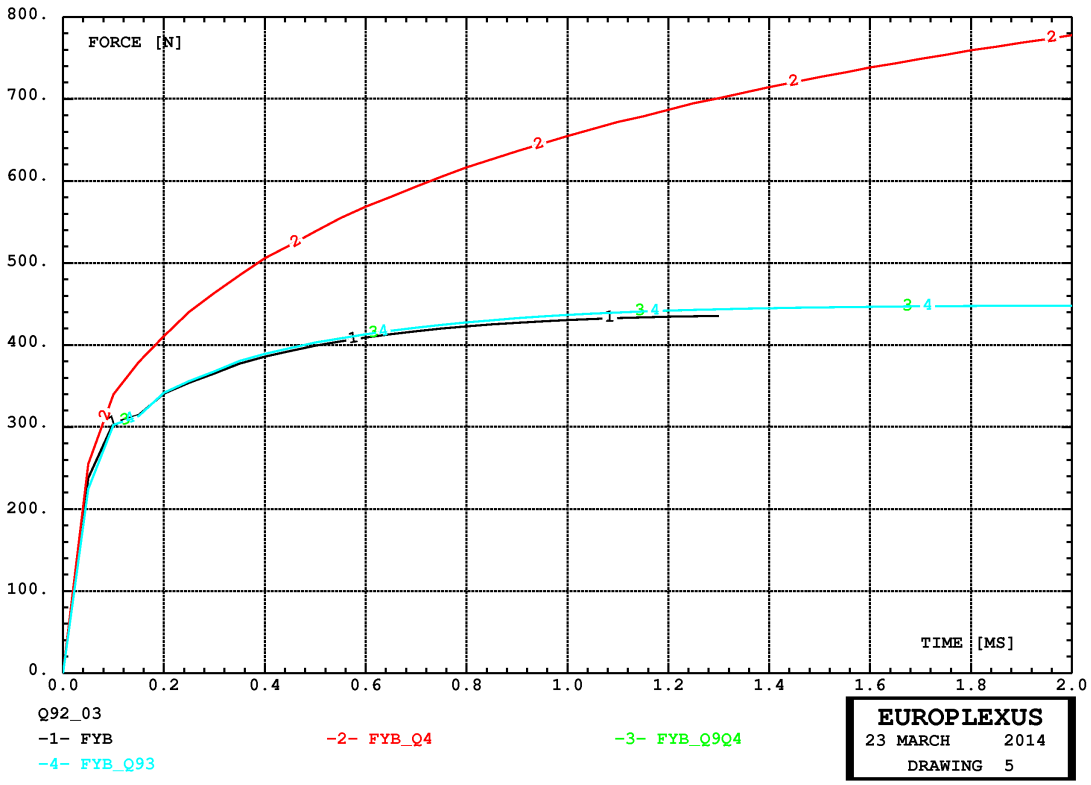


Figure 104 - Crushing force in case Q92_03 compared with previous solutions

Q9M_03

This calculation is identical to Q93_03 but uses a mixture of Q92 and Q93 elements, namely one Q93 every 5 elements (the remaining four being Q92). The scope is to obtain a solution with the advantages of the reduced-integrated element Q92 (cheap, no spurious early plasticization), but without its drawbacks (hourglassing).

The mixed mesh is obtained in Cast3m by an ad-hoc procedure, see file `readq4q9mixed.dgibi` in the Appendix. This results in 3,264 Q92 and 816 Q93.

This calculation became very slow at step 3,516,188 and time 8.77 s because the critical step of an element became very small ($\Delta t = 7.\times 10^{-8}$) and the calculation could hardly advance, due to severe distortion of elements near the folds. The CPU at 8.77 s was 52,637 s. However, the energy check was still perfectly OK at that time so the solution was (repeated and) left to continue on a different machine (\\sm02 at JRC), and terminated normally at step 8,827,232 with a total CPU time of 231,252 s for 10 s of physical time.

The solution was (as could be expected) slightly more ductile than with Q93 and for this reason some elements near the folds became very distorted. A calculation with time step partitioning could per-

haps make it until 10 s of physical time with more reasonable CPU, but it remains to try (see cases Q9M_04 and Q9M_05 below). No sign of (significant) hourglassing is present in this solution, except perhaps in the most severely distorted elements at the folds, but this is difficult to distinguish from physical distortion.

Figure 105 shows the final configuration, showing a few contacts. More details are visible in Figure 106. Figure 107 shows the equivalent plastic strain, reaching a maximum of 163% in some folds. No spurious early plasticization is observed. The deformation with the element types (green for the Q92, red for the Q93) is shown in Figure 108.

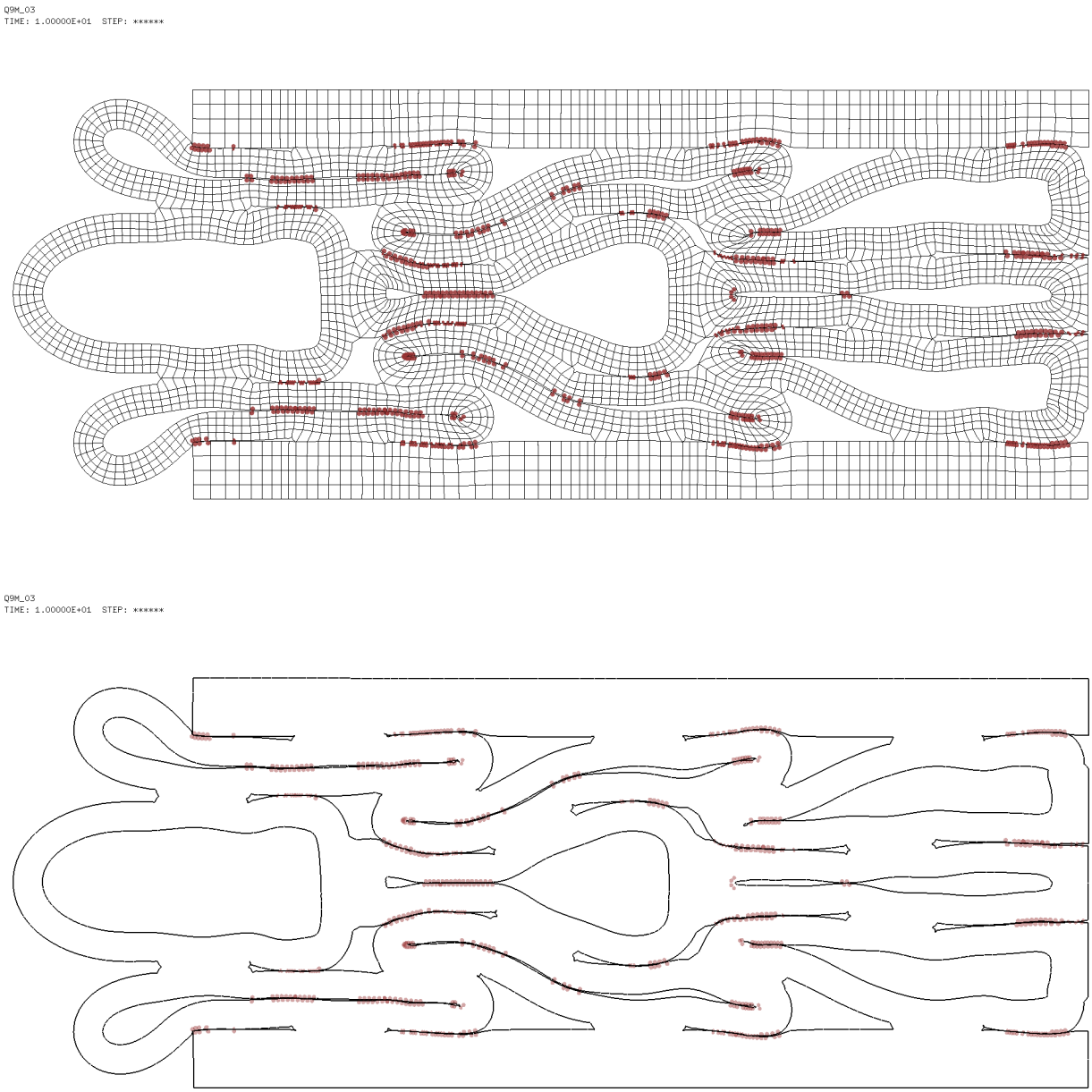


Figure 105 - Distorted mesh with contacts at 8.75 s in case Q9M_03

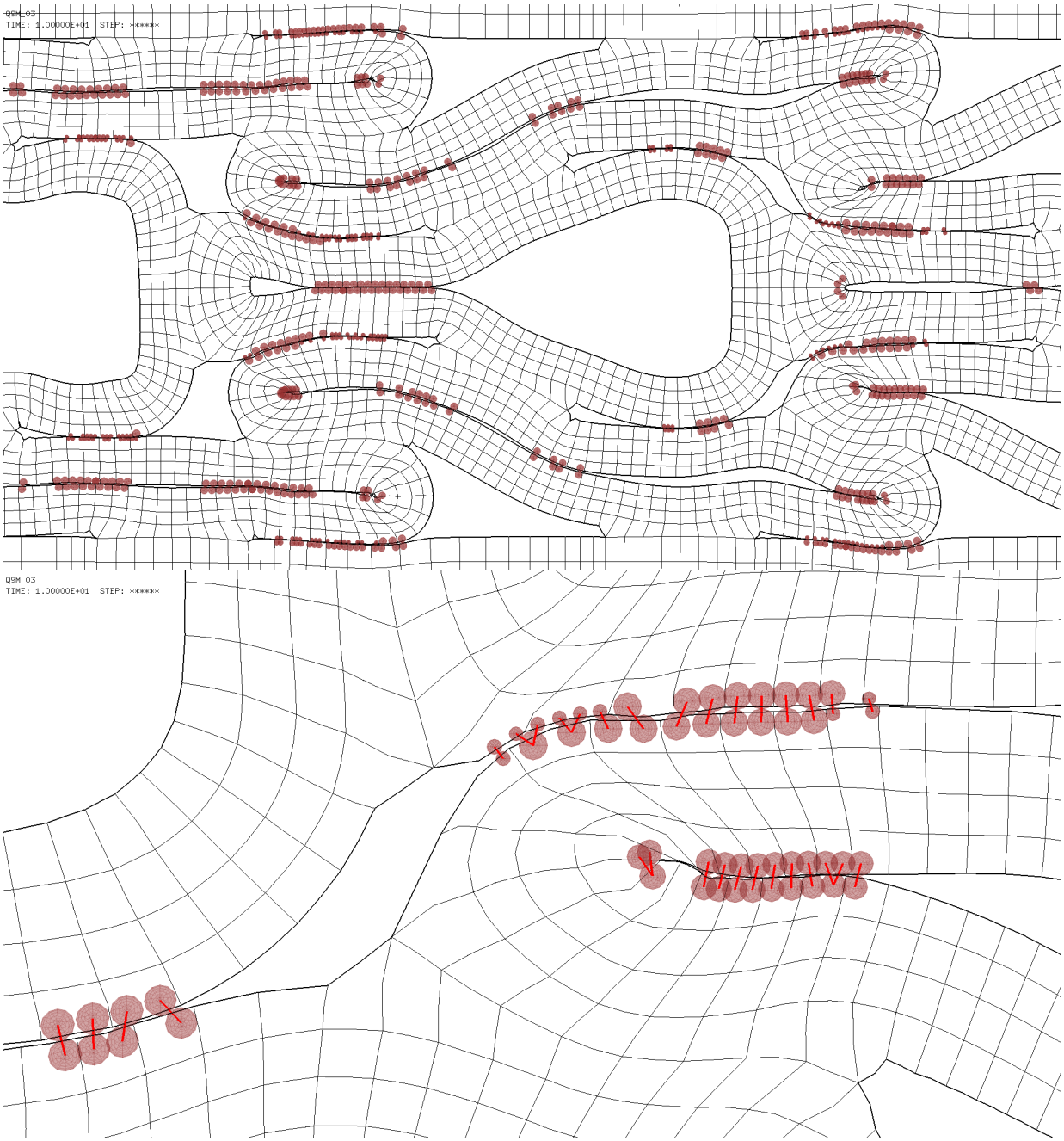


Figure 106 - Distorted mesh and contact details at 8.75 s in case Q9M_03

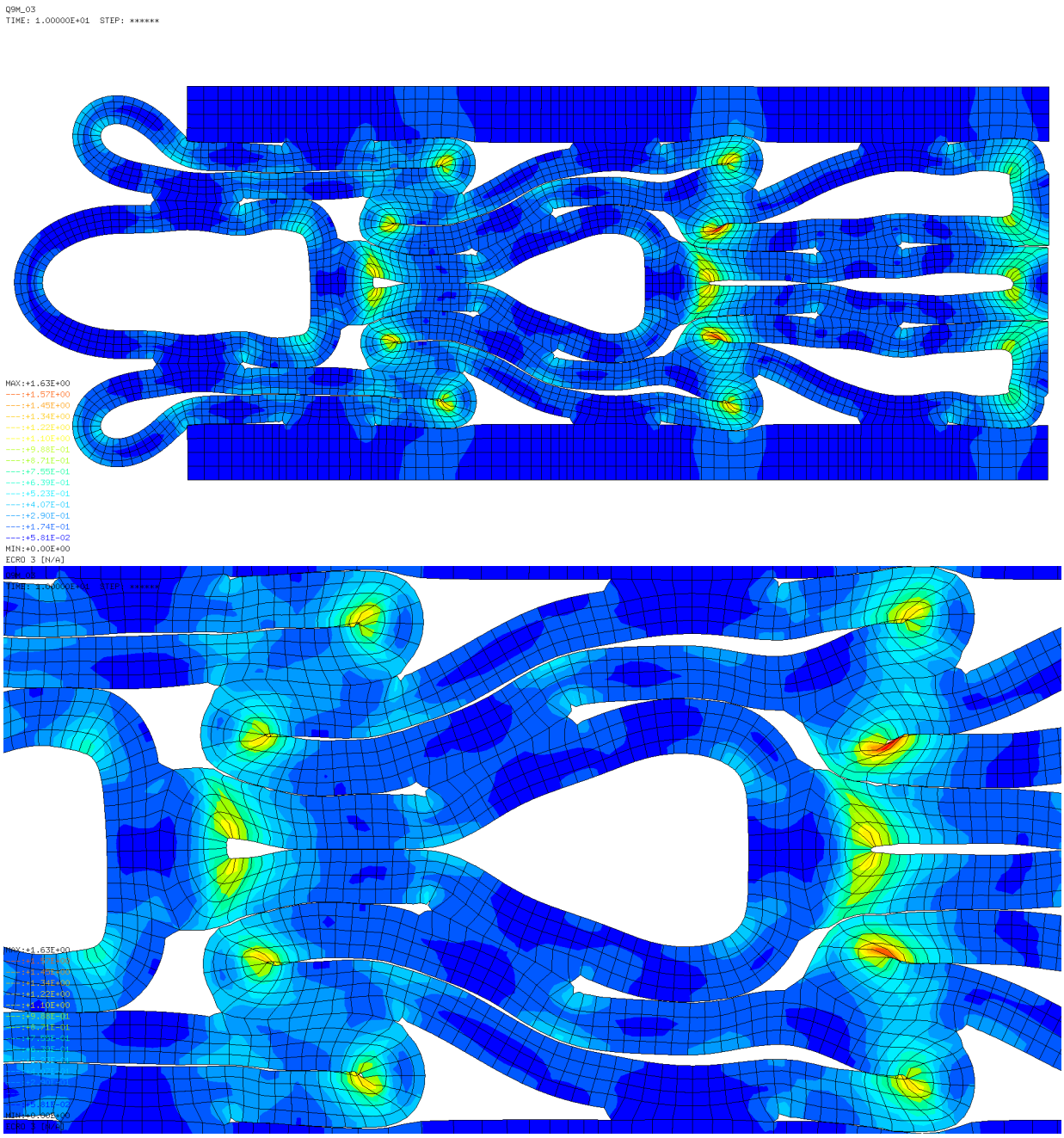


Figure 107 - Equivalent plastic strain at 8.75 s in case Q9M_03

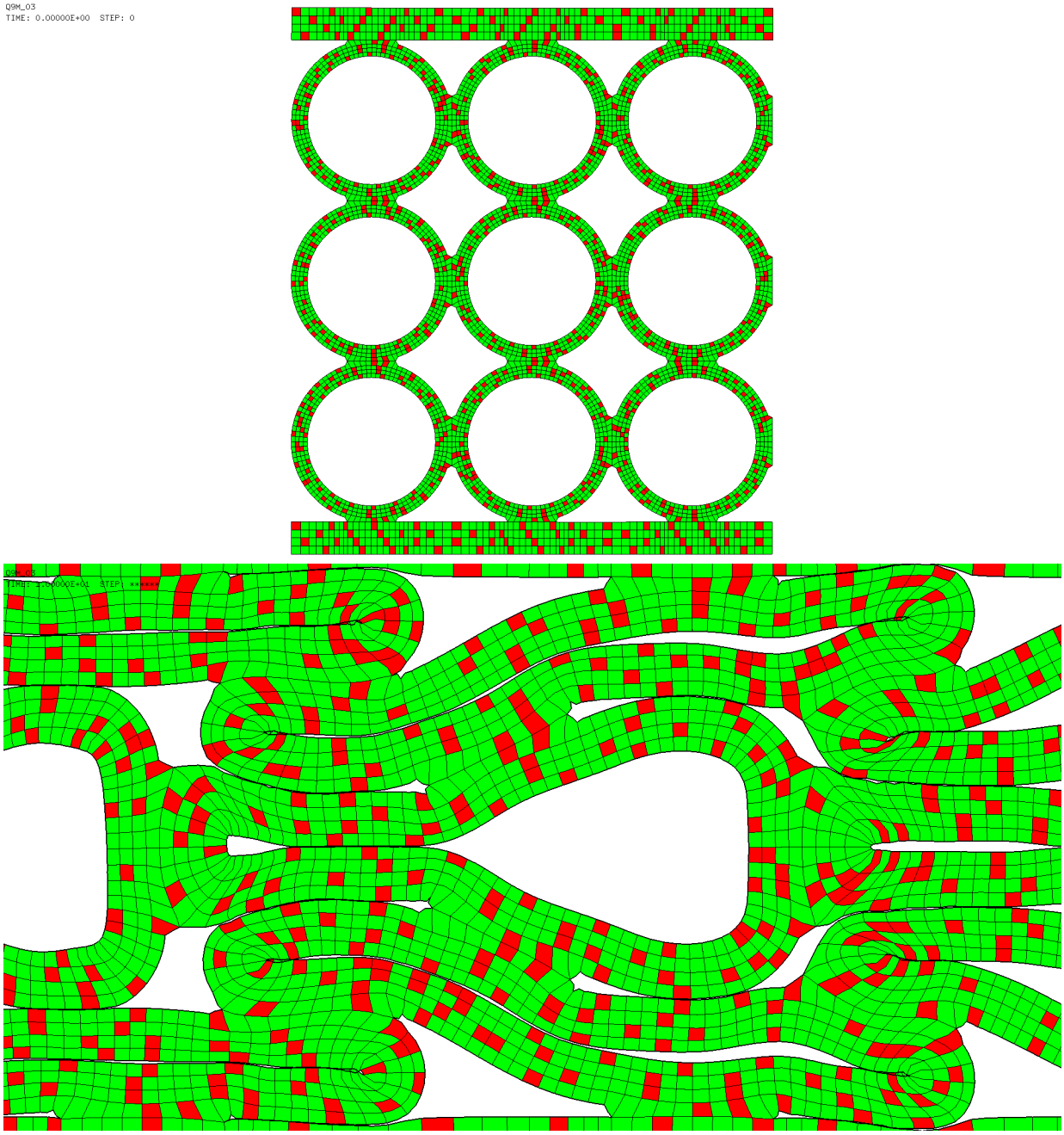


Figure 108 - Element types in case Q9M_03

Figures 109 and 110 compare the crushing force with those of previous solutions and Figure 111 compares the critical time step with that of the calculation with all Q93.

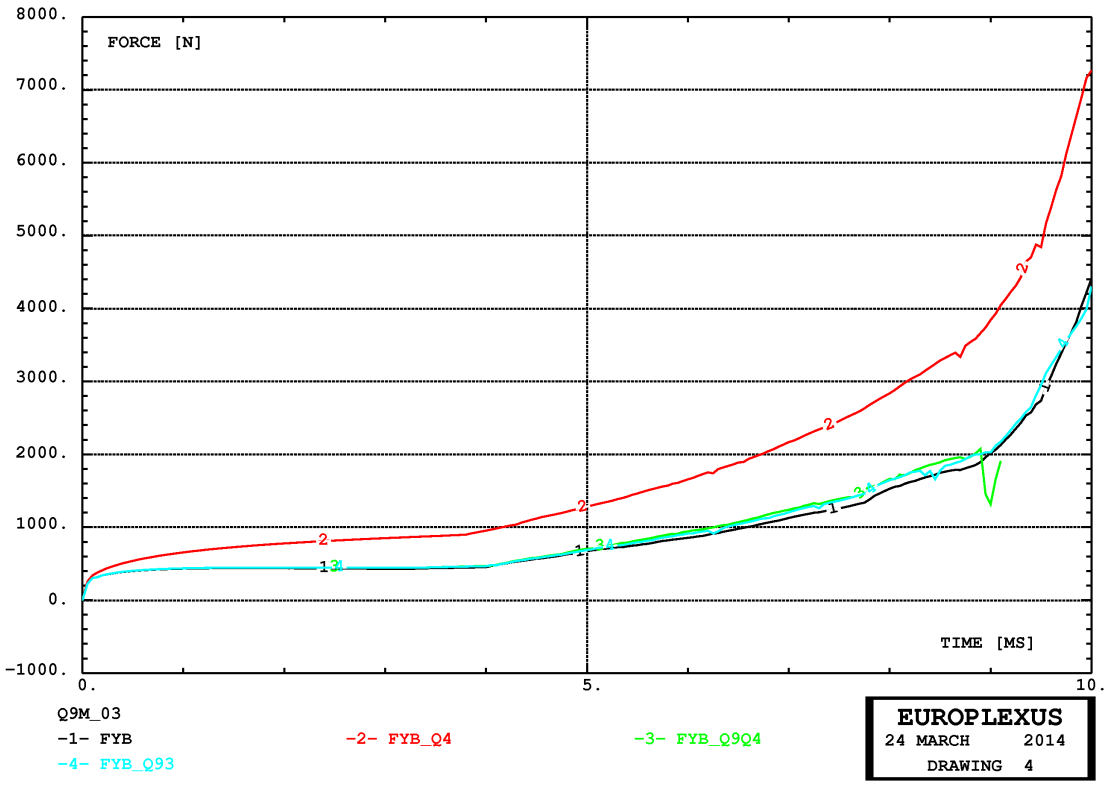


Figure 109 - Crushing force in case Q9M_03 compared with previous solutions

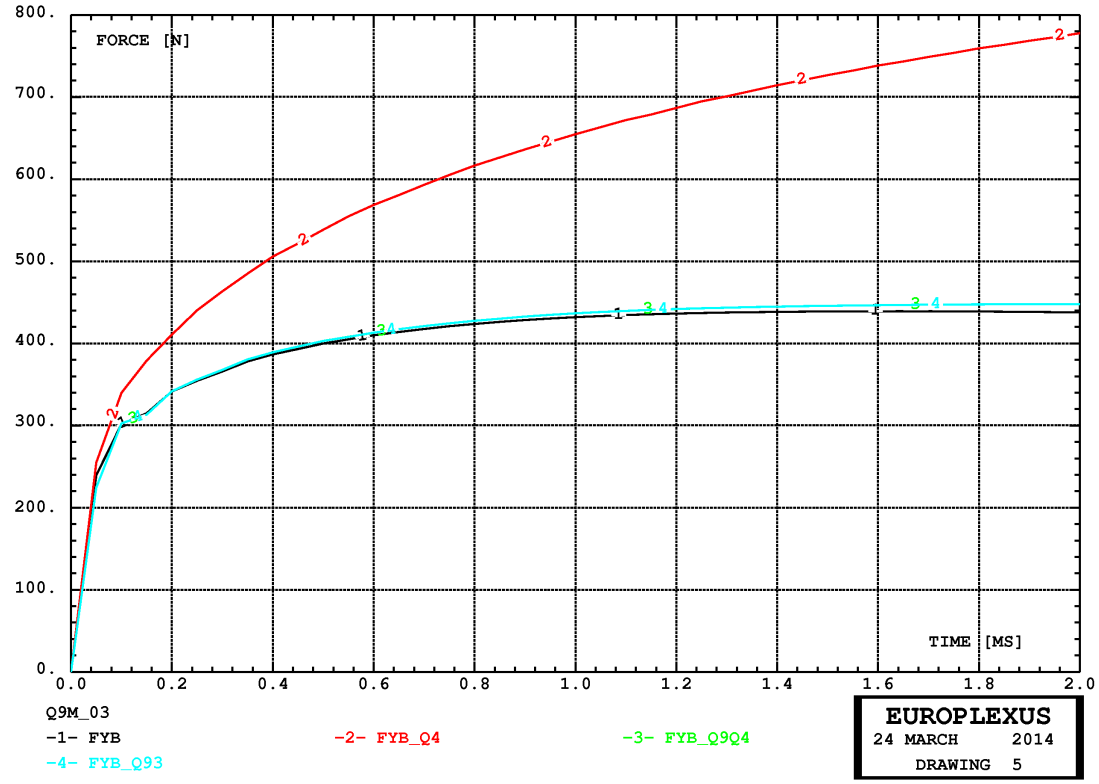


Figure 110 - Crushing force (detail) in case Q9M_03 compared with previous solutions

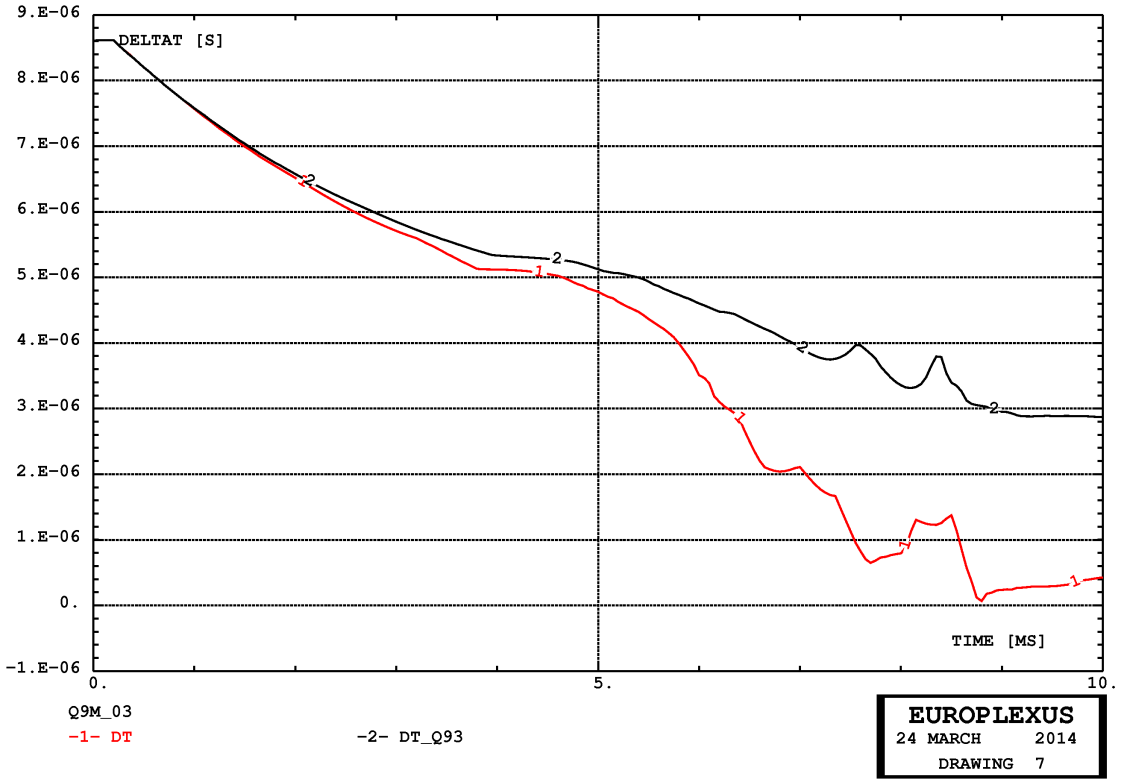


Figure 111 - Critical step in case Q9M_03 (red) and Q93_03 (black)

Q9M_04

This calculation is identical to Q93_03 but uses the `OPTI PART PLIN` option (spatial time step partitioning) in an attempt to reduce the CPU time. The calculation is unstable and stops at step 126,574, at a physical time of 2.26 s. This may happen with space partitioning since all elements are time-integrated with a local time step, which is therefore much closer to the stability limit of the element itself.

Figure 112 shows the distorted mesh with element types (Q93 in red, Q92 in green). In Figure 113 some local instabilities can be noted near the bottom of the model. Due to instabilities, almost the whole model plasticizes, as shown in Figure 114. A maximum equivalent plastic strain of 936 is reached, which is of course totally un-physical.

Q9M_05

This calculation is identical to Q93_04 but uses `CSTA 0.5`. The calculation is stable initially, but it stops at step 535,675, at a physical time of 5.99 s, due to the Jacobian becoming zero (too distorted element) in element 3370.

Figure 115 shows the distorted mesh with the element types (Q93 in red, Q92 in green). Figure 116 shows the contacts. Note that some strange element deformation takes place at contacts near the top and bottom of the model, between the plates and the rings.

Figure 117 shows the equivalent plastic strain. Spurious plasticization of the above mentioned contacting elements can be observed.

Figure 118 compares the crushing force (in black) with those of other solutions (in color). The crushing force is correct until about 5.5 s (see also Figure 119), when local oscillations start to appear probably due to the above-mentioned wrong contacts.

Finally, Figure 120 compares the critical time steps of the various solutions.

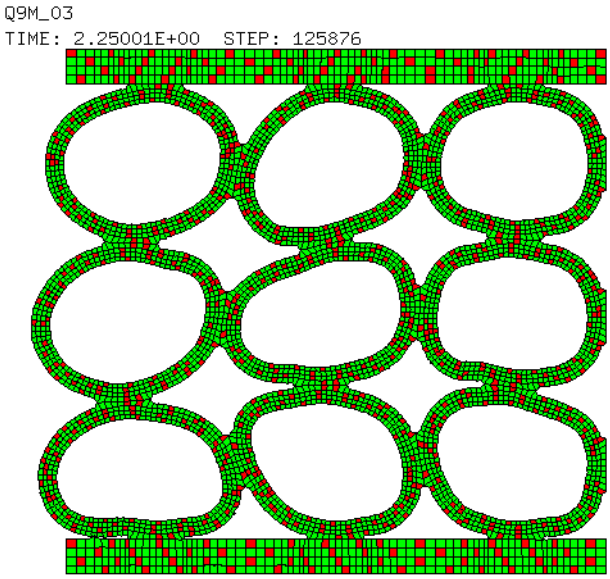


Figure 112 - Distorted mesh with element types in case Q9M_04

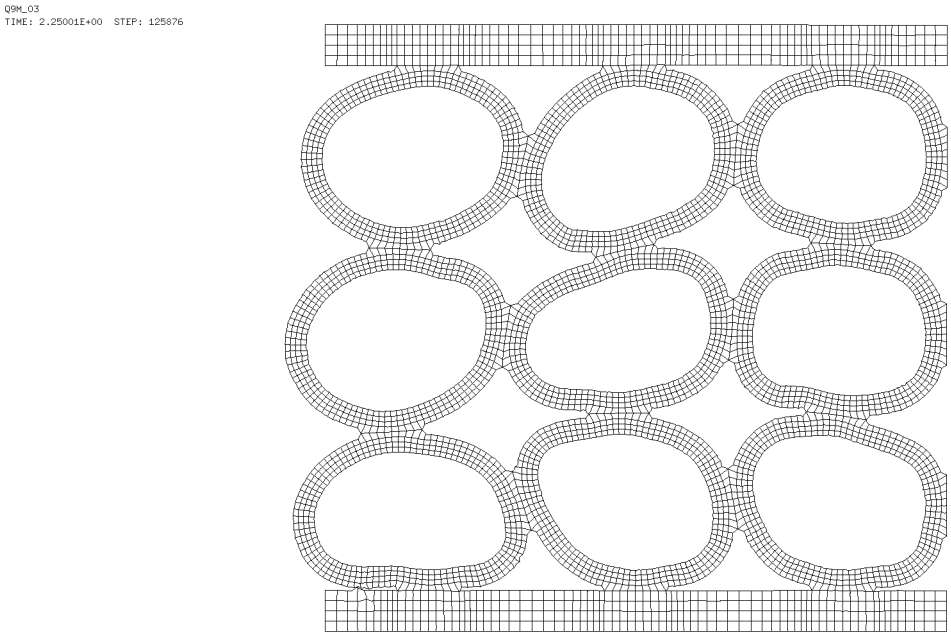
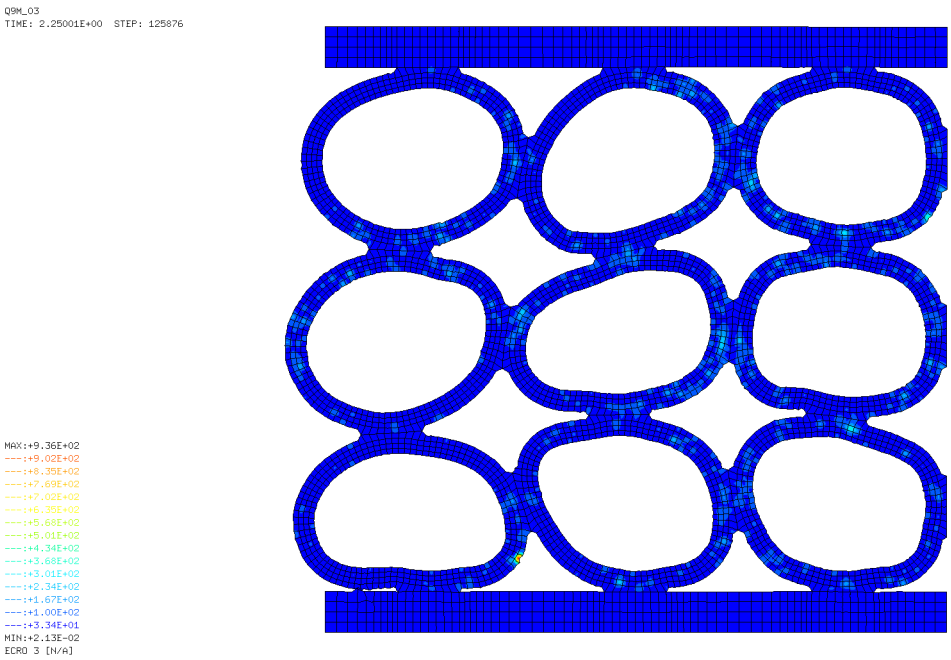


Figure 113 - Distorted mesh and some local instabilities in case Q9M_04



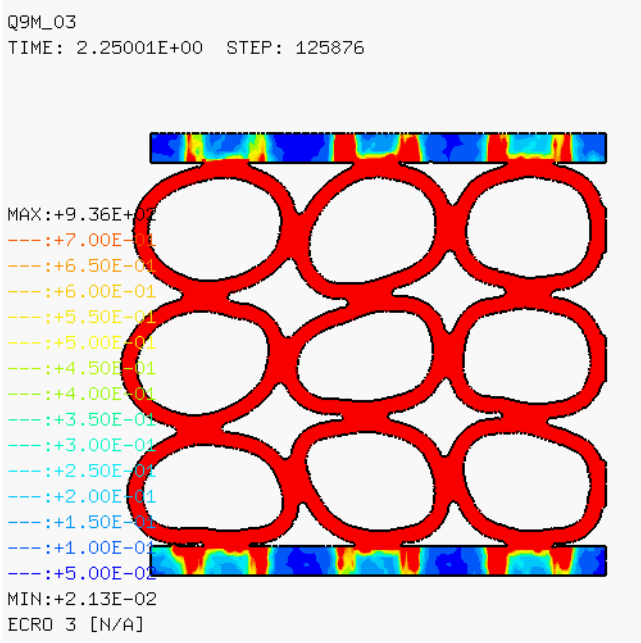


Figure 114 - Equivalent plastic strain (at two different scales) in case Q9M_04

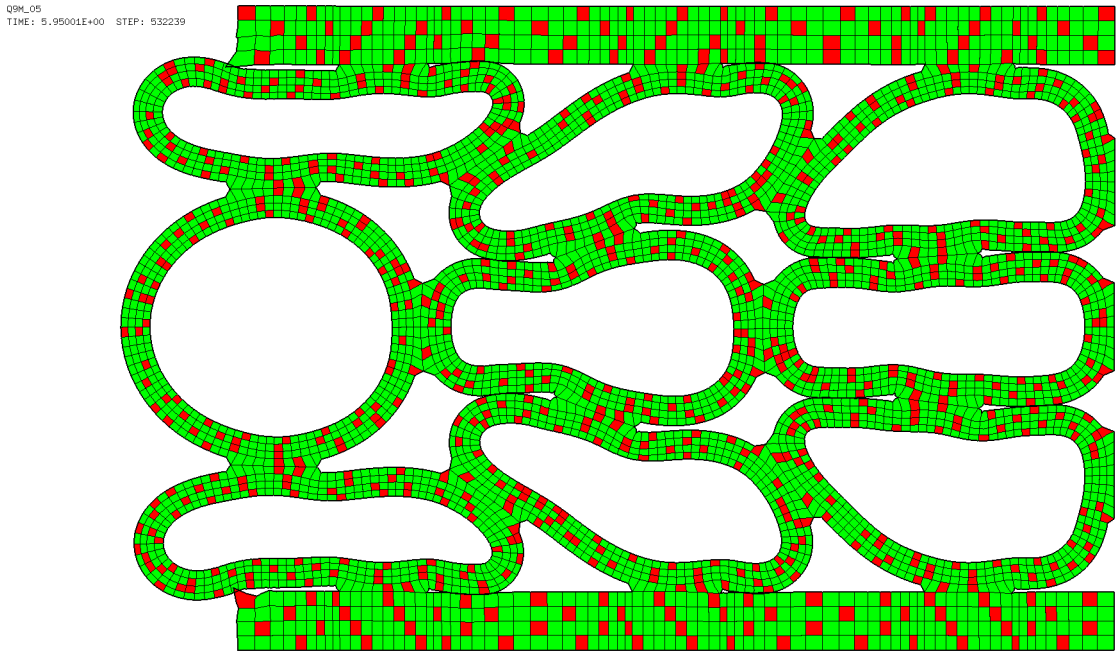


Figure 115 - Distorted mesh with element types in case Q9M_05

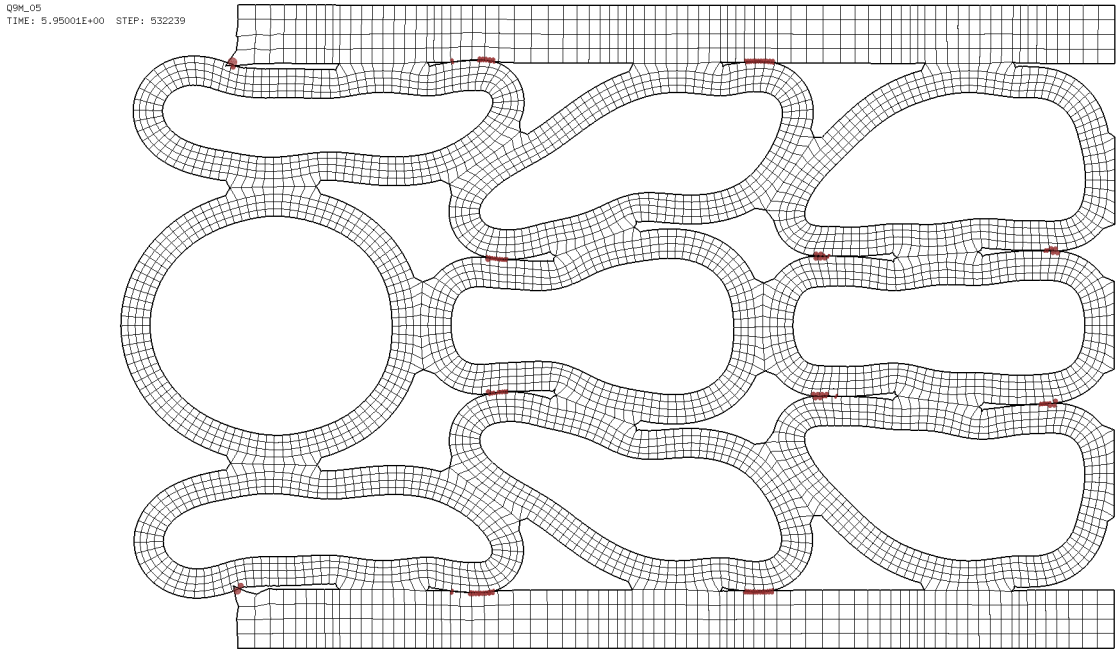


Figure 116 - Distorted mesh with contacts in case Q9M_05

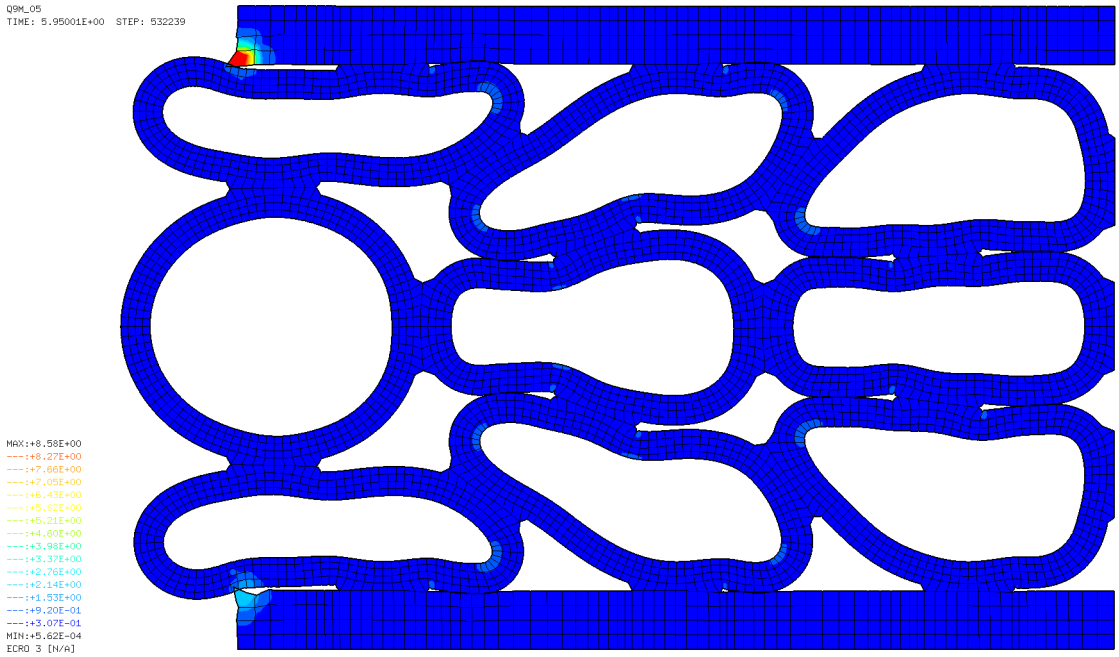


Figure 117 - Equivalent plastic strain in case Q9M_05

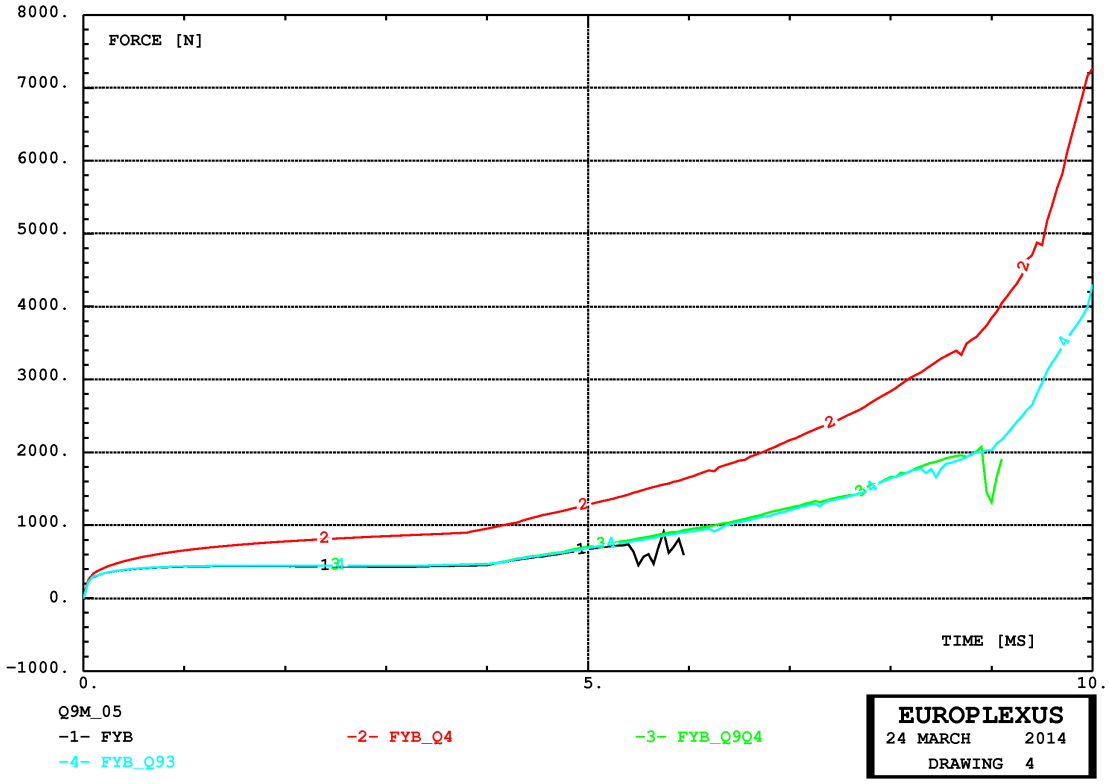


Figure 118 - Crushing force in case Q9M_05 compared with other solutions

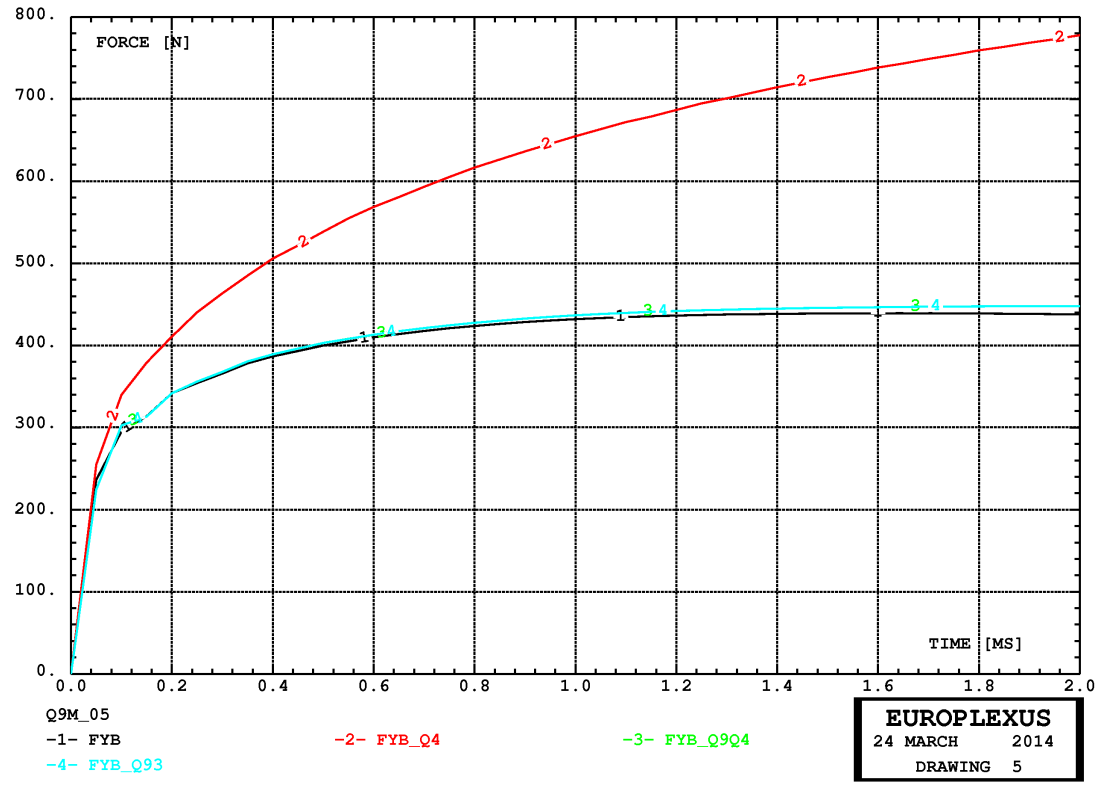


Figure 119 - Crushing force (zoom) in case Q9M_05 compared with other solutions

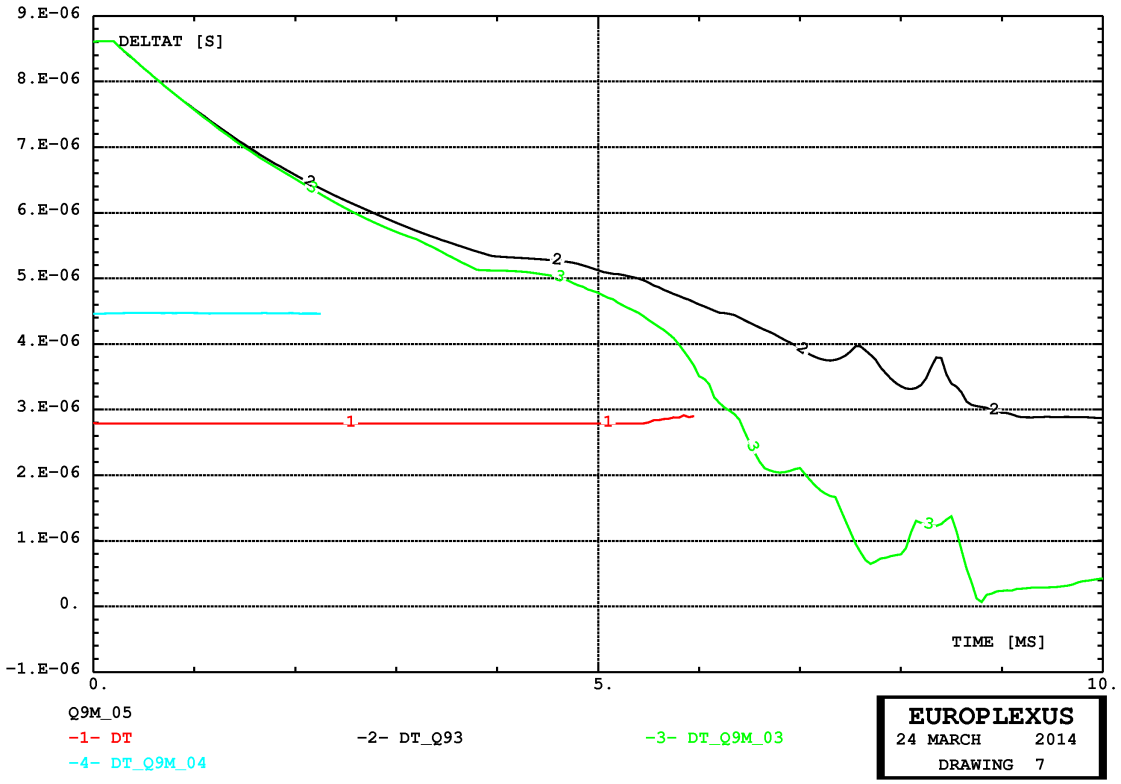


Figure 120 - Critical time step in case Q9M_05 compared with other solutions

Q95_03

This calculation is identical to Q93_03 but uses the Q95 element. This element uses a combination of full and reduced integration in an attempt to avoid both the mechanisms and the locking phenomena. It had been tentatively developed at the end of the eighties, but has been rarely (if ever) used since. This calculation is therefore just for curiosity.

The calculation stopped at step 511,060, at time 3.4 s, because of 0 Jacobian in element 1494. The Q95 element therefore is not completely free of hourglass modes.

Figure 121 shows the near-final configuration (3.4 s), showing a few contacts and some hourglassing. Figures 122 and 123 show the final equivalent plastic strain. No spurious early plasticization is observed.

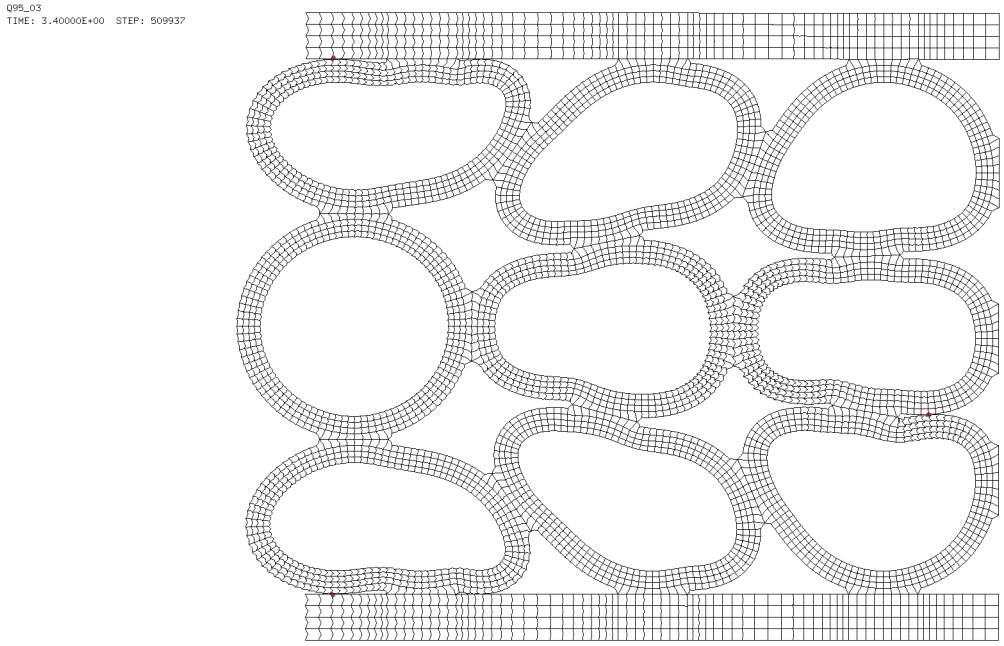


Figure 121 - Distorted mesh with contacts and hourglass modes in case Q95_03

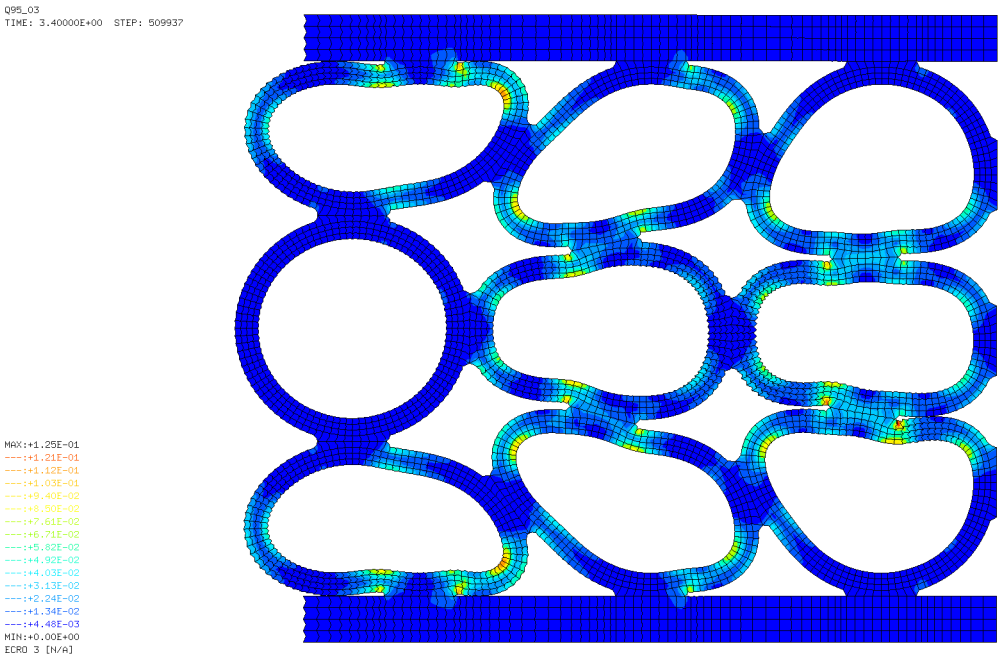


Figure 122 - Equivalent plastic strain in case Q95_03

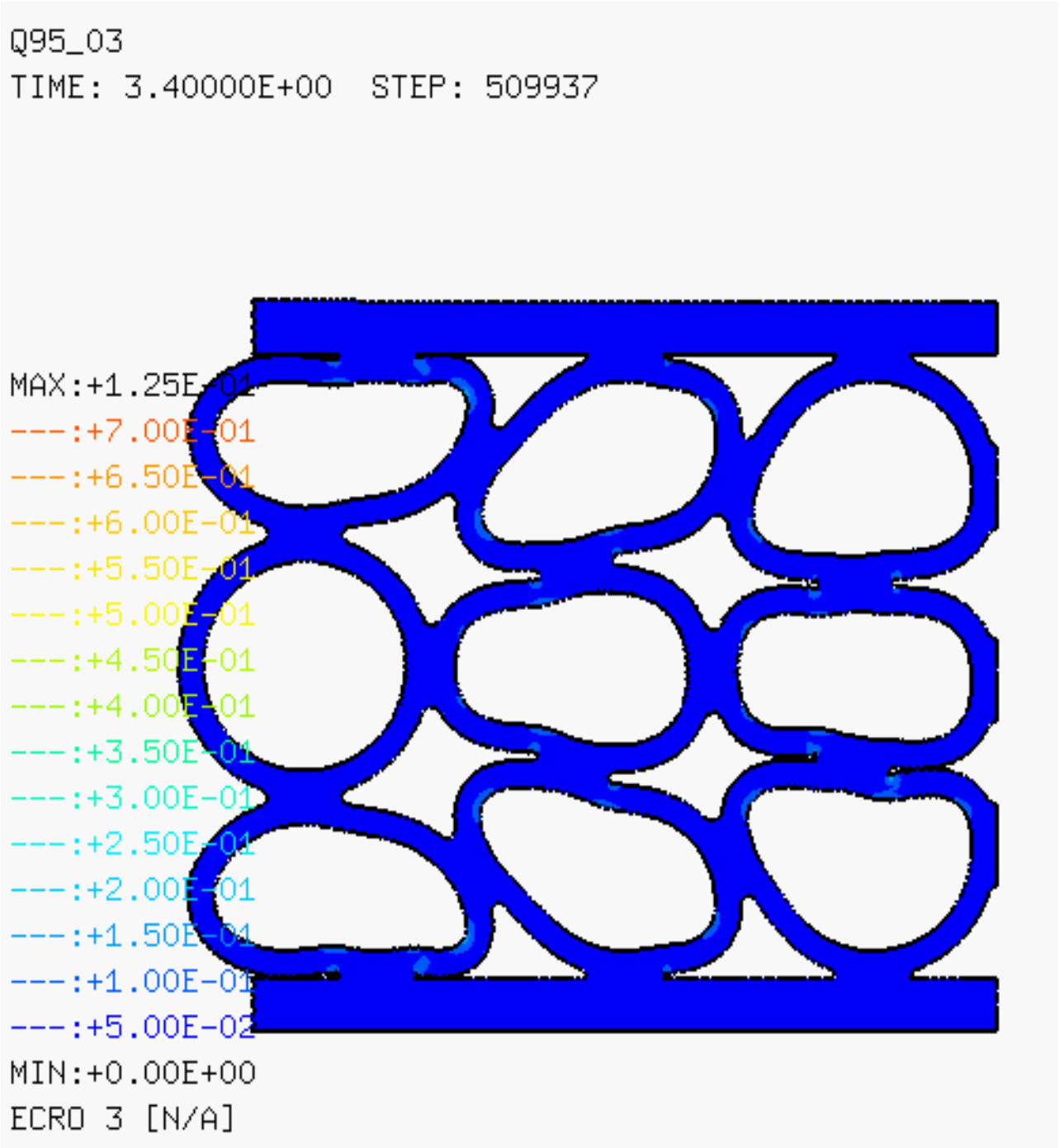


Figure 123 - Equivalent plastic strain (standard scale) in case Q95_03

Figure 124 compares the crushing force with those of previous solutions. The present solution is in good agreement with the previous QUA9 solutions, and only slightly more ductile.

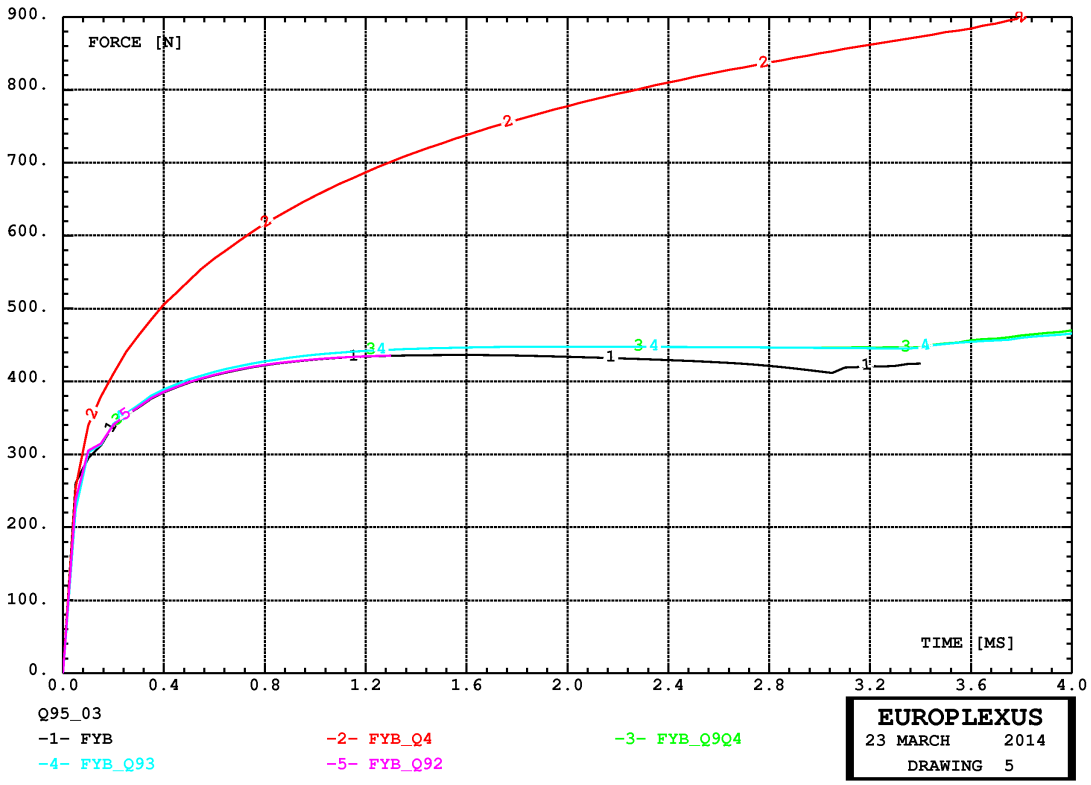


Figure 124 - Crushing force in case Q95_03 compared with previous solutions

5. Conclusions

In this report a native pinball formulation for parabolic elements has been presented, see Section 3. Although the basic tests performed with the new formulation show some problems (especially, but not exclusively, in 3D), the new formulation has been used with relatively good results in a realistic 2D application.

Concerning the practical contact problem of interest, *three alternative approaches* have been tested. The *first approach*, shown in Section 2.1, uses linear elements either fully integrated (CAR4), or reduced-integrated (CAR1) or a mixture of the two in the same calculation.

A complete solution (**CAR401**) up to 10 s of physical time can be obtained with the CAR4, despite some spurious contacts, but the response is too stiff in terms of crushing force with respect to experimental results. This is possibly due to locking phenomena in the fully integrated CAR4 element.

The CAR1 element suffers from mechanisms, so a purely CAR1 solution cannot be obtained because of strong hourglassing. With a mixture of CAR4 and CAR1 a solution (**CARM02**) could be obtained only until 7.2 s, when some hourglassing appeared and element distortion caused a large drop in stability step. Although incomplete, this solution shows a more ductile behavior and the crushing force is in much better agreement than the CAR4 solution with experimental observations.

ALE solutions with the four-node quadrilateral elements specialized for metal forming applications (Q41, Q42, Q41N, Q42N, Q42G) were also obtained. The under-integrated elements (Q41, Q41N) suffer from mechanisms, like their Lagrangian counterparts. The fully-integrated elements give overstiff solutions, but less stiff than the corresponding Lagrangian elements. Despite ALE and internal mesh rezoning, localized excessive deformation of some elements near the folds cannot be completely avoided, although it is less pronounced than in Lagrangian solutions.

The *second approach*, shown in Section 2.3, uses quadratic elements (Q93) with a superposed ghost mesh of linear elements to detect the contact. A solution could be obtained until almost the final time (**Q93_02**) and was interrupted just accidentally. Some spurious plasticization occurs early in the calculation, due to overly irregular initial shape of some elements (this behavior could be avoided by using Q92 instead of Q93 for these elements), and some spurious contacts. Towards the end of the transient, some oscillations are observed in the crushing force (possibly due to spurious contacts), but until then the solution is as ductile as the CARM02 solution mentioned above. Therefore, the Q93 seems not to suffer from locking in this case.

The *third approach*, shown in Section 4, uses quadratic elements (Q93, Q92 or Q95) with the new native pinball technique for contact detection. A solution with Q93 only (**Q93_03**) has been obtained until the final time. The same spurious localized plasticization as in case Q93_02 remains, but there

are no spurious contacts in the final configuration, and the crushing force is smooth (no oscillations) and as ductile as the best previous solutions. A solution with only Q92 is attempted but, as expected, it suffers from strong mechanisms. A mixed-mesh solution (Q92 and Q93) is also obtained (**Q9M_03**). However, this solution is more expensive than the purely Q93 solution because of greater localized element deformation, while the crushing force is nearly identical. An attempt of using time step partitioning to reduce the CPU time is not particularly successful.

A final comment concerns the **comparison of the present numerical simulations with experimental results**. At Onera, crushing experiments are being performed, but on a much larger array of tubes, of approximately 8 by 8. Here we have considered a simpler set-up involving only 3 by 3 tubes so as to reduce the CPU time of the simulations and make it possible to perform many more parametric studies. Experimental curves for this reduces set-up are not available and therefore cannot be presented here. However, from a few simulations of the full array done at Onera (where parallel machines are available for this purpose) it has been shown that in general the numerical results are “stiffer” than the observed ones. Therefore, any solution which yields a lower crushing force goes in the right direction. Work is also ongoing on a better calibration of the material parameters, especially as concerns the welded joints of the tubes. Once completed the assessment of the various contact and other models being tested, the best ones will be chosen and complete solutions of the full array will be obtained for direct comparison with the experimental curves (but this is left for a forthcoming publication).

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Appendix

Sample input files

This Section contains, in alphabetical file order, the listings of all input files related to the examples which were proposed in the previous Sections.

car101.epx

```
CAR101
ECHO
!CONV WIN
DPLA
$ *** Group B *** Geometry and mesh ************************************
GEOM
     LIBR POIN 4948 CAR1 4080 TERM
!    LIBR POIN 4950 CAR1 4080 PMAT 2 TERM
$ *** Group B *** Nodes ************************************
 1.50000E+01  5.95437E-30

 . . . (skip for brevity)

       3444       3483       3484       3445
!4949
!4950
$ *** Group C *** Geometrics complements ******************************
COMPLEMENT
!   GROU 2 'p0' LECT 4081 TERM
!          'p1' LECT 4082 TERM
!   EPAI 0.1 LECT p0 p1 TERM
    NGROU 3
      'noeuds_bas'
$---Gr: 42 NOEUDS_BAS NbNode: 79 ---$
 LECT
         1          6         11         16         21         26         31
        36         41         46         51         56         57         70
        78         80         94        104        107        118        130
       134        142        156        161        166        167        168
       169        170        171        172        190        215        236
       242        257        262        263        286        294        296
       320        330        333        354        366        370        388
       402        407        412        413        414        415        416
       417        418        446        481        512        518        543
       548        577        585        616        626        655        667
       694        708        713        714        715        716        717
       718        719 TERM
      'noeuds_haut'
$---Gr: 43 NOEUDS_HAUT NbNode: 79 ---$
 LECT
      4267       4268       4269       4270       4271       4272       4273
      4274       4275       4309       4314       4348       4353       4387
      4392       4421       4426       4455       4460       4493       4530
      4535       4548       4549       4550       4551       4552       4553
      4554       4555       4556       4576       4585       4590       4610
      4619       4624       4644       4653       4658       4678       4687
      4692       4707       4712       4731       4754       4781       4794
      4795       4796       4797       4798       4799       4800       4801
      4802       4812       4821       4826       4836       4845       4850
      4860       4869       4874       4884       4893       4898       4903
      4908       4913       4918       4923       4928       4933       4938
      4943       4948 TERM
$---Gr: 44 NOEUDS_SYM NbNode: 35 ---$
      'noeuds_sym'
 LECT
         2          3          4          5        528        562        601
       640        679        725        767        805        839       1933
      1967       2006       2045       2084       2130       2172       2210
      2243       3333       3370       3411       3452       3493       3538
      3579       3616       3648       4456       4457       4458       4459
 TERM
 GROU 25
$---Gr: 17 CONTACT_INTER_001 NbElem: 22 ---$
 'con01'
 LECT
       676        682        689        694        700        706        756
       757        758        759        760        761        762        763
       764        765        766        767        768        769        770
       771 TERM
$---Gr: 18 CONTACT_INTER_002 NbElem: 28 ---$
 'con02'
 LECT
       949        955        962        967        973        979       1029
      1030       1031       1032       1033       1034       1035       1036
      1415       1421       1428       1433       1439       1445       1495
      1496       1497       1498       1499       1500       1501       1502
 TERM
$---Gr: 19 CONTACT_INTER_003 NbElem: 28 ---$
 'con03'
 LECT
      1182       1188       1195       1200       1206       1212       1262
      1263       1264       1265       1266       1267       1268       1269
      1935       1941       1948       1953       1959       1965       2015
      2016       2017       2018       2019       2020       2021       2022
 TERM
$---Gr: 20 CONTACT_INTER_004 NbElem: 23 ---$
 'con04'
 LECT
      1503       1662       1668       1675       1680       1686       1692
      1742       1743       1744       1745       1746       1747       1748
      1749       1750       1751       1752       1753       1754       1755
      1756       1757 TERM
$---Gr: 21 CONTACT_INTER_005 NbElem: 44 ---$
 'con05'
 LECT
       675        679        681        686        688        692        693
       698        699        704        705        710        740        741
       742        743        744        745        746        747        748
       749        750        751        752        753        754        755
       772        773        774        775        776        777        778
       779        780        781        782        783        784        785
       786        787 TERM
$---Gr: 22 CONTACT_INTER_006 NbElem: 56 ---$
 'con06'
 LECT
       948        952        954        959        961        965        966
       971        972        977        978        983       1013       1014
      1015       1016       1017       1018       1019       1020       1021
      1022       1023       1024       1025       1026       1027       1028
      1414       1418       1420       1425       1427       1431       1432
      1437       1438       1443       1444       1449       1479       1480
      1481       1482       1483       1484       1485       1486       1487
      1488       1489       1490       1491       1492       1493       1494
 TERM
$---Gr: 23 CONTACT_INTER_007 NbElem: 56 ---$
 'con07'
 LECT
      1181       1185       1187       1192       1194       1198       1199
      1204       1205       1210       1211       1216       1246       1247
      1248       1249       1250       1251       1252       1253       1254
      1255       1256       1257       1258       1259       1260       1261
      1934       1938       1940       1945       1947       1951       1952
      1957       1958       1963       1964       1969       1999       2000
      2001       2002       2003       2004       2005       2006       2007
      2008       2009       2010       2011       2012       2013       2014
 TERM
$---Gr: 24 CONTACT_INTER_008 NbElem: 46 ---$
 'con08'
 LECT
      1504       1505       1661       1665       1667       1672       1674
      1678       1679       1684       1685       1690       1691       1696
      1726       1727       1728       1729       1730       1731       1732
      1733       1734       1735       1736       1737       1738       1739
      1740       1741       1758       1759       1760       1761       1762
      1763       1764       1765       1766       1767       1768       1769
      1770       1771       1772       1773 TERM
$---Gr: 25 CONTACT_INTER_009 NbElem: 44 ---$
 'con09'
 LECT
       678        680        684        685        690        691        696
       697        702        703        708        709        724        725
       726        727        728        729        730        731        732
       733        734        735        736        737        738        739
       788        789        790        791        792        793        794
       795        796        797        798        799        800        801
       802        803 TERM
$---Gr: 26 CONTACT_INTER_010 NbElem: 56 ---$
 'con10'
 LECT
       951        953        957        958        963        964        969
       970        975        976        981        982        997        998
       999       1000       1001       1002       1003       1004       1005
      1006       1007       1008       1009       1010       1011       1012
      1417       1419       1423       1424       1429       1430       1435
      1436       1441       1442       1447       1448       1463       1464
      1465       1466       1467       1468       1469       1470       1471
      1472       1473       1474       1475       1476       1477       1478
 TERM
$---Gr: 27 CONTACT_INTER_011 NbElem: 56 ---$
 'con11'
 LECT
      1184       1186       1190       1191       1196       1197       1202
      1203       1208       1209       1214       1215       1230       1231
      1232       1233       1234       1235       1236       1237       1238
      1239       1240       1241       1242       1243       1244       1245
      1937       1939       1943       1944       1949       1950       1955
      1956       1961       1962       1967       1968       1983       1984
      1985       1986       1987       1988       1989       1990       1991
      1992       1993       1994       1995       1996       1997       1998
 TERM
$---Gr: 28 CONTACT_INTER_012 NbElem: 46 ---$
 'con12'
 LECT
      1506       1507       1664       1666       1670       1671       1676
      1677       1682       1683       1688       1689       1694       1695
      1710       1711       1712       1713       1714       1715       1716
      1717       1718       1719       1720       1721       1722       1723
      1724       1725       1774       1775       1776       1777       1778
      1779       1780       1781       1782       1783       1784       1785
      1786       1787       1788       1789 TERM
$---Gr: 29 CONTACT_EXTER_001 NbElem: 27 ---$
 'con13'
 LECT
       523        524        525        526        527        528        529
       530        677        683        687        695        701        707
       711        712        713        714        715        716        717
       718        719        720        721        722        723 TERM
$---Gr: 30 CONTACT_EXTER_002 NbElem: 38 ---$
 'con14'
 LECT
       950        956        960        968        974        980        984
       985        986        987        988        989        990        991
       992        993        994        995        996       1416       1422
      1426       1434       1440       1446       1450       1451       1452
      1453       1454       1455       1456       1457       1458       1459
      1460       1461       1462 TERM
$---Gr: 31 CONTACT_EXTER_003 NbElem: 38 ---$
 'con15'
 LECT
      1183       1189       1193       1201       1207       1213       1217
      1218       1219       1220       1221       1222       1223       1224
      1225       1226       1227       1228       1229       1936       1942
      1946       1954       1960       1966       1970       1971       1972
      1973       1974       1975       1976       1977       1978       1979
      1980       1981       1982 TERM
$---Gr: 32 CONTACT_EXTER_004 NbElem: 28 ---$
 'con16'
 LECT
      1508       1509       1510       1511       1512       1513       1514
      1515       1516       1663       1669       1673       1681       1687
      1693       1697       1698       1699       1700       1701       1702
      1703       1704       1705       1706       1707       1708       1709
 TERM
$---Gr: 33 CONTACT_TUBE_001 NbElem: 96 ---$
 'con17'
```

```
 LECT
       532       533       540       541       547       548       551
       554       559       560       563       566       569       572
       577       578       581       584       587       590       593
       596       649       650       651       652       653       654
       655       656       657       658       659       660       661
       662       663       664       665       666       667       668
       669       670       671       672       673       674       805
       806       813       814       820       821       824       827
       832       833       836       839       842       845       850
       851       854       857       860       863       866       869
       922       923       924       925       926       927       928
       929       930       931       932       933       934       935
       936       937       938       939       940       941       942
       943       944       945       946       947 TERM
$---Gr: 34 CONTACT_TUBE_002 NbElem: 96 ---$
 'con18'
 LECT
      1038      1039      1046      1047      1053      1054      1057
      1060      1065      1066      1069      1072      1075      1078
      1083      1084      1087      1090      1093      1096      1099
      1102      1155      1156      1157      1158      1159      1160
      1161      1162      1163      1164      1165      1166      1167
      1168      1169      1170      1171      1172      1173      1174
      1175      1176      1177      1178      1179      1180      1271
      1272      1279      1280      1286      1287      1290      1293
      1298      1299      1302      1305      1308      1311      1316
      1317      1320      1323      1326      1329      1332      1335
      1388      1389      1390      1391      1392      1393      1394
      1395      1396      1397      1398      1399      1400      1401
      1402      1403      1404      1405      1406      1407      1408
      1409      1410      1411      1412      1413 TERM
$---Gr: 35 CONTACT_TUBE_003 NbElem: 96 ---$
 'con19'
 LECT
      1518      1519      1526      1527      1533      1534      1537
      1540      1545      1546      1549      1552      1555      1558
      1563      1564      1567      1570      1573      1576      1579
      1582      1635      1636      1637      1638      1639      1640
      1641      1642      1643      1644      1645      1646      1647
      1648      1649      1650      1651      1652      1653      1654
      1655      1656      1657      1658      1659      1660      1791
      1792      1799      1800      1806      1807      1810      1813
      1818      1819      1822      1825      1828      1831      1836
      1837      1840      1843      1846      1849      1852      1855
      1908      1909      1910      1911      1912      1913      1914
      1915      1916      1917      1918      1919      1920      1921
      1922      1923      1924      1925      1926      1927      1928
      1929      1930      1931      1932      1933 TERM
$---Gr: 36 CONTACT_TUBE_004 NbElem: 96 ---$
 'con20'
 LECT
       531       536       539       542       545       546       550
       553       557       558       562       565       568       571
       575       576       580       583       586       589       592
       595       623       624       625       626       627       628
       629       630       631       632       633       634       635
       636       637       638       639       640       641       642
       643       644       645       646       647       648       804
       809       812       815       818       819       823       826
       830       831       835       838       841       844       848
       849       853       856       859       862       865       868
       896       897       898       899       900       901       902
       903       904       905       906       907       908       909
       910       911       912       913       914       915       916
       917       918       919       920       921 TERM
$---Gr: 37 CONTACT_TUBE_005 NbElem: 96 ---$
 'con21'
 LECT
      1037      1042      1045      1048      1051      1052      1056
      1059      1063      1064      1068      1071      1074      1077
      1081      1082      1086      1089      1092      1095      1098
      1101      1129      1130      1131      1132      1133      1134
      1135      1136      1137      1138      1139      1140      1141
      1142      1143      1144      1145      1146      1147      1148
      1149      1150      1151      1152      1153      1154      1270
      1275      1278      1281      1284      1285      1289      1292
      1296      1297      1301      1304      1307      1310      1314
      1315      1319      1322      1325      1328      1331      1334
      1362      1363      1364      1365      1366      1367      1368
      1369      1370      1371      1372      1373      1374      1375
      1376      1377      1378      1379      1380      1381      1382
      1383      1384      1385      1386      1387 TERM
$---Gr: 38 CONTACT_TUBE_006 NbElem: 96 ---$
 'con22'
 LECT
      1517      1522      1525      1528      1531      1532      1536
      1539      1543      1544      1548      1551      1554      1557
      1561      1562      1566      1569      1572      1575      1578
      1581      1609      1610      1611      1612      1613      1614
      1615      1616      1617      1618      1619      1620      1621
      1622      1623      1624      1625      1626      1627      1628
      1629      1630      1631      1632      1633      1634      1790
      1795      1798      1801      1804      1805      1809      1812
      1816      1817      1821      1824      1827      1830      1834
      1835      1839      1842      1845      1848      1851      1854
      1882      1883      1884      1885      1886      1887      1888
      1889      1890      1891      1892      1893      1894      1895
      1896      1897      1898      1899      1900      1901      1902
      1903      1904      1905      1906      1907 TERM
$---Gr: 39 CONTACT_TUBE_007 NbElem: 96 ---$
 'con23'
 LECT
       534       535       537       538       543       544       549
       552       555       556       561       564       567       570
       573       574       579       582       585       588       591
       594       597       598       599       600       601       602
       603       604       605       606       607       608       609
       610       611       612       613       614       615       616
       617       618       619       620       621       622       807
       808       810       811       816       817       822       825
       828       829       834       837       840       843       846
       847       852       855       858       861       864       867
       870       871       872       873       874       875       876
       877       878       879       880       881       882       883
       884       885       886       887       888       889       890
       891       892       893       894       895 TERM
$---Gr: 40 CONTACT_TUBE_008 NbElem: 96 ---$
 'con24'
 LECT
      1040      1041      1043      1044      1049      1050      1055
      1058      1061      1062      1067      1070      1073      1076
      1079      1080      1085      1088      1091      1094      1097
      1100      1103      1104      1105      1106      1107      1108
      1109      1110      1111      1112      1113      1114      1115
      1116      1117      1118      1119      1120      1121      1122
      1123      1124      1125      1126      1127      1128      1273
      1274      1276      1277      1282      1283      1288      1291
      1294      1295      1300      1303      1306      1309      1312
      1313      1318      1321      1324      1327      1330      1333
      1336      1337      1338      1339      1340      1341      1342
      1343      1344      1345      1346      1347      1348      1349
      1350      1351      1352      1353      1354      1355      1356
      1357      1358      1359      1360      1361 TERM
$---Gr: 41 CONTACT_TUBE_009 NbElem: 96 ---$
 'con25'
 LECT
      1520      1521      1523      1524      1529      1530      1535
      1538      1541      1542      1547      1550      1553      1556
      1559      1560      1565      1568      1571      1574      1577
      1580      1583      1584      1585      1586      1587      1588
      1589      1590      1591      1592      1593      1594      1595
      1596      1597      1598      1599      1600      1601      1602
      1603      1604      1605      1606      1607      1608      1793
      1794      1796      1797      1802      1803      1808      1811
      1814      1815      1820      1823      1826      1829      1832
      1833      1838      1841      1844      1847      1850      1853
      1856      1857      1858      1859      1860      1861      1862
      1863      1864      1865      1866      1867      1868      1869
      1870      1871      1872      1873      1874      1875      1876
      1877      1878      1879      1880      1881 TERM
$ *** Group C1 *** Materials ***************************************
MATERIAU
!   FANT 0.0 LECT p0 p1 TERM
    VMIS ISOT RO 0.00825 YOUN 197600.0 NU 0.29 ELAS 222.35
         TRAC 39
222.35 0.00112525303643725
228.192645571222 0.00117982108082602
230.758344471793 0.001217805387003
234.450726613396 0.00128649153144431
239.764555869277 0.00141338337990525
243.897432663364 0.00153429874829638
247.411863292444 0.00165208432840306
250.528021456793 0.00176785435959915
253.359622970924 0.00188218432677593
258.417356319849 0.00210778014331907
262.901922592959 0.00233047531676599
272.525831528572 0.00287917930935512
280.709612952488 0.00342059520724944
306.337249091751 0.00555028972212425
326.269365384357 0.00765116075599371
358.247494301277 0.0118129933922129
390.499112131117 0.0169762100816352
417.924578503771 0.0221150029276507
464.338948360747 0.0323498934633641
503.807844043327 0.0425496348382759
538.803931461142 0.0527267405438317
570.604298738599 0.0628876735766123
599.971697212392 0.0730362940142328
627.405291846074 0.0831751279951724
653.253096704044 0.0933059367242108
677.76931865327 0.103430006673347
734.395540393597 0.128716576621425
785.850853879881 0.153976978005465
833.369446403083 0.179217456712566
877.759003278812 0.204442100219022
959.251671749752 0.254854512508855
1033.30271513801 0.305229264752723
1165.57077256009 0.405898637512956
1282.84956691385 0.506492153678714
1389.41887249881 0.607031472026816
1579.77020835558 0.807994788503824
1748.55 1.00884893724696
2418.75489508018 2.0122406624245
5336.94734929116 10.0270088428608
         LECT                    1 PAS       1    4080 TERM
$------------------------------ Load Case considere : "Default" -------$
LINK COUP SPLT NONE
   BLOQ 12 LECT noeuds_bas TERM
   BLOQ 1  LECT noeuds_sym TERM
   BLOQ 1  LECT       4460 TERM
   DEPLA 2 -1. FONCT 1 LECT noeuds_haut TERM

PINB
$---Gr: 17 CONTACT_INTER_001 NbElem: 22 ---$
SELF DMIN 0.1
 LECT con01 TERM
$---Gr: 18 CONTACT_INTER_002 NbElem: 28 ---$
SELF DMIN 0.1
 LECT con02 TERM
$---Gr: 19 CONTACT_INTER_003 NbElem: 28 ---$
SELF DMIN 0.1
 LECT con03 TERM
$---Gr: 20 CONTACT_INTER_004 NbElem: 23 ---$
SELF DMIN 0.1
 LECT con04 TERM
$---Gr: 21 CONTACT_INTER_005 NbElem: 44 ---$
SELF DMIN 0.1
 LECT con05 TERM
$---Gr: 22 CONTACT_INTER_006 NbElem: 56 ---$
SELF DMIN 0.1
 LECT con06 TERM
$---Gr: 23 CONTACT_INTER_007 NbElem: 56 ---$
SELF DMIN 0.1
 LECT con07 TERM
$---Gr: 24 CONTACT_INTER_008 NbElem: 46 ---$
SELF DMIN 0.1
 LECT con08 TERM
$---Gr: 25 CONTACT_INTER_009 NbElem: 44 ---$
SELF DMIN 0.1
 LECT con09 TERM
$---Gr: 26 CONTACT_INTER_010 NbElem: 56 ---$
SELF DMIN 0.1
 LECT con10 TERM
$---Gr: 27 CONTACT_INTER_011 NbElem: 56 ---$
SELF DMIN 0.1
```

```
 LECT con11 TERM
$---Gr: 28 CONTACT_INTER_012 NbElem: 46 ---$
SELF DMIN 0.1
 LECT con12 TERM
$---Gr: 29 CONTACT_EXTER_001 NbElem: 27 ---$
SELF DMIN 0.1
 LECT con13 TERM
$---Gr: 30 CONTACT_EXTER_002 NbElem: 38 ---$
SELF DMIN 0.1
 LECT con14 TERM
$---Gr: 31 CONTACT_EXTER_003 NbElem: 38 ---$
SELF DMIN 0.1
 LECT con15 TERM
$---Gr: 32 CONTACT_EXTER_004 NbElem: 28 ---$
SELF DMIN 0.1
 LECT con16 TERM
$---Gr: 33 CONTACT_TUBE_001 NbElem: 96 ---$
SELF DMIN 0.1
 LECT con17 TERM
$---Gr: 34 CONTACT_TUBE_002 NbElem: 96 ---$
SELF DMIN 0.1
 LECT con18 TERM
$---Gr: 35 CONTACT_TUBE_003 NbElem: 96 ---$
SELF DMIN 0.1
 LECT con19 TERM
$---Gr: 36 CONTACT_TUBE_004 NbElem: 96 ---$
SELF DMIN 0.1
 LECT con20 TERM
$---Gr: 37 CONTACT_TUBE_005 NbElem: 96 ---$
SELF DMIN 0.1
 LECT con21 TERM
$---Gr: 38 CONTACT_TUBE_006 NbElem: 96 ---$
SELF DMIN 0.1
 LECT con22 TERM
$---Gr: 39 CONTACT_TUBE_007 NbElem: 96 ---$
SELF DMIN 0.1
 LECT con23 TERM
$---Gr: 40 CONTACT_TUBE_008 NbElem: 96 ---$
SELF DMIN 0.1
 LECT con24 TERM
$---Gr: 41 CONTACT_TUBE_009 NbElem: 96 ---$
SELF DMIN 0.1
 LECT con25 TERM
FONCT 1 TABLE 4 0. 0. 0.0001 0. 1.0001 1. 100.0001  100.
$---------------------------------------- Directives Generales --------$
ECRITURE
$                                        impressions LISTING           $
    DEPL TFRE 0.1 !FREQ 1000
    POINT LECT 4460 TERM
$                                       Donnees Fichier ALICE          $
    FICHIER SPLI ALICE TFRE 0.05 !TFREQ   50.0000
$   POIN LECT 1 PAS 1 4948 TERM
$   ELEM LECT 1 PAS 1 4080 TERM
$                                    Donnees Fichier ALICE Temps       $
!   FICHIER ALICE TEMPS TFREQ 0.05
!   POIN LECT TOUS TERM
!   ELEM LECT TOUS TERM
$                                    Donnees Fichier PARAVIEW          $
!   FICHIER FORMAT PVTK TFREQ 0.5
!   GROUP AUTO
!   VARI DEPL VITE FEXT ACCE CONT EPST ECRO PINB
$ Regions
$                  "OPTION" de Calcul : methode Pas, amortissement     $
OPTION
    PAS AUTO CSTA 0.5
    STEP IO
    PASMINI  1.00000E-12
    LOG 1
    PINS GRID DGRI
$                                "OPTION" liee a la fragmentation      $
$                                "OPTION" liee a l'amortissement       $
$   QUASI STATIQUE 50.0E-3 0.7
$   AMORT LINE 0.5
$                                "OPTION" liee aux multi-domaines      $
$                                    Directives du Pas de Calcul       $
$                  Tps_depart - Pas_fixe - Nbr_pas_max - Tps_Final     $
CALCUL TINI 0.00 DTMIN 1E-12 DTMAX 1E-04 TFIN 10.0 !NMAX 100
FIN
```

car101a.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'car101.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

car101b.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'car101.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
          LINE HEOU SFRE
     ISO FILL FIEL ECRO 3 SCAL USER PROG 0.05 PAS 0.05 0.7 TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

car101c.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'car101.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
         !LINE HEOU SFRE
          FACE HFRO
          PINB CDES
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

car101d.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'car101.ali' GARD PSCR
OPTI PRIN
SORT GRAP
AXTE 1.0 'Time [ms]'
COUR 1 'dy_4267' DEPL COMP 2 NOEU LECT 4267 TERM
COUR 2 'dy' MULC 1 -1.0
COUR 3 'fyh' FLIA COMP 2 ZONE LECT noeuds_haut TERM
COUR 4 'fyb' FLIA COMP 2 ZONE LECT noeuds_bas TERM
TRAC 2 AXES 1.0 'DISPL. [MM]' YZER XGRD YGRD
TRAC 3 4 AXES 1.0 'FORCE [N]'
LIST 3 4 AXES 1.0 'FORCE [N]'
TRAC 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
RCOU 44 'fyb' FICH 'car401d.pun' RENA 'fyb_401'
TRAC 4 44 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR ROUG
FIN
```

car102.epx

```
CAR102
ECHO
!CONV WIN
DPLA
$ *** Group B *** Geometry and mesh ************************************
GEOM
     LIBR POIN 4948 CAR1 4080 TERM
!    LIBR POIN 4950 CAR1 4080 PMAT 2 TERM
$ *** Group B *** Nodes ************************************
 1.50000E+01  5.95437E-30

 . . . (skip for brevity)
```

```
      3444       3483       3484       3445
!4949
!4950
$ *** Group C *** Geometrics complements *******************************
COMPLEMENT
!   GROU 2 'p0' LECT 4081 TERM
!          'p1' LECT 4082 TERM
!   EPAI 0.1 LECT p0 p1 TERM
    NGROU 3
     'noeuds_bas'
$---Gr: 42 NOEUDS_BAS NbNode: 79 ---$
 LECT
         1         6        11        16        21        26        31
        36        41        46        51        56        57        70
        78        80        94       104       107       118       130
       134       142       156       161       166       167       168
       169       170       171       172       190       215       236
       242       257       262       263       286       294       296
       320       330       333       354       366       370       388
       402       407       412       413       414       415       416
       417       418       446       481       512       518       543
       548       577       585       616       626       655       667
       694       708       713       714       715       716       717
       718       719 TERM
     'noeuds_haut'
$---Gr: 43 NOEUDS_HAUT NbNode: 79 ---$
 LECT
      4267      4268      4269      4270      4271      4272      4273
      4274      4275      4309      4314      4348      4353      4387
      4392      4421      4426      4455      4460      4493      4530
      4535      4548      4549      4550      4551      4552      4553
      4554      4555      4556      4576      4585      4590      4610
      4619      4624      4644      4653      4658      4678      4687
      4692      4707      4712      4731      4754      4781      4794
      4795      4796      4797      4798      4799      4800      4801
      4802      4812      4821      4826      4836      4845      4850
      4860      4869      4874      4884      4893      4898      4903
      4908      4913      4918      4923      4928      4933      4938
      4943      4948 TERM
$---Gr: 44 NOEUDS_SYM NbNode: 35 ---$
     'noeuds_sym'
 LECT
         2         3         4         5       528       562       601
       640       679       725       767       805       839      1933
      1967      2006      2045      2084      2130      2172      2210
      2243      3333      3370      3411      3452      3493      3538
      3579      3616      3648      4456      4457      4458      4459
 TERM
 GROU 25
$---Gr: 17 CONTACT_INTER_001 NbElem: 22 ---$
 'con01'
 LECT
       676       682       689       694       700       706       756
       757       758       759       760       761       762       763
       764       765       766       767       768       769       770
       771 TERM
$---Gr: 18 CONTACT_INTER_002 NbElem: 28 ---$
 'con02'
 LECT
       949       955       962       967       973       979      1029
      1030      1031      1032      1033      1034      1035      1036
      1415      1421      1428      1433      1439      1445      1495
      1496      1497      1498      1499      1500      1501      1502
 TERM
$---Gr: 19 CONTACT_INTER_003 NbElem: 28 ---$
 'con03'
 LECT
      1182      1188      1195      1200      1206      1212      1262
      1263      1264      1265      1266      1267      1268      1269
      1935      1941      1948      1953      1959      1965      2015
      2016      2017      2018      2019      2020      2021      2022
 TERM
$---Gr: 20 CONTACT_INTER_004 NbElem: 23 ---$
 'con04'
 LECT
      1503      1662      1668      1675      1680      1686      1692
      1742      1743      1744      1745      1746      1747      1748
      1749      1750      1751      1752      1753      1754      1755
      1756      1757 TERM
$---Gr: 21 CONTACT_INTER_005 NbElem: 44 ---$
 'con05'
 LECT
       675       679       681       686       688       692       693
       698       699       704       705       710       740       741
       742       743       744       745       746       747       748
       749       750       751       752       753       754       755
       772       773       774       775       776       777       778
       779       780       781       782       783       784       785
       786       787 TERM
$---Gr: 22 CONTACT_INTER_006 NbElem: 56 ---$
 'con06'
 LECT
       948       952       954       959       961       965       966
       971       972       977       978       983      1013      1014
      1015      1016      1017      1018      1019      1020      1021
      1022      1023      1024      1025      1026      1027      1028
      1414      1418      1420      1425      1427      1431      1432
      1437      1438      1443      1444      1449      1479      1480
      1481      1482      1483      1484      1485      1486      1487
      1488      1489      1490      1491      1492      1493      1494
 TERM
$---Gr: 23 CONTACT_INTER_007 NbElem: 56 ---$
 'con07'
 LECT
      1181      1185      1187      1192      1194      1198      1199
      1204      1205      1210      1211      1216      1246      1247
      1248      1249      1250      1251      1252      1253      1254
      1255      1256      1257      1258      1259      1260      1261
      1934      1938      1940      1945      1947      1951      1952
      1957      1958      1963      1964      1969      1999      2000
      2001      2002      2003      2004      2005      2006      2007
      2008      2009      2010      2011      2012      2013      2014
 TERM
$---Gr: 24 CONTACT_INTER_008 NbElem: 46 ---$
 'con08'
 LECT
      1504      1505      1661      1665      1667      1672      1674
      1678      1679      1684      1685      1690      1691      1696
      1726      1727      1728      1729      1730      1731      1732
      1733      1734      1735      1736      1737      1738      1739
      1740      1741      1758      1759      1760      1761      1762
      1763      1764      1765      1766      1767      1768      1769
      1770      1771      1772      1773 TERM
$---Gr: 25 CONTACT_INTER_009 NbElem: 44 ---$
 'con09'
 LECT
       678       680       684       685       690       691       696
       697       702       703       708       709       724       725
       726       727       728       729       730       731       732
       733       734       735       736       737       738       739
       788       789       790       791       792       793       794
       795       796       797       798       799       800       801
       802       803 TERM
$---Gr: 26 CONTACT_INTER_010 NbElem: 56 ---$
 'con10'
 LECT
       951       953       957       958       963       964       969
       970       975       976       981       982       997       998
       999      1000      1001      1002      1003      1004      1005
      1006      1007      1008      1009      1010      1011      1012
      1417      1419      1423      1424      1429      1430      1435
      1436      1441      1442      1447      1448      1463      1464
      1465      1466      1467      1468      1469      1470      1471
      1472      1473      1474      1475      1476      1477      1478
 TERM
$---Gr: 27 CONTACT_INTER_011 NbElem: 56 ---$
 'con11'
 LECT
      1184      1186      1190      1191      1196      1197      1202
      1203      1208      1209      1214      1215      1230      1231
      1232      1233      1234      1235      1236      1237      1238
      1239      1240      1241      1242      1243      1244      1245
      1937      1939      1943      1944      1949      1950      1955
      1956      1961      1962      1967      1968      1983      1984
      1985      1986      1987      1988      1989      1990      1991
      1992      1993      1994      1995      1996      1997      1998
 TERM
$---Gr: 28 CONTACT_INTER_012 NbElem: 46 ---$
 'con12'
 LECT
      1506      1507      1664      1666      1670      1671      1676
      1677      1682      1683      1688      1689      1694      1695
      1710      1711      1712      1713      1714      1715      1716
      1717      1718      1719      1720      1721      1722      1723
      1724      1725      1774      1775      1776      1777      1778
      1779      1780      1781      1782      1783      1784      1785
      1786      1787      1788      1789 TERM
$---Gr: 29 CONTACT_EXTER_001 NbElem: 27 ---$
 'con13'
 LECT
       523       524       525       526       527       528       529
       530       677       683       687       695       701       707
       711       712       713       714       715       716       717
       718       719       720       721       722       723 TERM
$---Gr: 30 CONTACT_EXTER_002 NbElem: 38 ---$
 'con14'
 LECT
       950       956       960       968       974       980       984
       985       986       987       988       989       990       991
       992       993       994       995       996      1416      1422
      1426      1434      1440      1446      1450      1451      1452
      1453      1454      1455      1456      1457      1458      1459
      1460      1461      1462 TERM
$---Gr: 31 CONTACT_EXTER_003 NbElem: 38 ---$
 'con15'
 LECT
      1183      1189      1193      1201      1207      1213      1217
      1218      1219      1220      1221      1222      1223      1224
      1225      1226      1227      1228      1229      1936      1942
      1946      1954      1960      1966      1970      1971      1972
      1973      1974      1975      1976      1977      1978      1979
      1980      1981      1982 TERM
$---Gr: 32 CONTACT_EXTER_004 NbElem: 28 ---$
 'con16'
 LECT
      1508      1509      1510      1511      1512      1513      1514
      1515      1516      1663      1669      1673      1681      1687
      1693      1697      1698      1699      1700      1701      1702
      1703      1704      1705      1706      1707      1708      1709
 TERM
$---Gr: 33 CONTACT_TUBE_001 NbElem: 96 ---$
 'con17'
 LECT
       532       533       540       541       547       548       551
       554       559       560       563       566       569       572
       577       578       581       584       587       590       593
       596       649       650       651       652       653       654
       655       656       657       658       659       660       661
       662       663       664       665       666       667       668
       669       670       671       672       673       674       805
       806       813       814       820       821       824       827
       832       833       836       839       842       845       850
       851       854       857       860       863       866       869
       922       923       924       925       926       927       928
       929       930       931       932       933       934       935
       936       937       938       939       940       941       942
       943       944       945       946       947 TERM
$---Gr: 34 CONTACT_TUBE_002 NbElem: 96 ---$
 'con18'
 LECT
      1038      1039      1046      1047      1053      1054      1057
      1060      1065      1066      1069      1072      1075      1078
      1083      1084      1087      1090      1093      1096      1099
      1102      1155      1156      1157      1158      1159      1160
      1161      1162      1163      1164      1165      1166      1167
      1168      1169      1170      1171      1172      1173      1174
      1175      1176      1177      1178      1179      1180      1271
      1272      1279      1280      1286      1287      1290      1293
      1298      1299      1302      1305      1308      1311      1316
      1317      1320      1323      1326      1329      1332      1335
      1388      1389      1390      1391      1392      1393      1394
      1395      1396      1397      1398      1399      1400      1401
      1402      1403      1404      1405      1406      1407      1408
      1409      1410      1411      1412      1413 TERM
$---Gr: 35 CONTACT_TUBE_003 NbElem: 96 ---$
```

```
 'con19'
 LECT
       1518       1519       1526       1527       1533       1534       1537
       1540       1545       1546       1549       1552       1555       1558
       1563       1564       1567       1570       1573       1576       1579
       1582       1635       1636       1637       1638       1639       1640
       1641       1642       1643       1644       1645       1646       1647
       1648       1649       1650       1651       1652       1653       1654
       1655       1656       1657       1658       1659       1660       1791
       1792       1799       1800       1806       1807       1810       1813
       1818       1819       1822       1825       1828       1831       1836
       1837       1840       1843       1846       1849       1852       1855
       1908       1909       1910       1911       1912       1913       1914
       1915       1916       1917       1918       1919       1920       1921
       1922       1923       1924       1925       1926       1927       1928
       1929       1930       1931       1932 1933 TERM
$---Gr: 36 CONTACT_TUBE_004 NbElem: 96 ---$
 'con20'
 LECT
        531        536        539        542        545        546        550
        553        557        558        562        565        568        571
        575        576        580        583        586        589        592
        595        623        624        625        626        627        628
        629        630        631        632        633        634        635
        636        637        638        639        640        641        642
        643        644        645        646        647        648        804
        809        812        815        818        819        823        826
        830        831        835        838        841        844        848
        849        853        856        859        862        865        868
        896        897        898        899        900        901        902
        903        904        905        906        907        908        909
        910        911        912        913        914        915        916
        917        918        919        920        921 TERM
$---Gr: 37 CONTACT_TUBE_005 NbElem: 96 ---$
 'con21'
 LECT
       1037       1042       1045       1048       1051       1052       1056
       1059       1063       1064       1068       1071       1074       1077
       1081       1082       1086       1089       1092       1095       1098
       1101       1129       1130       1131       1132       1133       1134
       1135       1136       1137       1138       1139       1140       1141
       1142       1143       1144       1145       1146       1147       1148
       1149       1150       1151       1152       1153       1154       1270
       1275       1278       1281       1284       1285       1289       1292
       1296       1297       1301       1304       1307       1310       1314
       1315       1319       1322       1325       1328       1331       1334
       1362       1363       1364       1365       1366       1367       1368
       1369       1370       1371       1372       1373       1374       1375
       1376       1377       1378       1379       1380       1381       1382
       1383       1384       1385       1386       1387 TERM
$---Gr: 38 CONTACT_TUBE_006 NbElem: 96 ---$
 'con22'
 LECT
       1517       1522       1525       1528       1531       1532       1536
       1539       1543       1544       1548       1551       1554       1557
       1561       1562       1566       1569       1572       1575       1578
       1581       1609       1610       1611       1612       1613       1614
       1615       1616       1617       1618       1619       1620       1621
       1622       1623       1624       1625       1626       1627       1628
       1629       1630       1631       1632       1633       1634       1790
       1795       1798       1801       1804       1805       1809       1812
       1816       1817       1821       1824       1827       1830       1834
       1835       1839       1842       1845       1848       1851       1854
       1882       1883       1884       1885       1886       1887       1888
       1889       1890       1891       1892       1893       1894       1895
       1896       1897       1898       1899       1900       1901       1902
       1903       1904       1905       1906       1907 TERM
$---Gr: 39 CONTACT_TUBE_007 NbElem: 96 ---$
 'con23'
 LECT
        534        535        537        538        543        544        549
        552        555        556        561        564        567        570
        573        574        579        582        585        588        591
        594        597        598        599        600        601        602
        603        604        605        606        607        608        609
        610        611        612        613        614        615        616
        617        618        619        620        621        622        807
        808        810        811        816        817        822        825
        828        829        834        837        840        843        846
        847        852        855        858        861        864        867
        870        871        872        873        874        875        876
        877        878        879        880        881        882        883
        884        885        886        887        888        889        890
        891        892        893        894        895 TERM
$---Gr: 40 CONTACT_TUBE_008 NbElem: 96 ---$
 'con24'
 LECT
       1040       1041       1043       1044       1049       1050       1055
       1058       1061       1062       1067       1070       1073       1076
       1079       1080       1085       1088       1091       1094       1097
       1100       1103       1104       1105       1106       1107       1108
       1109       1110       1111       1112       1113       1114       1115
       1116       1117       1118       1119       1120       1121       1122
       1123       1124       1125       1126       1127       1128       1273
       1274       1276       1277       1282       1283       1288       1291
       1294       1295       1300       1303       1306       1309       1312
       1313       1318       1321       1324       1327       1330       1333
       1336       1337       1338       1339       1340       1341       1342
       1343       1344       1345       1346       1347       1348       1349
       1350       1351       1352       1353       1354       1355       1356
       1357       1358       1359       1360       1361 TERM
$---Gr: 41 CONTACT_TUBE_009 NbElem: 96 ---$
 'con25'
 LECT
       1520       1521       1523       1524       1529       1530       1535
       1538       1541       1542       1547       1550       1553       1556
       1559       1560       1565       1568       1571       1574       1577
       1580       1583       1584       1585       1586       1587       1588
       1589       1590       1591       1592       1593       1594       1595
       1596       1597       1598       1599       1600       1601       1602
       1603       1604       1605       1606       1607       1608       1793
       1794       1796       1797       1802       1803       1808       1811
       1814       1815       1820       1823       1826       1829       1832
       1833       1838       1841       1844       1847       1850       1853
       1856       1857       1858       1859       1860       1861       1862
       1863       1864       1865       1866       1867       1868       1869
       1870       1871       1872       1873       1874       1875       1876
       1877       1878       1879       1880       1881 TERM
```

```
$ *** Group C1 *** Materials ***************************************
MATERIAU
!   FANT 0.0 LECT p0 p1 TERM
    VMIS ISOT RO 0.00825 YOUN 197600.0 NU 0.29 ELAS 222.35
         TRAC 39
222.35 0.00112525303643725
228.192645571222 0.00117982108082602
230.758344471793 0.001217805387003
234.450726613396 0.00128649153144431
239.764555869277 0.00141338337990525
243.897432663364 0.00153429874829638
247.411863292444 0.00165208432840306
250.528021456793 0.00176785435959915
253.359622970924 0.00188218432677593
258.417356319849 0.00210778014331907
262.901922592959 0.00233047531676599
272.525831528572 0.00287917930935512
280.709612952488 0.00342059520724944
306.337249091751 0.00555028972212425
326.269365384357 0.00765116075599371
358.247494301277 0.0118129933922129
390.499112131117 0.0169762100816352
417.924578503771 0.0221150029276507
464.338948360747 0.0323498934633641
503.807844043327 0.0425496348382759
538.803931461142 0.0527267405438317
570.604298738599 0.0628876735766123
599.971697212392 0.0730362940142328
627.405291846074 0.0831751279951724
653.253096704044 0.0933059367242108
677.76931865327 0.103430006673347
734.395540393597 0.128716576621425
785.850853879881 0.153976978005465
833.369446403083 0.179217456712566
877.759003278812 0.204442100219022
959.251671749752 0.254854512508855
1033.30271513801 0.305229264752723
1165.57077256009 0.405898637512956
1282.84956691385 0.506492153678714
1389.41887249881 0.607031472026816
1579.77020835558 0.807994788503824
1748.55 1.00884893724696
2418.75489508018 2.0122406624245
5336.94734929116 10.0270088428608
          LECT                    1 PAS       1    4080 TERM
$------------------------------ Load Case considere : "Default" -------$
LINK COUP SPLT NONE
   BLOQ 12 LECT noeuds_bas TERM
   BLOQ 1  LECT noeuds_sym TERM
   BLOQ 1  LECT       4460 TERM
   DEPLA 2 -1. FONCT 1 LECT noeuds_haut TERM

PINB
$---Gr: 17 CONTACT_INTER_001 NbElem: 22 ---$
SELF DMIN 0.1
 LECT con01 TERM
$---Gr: 18 CONTACT_INTER_002 NbElem: 28 ---$
SELF DMIN 0.1
 LECT con02 TERM
$---Gr: 19 CONTACT_INTER_003 NbElem: 28 ---$
SELF DMIN 0.1
 LECT con03 TERM
$---Gr: 20 CONTACT_INTER_004 NbElem: 23 ---$
SELF DMIN 0.1
 LECT con04 TERM
$---Gr: 21 CONTACT_INTER_005 NbElem: 44 ---$
SELF DMIN 0.1
 LECT con05 TERM
$---Gr: 22 CONTACT_INTER_006 NbElem: 56 ---$
SELF DMIN 0.1
 LECT con06 TERM
$---Gr: 23 CONTACT_INTER_007 NbElem: 56 ---$
SELF DMIN 0.1
 LECT con07 TERM
$---Gr: 24 CONTACT_INTER_008 NbElem: 46 ---$
SELF DMIN 0.1
 LECT con08 TERM
$---Gr: 25 CONTACT_INTER_009 NbElem: 44 ---$
SELF DMIN 0.1
 LECT con09 TERM
$---Gr: 26 CONTACT_INTER_010 NbElem: 56 ---$
SELF DMIN 0.1
 LECT con10 TERM
$---Gr: 27 CONTACT_INTER_011 NbElem: 56 ---$
SELF DMIN 0.1
 LECT con11 TERM
$---Gr: 28 CONTACT_INTER_012 NbElem: 46 ---$
SELF DMIN 0.1
 LECT con12 TERM
$---Gr: 29 CONTACT_EXTER_001 NbElem: 27 ---$
SELF DMIN 0.1
 LECT con13 TERM
$---Gr: 30 CONTACT_EXTER_002 NbElem: 38 ---$
SELF DMIN 0.1
 LECT con14 TERM
$---Gr: 31 CONTACT_EXTER_003 NbElem: 38 ---$
SELF DMIN 0.1
 LECT con15 TERM
$---Gr: 32 CONTACT_EXTER_004 NbElem: 28 ---$
SELF DMIN 0.1
 LECT con16 TERM
$---Gr: 33 CONTACT_TUBE_001 NbElem: 96 ---$
SELF DMIN 0.1
 LECT con17 TERM
$---Gr: 34 CONTACT_TUBE_002 NbElem: 96 ---$
SELF DMIN 0.1
 LECT con18 TERM
$---Gr: 35 CONTACT_TUBE_003 NbElem: 96 ---$
SELF DMIN 0.1
 LECT con19 TERM
$---Gr: 36 CONTACT_TUBE_004 NbElem: 96 ---$
SELF DMIN 0.1
 LECT con20 TERM
$---Gr: 37 CONTACT_TUBE_005 NbElem: 96 ---$
SELF DMIN 0.1
 LECT con21 TERM
$---Gr: 38 CONTACT_TUBE_006 NbElem: 96 ---$
SELF DMIN 0.1
```

```
 LECT con22 TERM
$---Gr: 39 CONTACT_TUBE_007 NbElem: 96 ---$
SELF DMIN 0.1
 LECT con23 TERM
$---Gr: 40 CONTACT_TUBE_008 NbElem: 96 ---$
SELF DMIN 0.1
 LECT con24 TERM
$---Gr: 41 CONTACT_TUBE_009 NbElem: 96 ---$
SELF DMIN 0.1
 LECT con25 TERM
FONCT 1 TABLE 4 0. 0. 0.0001 0. 1.0001 1. 100.0001  100.
$---------------------------------------- Directives Generales --------$
ECRITURE
$                                         impressions LISTING           $
    DEPL TFRE 0.1 !FREQ 1000
    POINT LECT 4460 TERM
$                                       Donnees Fichier ALICE           $
    FICHIER SPLI ALICE TFRE 0.05 !TFREQ   50.0000
$   POIN LECT 1 PAS 1 4948 TERM
$   ELEM LECT 1 PAS 1 4080 TERM
$                                    Donnees Fichier ALICE Temps        $
!   FICHIER ALICE TEMPS TFREQ 0.05
!   POIN LECT TOUS TERM
!   ELEM LECT TOUS TERM
$                                    Donnees Fichier PARAVIEW           $
!   FICHIER FORMAT PVTK TFREQ 0.5
!   GROUP AUTO
!   VARI DEPL VITE FEXT ACCE CONT EPST ECRO PINB
$ Regions
$                  "OPTION" de Calcul : methode Pas, amortissement      $
OPTION
    PAS AUTO CSTA 0.5
    STEP IO
    PASMINI  1.00000E-12
    LOG 1
    PINS GRID DGRI
$                                "OPTION" liee a la fragmentation       $
$                                "OPTION" liee a l'amortissement        $
$   QUASI STATIQUE 50.0E-3 0.7
$   AMORT LINE 0.5
$                                "OPTION" liee aux multi-domaines       $
$                                   Directives du Pas de Calcul         $
$                  Tps_depart - Pas_fixe - Nbr_pas_max - Tps_Final      $
CALCUL TINI 0.00 DTMIN 1E-12 DTMAX 1E-04 TFIN 10.0 NMAX 90000000
FIN
```

car102a.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'car102.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

car102b.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'car102.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
          LINE HEOU SFRE
     ISO FILL FIEL ECRO 3 SCAL USER PROG 0.05 PAS 0.05 0.7 TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

car102c.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'car102.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
          !LINE HEOU SFRE
           FACE HFRO
           PINB CDES
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

car102d.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'car102.ali' GARD PSCR
OPTI PRIN
SORT GRAP
AXTE 1.0 'Time [ms]'
COUR 1 'dy_4267' DEPL COMP 2 NOEU LECT 4267 TERM
COUR 2 'dy' MULC 1 -1.0
COUR 3 'fyh' FLIA COMP 2 ZONE LECT noeuds_haut TERM
COUR 4 'fyb' FLIA COMP 2 ZONE LECT noeuds_bas TERM
TRAC 2 AXES 1.0 'DISPL. [MM]' YZER XGRD YGRD
TRAC 3 4 AXES 1.0 'FORCE [N]'
LIST 3 4 AXES 1.0 'FORCE [N]'
TRAC 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
RCOU 44 'fyb' FICH 'car401d.pun' RENA 'fyb_401'
TRAC 4 44 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR ROUG
FIN
```

car401.epx

```
CAR401
ECHO
!CONV WIN
DPLA
$ *** Group B *** Geometry and mesh ***********************************
GEOM
     LIBR POIN 4948 CAR4 4080 TERM
!    LIBR POIN 4950 CAR4 4080 PMAT 2 TERM
$ *** Group B *** Nodes ***********************************
 1.50000E+01  5.95437E-30

 . . . (skip for brevity)

       3444       3483       3484       3445
!4949
!4950
$ *** Group C *** Geometrics complements ******************************
COMPLEMENT
!   GROU 2 'p0' LECT 4081 TERM
!          'p1' LECT 4082 TERM
!   EPAI 0.1 LECT p0 p1 TERM
    NGROU 3
      'noeuds_bas'
$---Gr: 42 NOEUDS_BAS NbNode: 79 ---$
 LECT
         1         6        11        16        21        26        31
        36        41        46        51        56        57        70
        78        80        94       104       107       118       130
       134       142       156       161       166       167       168
       169       170       171       172       190       215       236
       242       257       262       263       286       294       296
       320       330       333       354       366       370       388
       402       407       412       413       414       415       416
       417       418       446       481       512       518       543
       548       577       585       616       626       655       667
       694       708       713       714       715       716       717
       718       719 TERM
      'noeuds_haut'
$---Gr: 43 NOEUDS_HAUT NbNode: 79 ---$
 LECT
      4267      4268      4269      4270      4271      4272      4273
      4274      4275      4309      4314      4348      4353      4387
      4392      4421      4426      4455      4460      4493      4530
      4535      4548      4549      4550      4551      4552      4553
      4554      4555      4556      4576      4585      4590      4610
      4619      4624      4644      4653      4658      4678      4687
      4692      4707      4712      4731      4754      4781      4794
```

```
      4795      4796      4797      4798      4799      4800      4801
      4802      4812      4821      4826      4836      4845      4850
      4860      4869      4874      4884      4893      4898      4903
      4908      4913      4918      4923      4928      4933      4938
      4943      4948 TERM
$---Gr: 44 NOEUDS_SYM NbNode: 35 ---$
     'noeuds_sym'
 LECT
         2         3         4         5       528       562       601
       640       679       725       767       805       839      1933
      1967      2006      2045      2084      2130      2172      2210
      2243      3333      3370      3411      3452      3493      3538
      3579      3616      3648      4456      4457      4458      4459
 TERM
 GROU 25
$---Gr: 17 CONTACT_INTER_001 NbElem: 22 ---$
 'con01'
 LECT
       676       682       689       694       700       706       756
       757       758       759       760       761       762       763
       764       765       766       767       768       769       770
       771 TERM
$---Gr: 18 CONTACT_INTER_002 NbElem: 28 ---$
 'con02'
 LECT
       949       955       962       967       973       979      1029
      1030      1031      1032      1033      1034      1035      1036
      1415      1421      1428      1433      1439      1445      1495
      1496      1497      1498      1499      1500      1501      1502
 TERM
$---Gr: 19 CONTACT_INTER_003 NbElem: 28 ---$
 'con03'
 LECT
      1182      1188      1195      1200      1206      1212      1262
      1263      1264      1265      1266      1267      1268      1269
      1935      1941      1948      1953      1959      1965      2015
      2016      2017      2018      2019      2020      2021      2022
 TERM
$---Gr: 20 CONTACT_INTER_004 NbElem: 23 ---$
 'con04'
 LECT
      1503      1662      1668      1675      1680      1686      1692
      1742      1743      1744      1745      1746      1747      1748
      1749      1750      1751      1752      1753      1754      1755
      1756      1757 TERM
$---Gr: 21 CONTACT_INTER_005 NbElem: 44 ---$
 'con05'
 LECT
       675       679       681       686       688       692       693
       698       699       704       705       710       740       741
       742       743       744       745       746       747       748
       749       750       751       752       753       754       755
       772       773       774       775       776       777       778
       779       780       781       782       783       784       785
       786       787 TERM
$---Gr: 22 CONTACT_INTER_006 NbElem: 56 ---$
 'con06'
 LECT
       948       952       954       959       961       965       966
       971       972       977       978       983      1013      1014
      1015      1016      1017      1018      1019      1020      1021
      1022      1023      1024      1025      1026      1027      1028
      1414      1418      1420      1425      1427      1431      1432
      1437      1438      1443      1444      1449      1479      1480
      1481      1482      1483      1484      1485      1486      1487
      1488      1489      1490      1491      1492      1493      1494
 TERM
$---Gr: 23 CONTACT_INTER_007 NbElem: 56 ---$
 'con07'
 LECT
      1181      1185      1187      1192      1194      1198      1199
      1204      1205      1210      1211      1216      1246      1247
      1248      1249      1250      1251      1252      1253      1254
      1255      1256      1257      1258      1259      1260      1261
      1934      1938      1940      1945      1947      1951      1952
      1957      1958      1963      1964      1969      1999      2000
      2001      2002      2003      2004      2005      2006      2007
      2008      2009      2010      2011      2012      2013      2014
 TERM
$---Gr: 24 CONTACT_INTER_008 NbElem: 46 ---$
 'con08'
 LECT
      1504      1505      1661      1665      1667      1672      1674
      1678      1679      1684      1685      1690      1691      1696
      1726      1727      1728      1729      1730      1731      1732
      1733      1734      1735      1736      1737      1738      1739
      1740      1741      1758      1759      1760      1761      1762
      1763      1764      1765      1766      1767      1768      1769
      1770      1771      1772      1773 TERM
$---Gr: 25 CONTACT_INTER_009 NbElem: 44 ---$
 'con09'
 LECT
       678       680       684       685       690       691       696
       697       702       703       708       709       724       725
       726       727       728       729       730       731       732
       733       734       735       736       737       738       739
       788       789       790       791       792       793       794
       795       796       797       798       799       800       801
       802       803 TERM
$---Gr: 26 CONTACT_INTER_010 NbElem: 56 ---$
 'con10'
 LECT
       951       953       957       958       963       964       969
       970       975       976       981       982       997       998
       999      1000      1001      1002      1003      1004      1005
      1006      1007      1008      1009      1010      1011      1012
      1417      1419      1423      1424      1429      1430      1435
      1436      1441      1442      1447      1448      1463      1464
      1465      1466      1467      1468      1469      1470      1471
      1472      1473      1474      1475      1476      1477      1478
 TERM
$---Gr: 27 CONTACT_INTER_011 NbElem: 56 ---$
 'con11'
 LECT
      1184      1186      1190      1191      1196      1197      1202
      1203      1208      1209      1214      1215      1230      1231
      1232      1233      1234      1235      1236      1237      1238
      1239      1240      1241      1242      1243      1244      1245
      1937      1939      1943      1944      1949      1950      1955
      1956      1961      1962      1967      1968      1983      1984
      1985      1986      1987      1988      1989      1990      1991
      1992      1993      1994      1995      1996      1997      1998
 TERM
$---Gr: 28 CONTACT_INTER_012 NbElem: 46 ---$
 'con12'
 LECT
      1506      1507      1664      1666      1670      1671      1676
      1677      1682      1683      1688      1689      1694      1695
      1710      1711      1712      1713      1714      1715      1716
      1717      1718      1719      1720      1721      1722      1723
      1724      1725      1774      1775      1776      1777      1778
      1779      1780      1781      1782      1783      1784      1785
      1786      1787      1788      1789 TERM
$---Gr: 29 CONTACT_EXTER_001 NbElem: 27 ---$
 'con13'
 LECT
       523       524       525       526       527       528       529
       530       677       683       687       695       701       707
       711       712       713       714       715       716       717
       718       719       720       721       722       723 TERM
$---Gr: 30 CONTACT_EXTER_002 NbElem: 38 ---$
 'con14'
 LECT
       950       956       960       968       974       980       984
       985       986       987       988       989       990       991
       992       993       994       995       996      1416      1422
      1426      1434      1440      1446      1450      1451      1452
      1453      1454      1455      1456      1457      1458      1459
      1460      1461      1462 TERM
$---Gr: 31 CONTACT_EXTER_003 NbElem: 38 ---$
 'con15'
 LECT
      1183      1189      1193      1201      1207      1213      1217
      1218      1219      1220      1221      1222      1223      1224
      1225      1226      1227      1228      1229      1936      1942
      1946      1954      1960      1966      1970      1971      1972
      1973      1974      1975      1976      1977      1978      1979
      1980      1981      1982 TERM
$---Gr: 32 CONTACT_EXTER_004 NbElem: 28 ---$
 'con16'
 LECT
      1508      1509      1510      1511      1512      1513      1514
      1515      1516      1663      1669      1673      1681      1687
      1693      1697      1698      1699      1700      1701      1702
      1703      1704      1705      1706      1707      1708      1709
 TERM
$---Gr: 33 CONTACT_TUBE_001 NbElem: 96 ---$
 'con17'
 LECT
       532       533       540       541       547       548       551
       554       559       560       563       566       569       572
       577       578       581       584       587       590       593
       596       649       650       651       652       653       654
       655       656       657       658       659       660       661
       662       663       664       665       666       667       668
       669       670       671       672       673       674       805
       806       813       814       820       821       824       827
       832       833       836       839       842       845       850
       851       854       857       860       863       866       869
       922       923       924       925       926       927       928
       929       930       931       932       933       934       935
       936       937       938       939       940       941       942
       943       944       945       946       947 TERM
$---Gr: 34 CONTACT_TUBE_002 NbElem: 96 ---$
 'con18'
 LECT
      1038      1039      1046      1047      1053      1054      1057
      1060      1065      1066      1069      1072      1075      1078
      1083      1084      1087      1090      1093      1096      1099
      1102      1155      1156      1157      1158      1159      1160
      1161      1162      1163      1164      1165      1166      1167
      1168      1169      1170      1171      1172      1173      1174
      1175      1176      1177      1178      1179      1180      1271
      1272      1279      1280      1286      1287      1290      1293
      1298      1299      1302      1305      1308      1311      1316
      1317      1320      1323      1326      1329      1332      1335
      1388      1389      1390      1391      1392      1393      1394
      1395      1396      1397      1398      1399      1400      1401
      1402      1403      1404      1405      1406      1407      1408
      1409      1410      1411      1412      1413 TERM
$---Gr: 35 CONTACT_TUBE_003 NbElem: 96 ---$
 'con19'
 LECT
      1518      1519      1526      1527      1533      1534      1537
      1540      1545      1546      1549      1552      1555      1558
      1563      1564      1567      1570      1573      1576      1579
      1582      1635      1636      1637      1638      1639      1640
      1641      1642      1643      1644      1645      1646      1647
      1648      1649      1650      1651      1652      1653      1654
      1655      1656      1657      1658      1659      1660      1791
      1792      1799      1800      1806      1807      1810      1813
      1818      1819      1822      1825      1828      1831      1836
      1837      1840      1843      1846      1849      1852      1855
      1908      1909      1910      1911      1912      1913      1914
      1915      1916      1917      1918      1919      1920      1921
      1922      1923      1924      1925      1926      1927      1928
      1929      1930      1931      1932      1933 TERM
$---Gr: 36 CONTACT_TUBE_004 NbElem: 96 ---$
 'con20'
 LECT
       531       536       539       542       545       546       550
       553       557       558       562       565       568       571
       575       576       580       583       586       589       592
       595       623       624       625       626       627       628
       629       630       631       632       633       634       635
       636       637       638       639       640       641       642
       643       644       645       646       647       648       804
       809       812       815       818       819       823       826
       830       831       835       838       841       844       848
       849       853       856       859       862       865       868
       896       897       898       899       900       901       902
       903       904       905       906       907       908       909
       910       911       912       913       914       915       916
       917       918       919       920       921 TERM
$---Gr: 37 CONTACT_TUBE_005 NbElem: 96 ---$
 'con21'
```

```
 LECT
      1037      1042      1045      1048      1051      1052      1056
      1059      1063      1064      1068      1071      1074      1077
      1081      1082      1086      1089      1092      1095      1098
      1101      1129      1130      1131      1132      1133      1134
      1135      1136      1137      1138      1139      1140      1141
      1142      1143      1144      1145      1146      1147      1148
      1149      1150      1151      1152      1153      1154      1270
      1275      1278      1281      1284      1285      1289      1292
      1296      1297      1301      1304      1307      1310      1314
      1315      1319      1322      1325      1328      1331      1334
      1362      1363      1364      1365      1366      1367      1368
      1369      1370      1371      1372      1373      1374      1375
      1376      1377      1378      1379      1380      1381      1382
      1383      1384      1385      1386      1387 TERM
$---Gr: 38 CONTACT_TUBE_006 NbElem: 96 ---$
 'con22'
 LECT
      1517      1522      1525      1528      1531      1532      1536
      1539      1543      1544      1548      1551      1554      1557
      1561      1562      1566      1569      1572      1575      1578
      1581      1609      1610      1611      1612      1613      1614
      1615      1616      1617      1618      1619      1620      1621
      1622      1623      1624      1625      1626      1627      1628
      1629      1630      1631      1632      1633      1634      1790
      1795      1798      1801      1804      1805      1809      1812
      1816      1817      1821      1824      1827      1830      1834
      1835      1839      1842      1845      1848      1851      1854
      1882      1883      1884      1885      1886      1887      1888
      1889      1890      1891      1892      1893      1894      1895
      1896      1897      1898      1899      1900      1901      1902
      1903      1904      1905      1906      1907 TERM
$---Gr: 39 CONTACT_TUBE_007 NbElem: 96 ---$
 'con23'
 LECT
       534       535       537       538       543       544       549
       552       555       556       561       564       567       570
       573       574       579       582       585       588       591
       594       597       598       599       600       601       602
       603       604       605       606       607       608       609
       610       611       612       613       614       615       616
       617       618       619       620       621       622       807
       808       810       811       816       817       822       825
       828       829       834       837       840       843       846
       847       852       855       858       861       864       867
       870       871       872       873       874       875       876
       877       878       879       880       881       882       883
       884       885       886       887       888       889       890
       891       892       893       894       895 TERM
$---Gr: 40 CONTACT_TUBE_008 NbElem: 96 ---$
 'con24'
 LECT
      1040      1041      1043      1044      1049      1050      1055
      1058      1061      1062      1067      1070      1073      1076
      1079      1080      1085      1088      1091      1094      1097
      1100      1103      1104      1105      1106      1107      1108
      1109      1110      1111      1112      1113      1114      1115
      1116      1117      1118      1119      1120      1121      1122
      1123      1124      1125      1126      1127      1128      1273
      1274      1276      1277      1282      1283      1288      1291
      1294      1295      1300      1303      1306      1309      1312
      1313      1318      1321      1324      1327      1330      1333
      1336      1337      1338      1339      1340      1341      1342
      1343      1344      1345      1346      1347      1348      1349
      1350      1351      1352      1353      1354      1355      1356
      1357      1358      1359      1360      1361 TERM
$---Gr: 41 CONTACT_TUBE_009 NbElem: 96 ---$
 'con25'
 LECT
      1520      1521      1523      1524      1529      1530      1535
      1538      1541      1542      1547      1550      1553      1556
      1559      1560      1565      1568      1571      1574      1577
      1580      1583      1584      1585      1586      1587      1588
      1589      1590      1591      1592      1593      1594      1595
      1596      1597      1598      1599      1600      1601      1602
      1603      1604      1605      1606      1607      1608      1793
      1794      1796      1797      1802      1803      1808      1811
      1814      1815      1820      1823      1826      1829      1832
      1833      1838      1841      1844      1847      1850      1853
      1856      1857      1858      1859      1860      1861      1862
      1863      1864      1865      1866      1867      1868      1869
      1870      1871      1872      1873      1874      1875      1876
      1877      1878      1879      1880      1881 TERM
$ *** Group C1 *** Materials ******************************************
MATERIAU
!   FANT 0.0 LECT p0 p1 TERM
    VMIS ISOT RO 0.00825 YOUN 197600.0 NU 0.29 ELAS 222.35
         TRAC 39
222.35 0.00112525303643725
228.192645571222 0.00117982108082602
230.758344471793 0.001217805387003
234.450726613396 0.00128649153144431
239.764555869277 0.00141338337990525
243.897432663364 0.00153429874829638
247.411863292444 0.00165208432840306
250.528021456793 0.00176785435959915
253.359622970924 0.00188218432677593
258.417356319849 0.00210778014331907
262.901922592959 0.00233047531676599
272.525831528572 0.00287917930935512
280.709612952488 0.00342059520724944
306.337249091751 0.00555028972212425
326.269365384357 0.00765116075599371
358.247494301277 0.0118129933922129
390.499112131117 0.0169762100816352
417.924578503771 0.0221150029276507
464.338948360747 0.0323498934633641
503.807844043327 0.0425496348382759
538.803931461142 0.0527267405438317
570.604298738599 0.0628876735766123
599.971697212392 0.0730362940142328
627.405291846074 0.0831751279951724
653.253096704044 0.0933059367242108
677.76931865327 0.103430006673347
734.395540393597 0.128716576621425
785.850853879881 0.153976978005465
833.369446403083 0.179217456712566
877.759003278812 0.204442100219022
959.251671749752 0.2548545125088855
1033.30271513801 0.305229264752723
1165.57077256009 0.405898637512956
1282.84956691385 0.506492153678714
1389.41887249881 0.607031472026816
1579.77020835558 0.807994788503824
1748.55 1.00884893724696
2418.75489508018 2.0122406624245
5336.94734929116 10.0270088428608
          LECT                      1 PAS       1    4080 TERM
$---------------------------- Load Case considere : "Default" -------$
LINK COUP SPLT NONE
   BLOQ 12 LECT noeuds_bas TERM
   BLOQ 1  LECT noeuds_sym TERM
   BLOQ 1  LECT       4460 TERM
   DEPLA 2 -1. FONCT 1 LECT noeuds_haut TERM

PINB
$---Gr: 17 CONTACT_INTER_001 NbElem: 22 ---$
SELF DMIN 0.1
 LECT con01 TERM
$---Gr: 18 CONTACT_INTER_002 NbElem: 28 ---$
SELF DMIN 0.1
 LECT con02 TERM
$---Gr: 19 CONTACT_INTER_003 NbElem: 28 ---$
SELF DMIN 0.1
 LECT con03 TERM
$---Gr: 20 CONTACT_INTER_004 NbElem: 23 ---$
SELF DMIN 0.1
 LECT con04 TERM
$---Gr: 21 CONTACT_INTER_005 NbElem: 44 ---$
SELF DMIN 0.1
 LECT con05 TERM
$---Gr: 22 CONTACT_INTER_006 NbElem: 56 ---$
SELF DMIN 0.1
 LECT con06 TERM
$---Gr: 23 CONTACT_INTER_007 NbElem: 56 ---$
SELF DMIN 0.1
 LECT con07 TERM
$---Gr: 24 CONTACT_INTER_008 NbElem: 46 ---$
SELF DMIN 0.1
 LECT con08 TERM
$---Gr: 25 CONTACT_INTER_009 NbElem: 44 ---$
SELF DMIN 0.1
 LECT con09 TERM
$---Gr: 26 CONTACT_INTER_010 NbElem: 56 ---$
SELF DMIN 0.1
 LECT con10 TERM
$---Gr: 27 CONTACT_INTER_011 NbElem: 56 ---$
SELF DMIN 0.1
 LECT con11 TERM
$---Gr: 28 CONTACT_INTER_012 NbElem: 46 ---$
SELF DMIN 0.1
 LECT con12 TERM
$---Gr: 29 CONTACT_EXTER_001 NbElem: 27 ---$
SELF DMIN 0.1
 LECT con13 TERM
$---Gr: 30 CONTACT_EXTER_002 NbElem: 38 ---$
SELF DMIN 0.1
 LECT con14 TERM
$---Gr: 31 CONTACT_EXTER_003 NbElem: 38 ---$
SELF DMIN 0.1
 LECT con15 TERM
$---Gr: 32 CONTACT_EXTER_004 NbElem: 28 ---$
SELF DMIN 0.1
 LECT con16 TERM
$---Gr: 33 CONTACT_TUBE_001 NbElem: 96 ---$
SELF DMIN 0.1
 LECT con17 TERM
$---Gr: 34 CONTACT_TUBE_002 NbElem: 96 ---$
SELF DMIN 0.1
 LECT con18 TERM
$---Gr: 35 CONTACT_TUBE_003 NbElem: 96 ---$
SELF DMIN 0.1
 LECT con19 TERM
$---Gr: 36 CONTACT_TUBE_004 NbElem: 96 ---$
SELF DMIN 0.1
 LECT con20 TERM
$---Gr: 37 CONTACT_TUBE_005 NbElem: 96 ---$
SELF DMIN 0.1
 LECT con21 TERM
$---Gr: 38 CONTACT_TUBE_006 NbElem: 96 ---$
SELF DMIN 0.1
 LECT con22 TERM
$---Gr: 39 CONTACT_TUBE_007 NbElem: 96 ---$
SELF DMIN 0.1
 LECT con23 TERM
$---Gr: 40 CONTACT_TUBE_008 NbElem: 96 ---$
SELF DMIN 0.1
 LECT con24 TERM
$---Gr: 41 CONTACT_TUBE_009 NbElem: 96 ---$
SELF DMIN 0.1
 LECT con25 TERM
FONCT 1 TABLE 4 0. 0. 0.0001 0. 1.0001 1. 100.0001  100.
$---------------------------------------- Directives Generales --------$
ECRITURE
$                                          impressions LISTING           $
    DEPL TFRE 0.1 !FREQ 1000
    POINT LECT 4460 TERM
$                                       Donnees Fichier ALICE            $
    FICHIER SPLI ALICE TFRE 0.05 !TFREQ   50.0000
$   POIN LECT 1 PAS 1 4948 TERM
$   ELEM LECT 1 PAS 1 4080 TERM
$                                    Donnees Fichier ALICE Temps         $
!   FICHIER ALICE TEMPS TFREQ 0.05
!   POIN LECT TOUS TERM
!   ELEM LECT TOUS TERM
$                                    Donnees Fichier PARAVIEW            $
!   FICHIER FORMAT PVTK TFREQ 0.5
!   GROUP AUTO
!   VARI DEPL VITE FEXT ACCE CONT EPST ECRO PINB
$ Regions
$                 "OPTION" de Calcul : methode Pas, amortissement       $
OPTION
    PAS AUTO
    STEP IO
    PASMINI  1.00000E-12
    LOG 1
```

```
    PINS GRID DGRI
$                             "OPTION" liee a la fragmentation        $
$                             "OPTION" liee a l'amortissement         $
$   QUASI STATIQUE 50.0E-3 0.7
$   AMORT LINE 0.5
$                             "OPTION" liee aux multi-domaines        $
$                                 Directives du Pas de Calcul         $
$                 Tps_depart - Pas_fixe - Nbr_pas_max - Tps_Final     $
CALCUL TINI 0.00 DTMIN 1E-12 DTMAX 1E-04 TFIN 10.0 !NMAX 100
FIN
```

car401a.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'car401.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

car401b.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'car401.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
          LINE HEOU SFRE
     ISO FILL FIEL ECRO 3 SCAL USER PROG 0.05 PAS 0.05 0.7 TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

car401c.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'car401.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
         !LINE HEOU SFRE
          FACE HFRO
          PINB CDES
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

car401d.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'car401.ali' GARD PSCR
OPTI PRIN
SORT GRAP
AXTE 1.0 'Time [ms]'
COUR 1 'dy_4267' DEPL COMP 2 NOEU LECT 4267 TERM
COUR 2 'dy' MULC 1 -1.0
COUR 3 'fyh' FLIA COMP 2 ZONE LECT noeuds_haut TERM
COUR 4 'fyb' FLIA COMP 2 ZONE LECT noeuds_bas TERM
TRAC 2 AXES 1.0 'DISPL. [MM]' YZER XGRD YGRD
TRAC 3 4 AXES 1.0 'FORCE [N]'
LIST 3 4 AXES 1.0 'FORCE [N]'
TRAC 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
FIN
```

cara01.epx

```
CARA01
ECHO
!CONV WIN
CAST mesh
ALE DPLA
DIME NALE 1 NBLE 3180 TERM
GEOM Q42G sur4 TERM
COMP EPAI 1. LECT sur4 TERM
     NGRO 3
       'noeuds_sym'  LECT nodlag TERM COND X GT 14.95
       'noeuds_haut' LECT nodlag TERM COND Y GT 16.95
       'noeuds_bas'  LECT nodlag TERM COND Y LT  0.05
     COUL VERT LECT sur4 TERM
GRIL LAGR LECT nodlag TERM
     AUTO AUTR
MATE VM23 RO 0.00825 YOUN 197600.0 NU 0.29 ELAS 222.35
          TRAC 39
            222.35           0.00112525303643725
            228.192645571222 0.00117982108082602
            230.758344471793 0.001217805387003
            234.450726613396 0.00128649153144431
            239.764555869277 0.00141338337990525
            243.897432663364 0.00153429874829638
            247.411863292444 0.00165208432840306
            250.528021456793 0.00176785435959915
            253.359622970924 0.00188218432677593
            258.417356319849 0.00201078014331907
            262.901922592959 0.00233047531676599
            272.525831528572 0.00287917930935512
            280.709612952488 0.00342059520724944
            306.337249091751 0.00555028972212425
            326.269365384357 0.00765116075599371
            358.247494301277 0.0118129933922129
            390.499112131117 0.0169762100816352
            417.924578503771 0.0221150029276507
            464.338948360747 0.0323498934633641
            503.807844043327 0.0425496348382759
            538.803931461142 0.0527267405438317
            570.604298738599 0.0628876735766123
            599.971697212392 0.0730362940142328
            627.405291846074 0.0831751279951724
            653.253096704044 0.0933059367242108
            677.76931865327  0.103430006673347
            734.395540393597 0.128716576621425
            785.850853879881 0.153976978005465
            833.369446403083 0.179217456712566
            877.759003278812 0.204442100219022
            959.251671749752 0.254854512508855
            1033.30271513801 0.305229264752723
            1165.57077256009 0.405898637512956
            1282.84956691385 0.506492153678714
            1389.41887249881 0.607031472026816
            1579.77020835558 0.807994788503824
            1748.55          1.00884893724696
            2418.75489508018 2.0122406624245
            5336.94734929116 10.0270088428608
          LECT sur4 TERM
LINK COUP SPLT NONE
     BLOQ 12 LECT noeuds_bas TERM
     BLOQ 1  LECT noeuds_sym TERM
     BLOQ 1  LECT       4460 TERM
     DEPL 2 -1. FONC 1 LECT noeuds_haut TERM
     PINB SELF DMIN 0.1 LECT elepin TERM
FONCT 1 TABLE 4 0. 0. 0.0001 0. 1.0001 1. 100.0001  100.
ECRI DEPL TFRE 0.1 POIN LECT 4460 TERM
     FICH SPLI ALIC TFRE 0.05
REGI 'HAUT' TOUT POIN LECT noeuds_haut TERM
     'BAS'  TOUT POIN LECT noeuds_bas TERM
OPTI PAS AUTO
     PASM 1.0E-12
     LOG 1
     PINS GRID DGRI EQVF CNOR
CALC TINI 0.0 DTMI 1.E-12 DTMA 1.E-04 TFIN 10.0 NMAX 900000000
FIN
```

cara01a.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara01.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
```

```
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

cara01b.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara01.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
          LINE HEOU SFRE
     ISO FILL FIEL ECRO 3 SCAL USER PROG 0.05 PAS 0.05 0.7 TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

cara01c.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara01.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
         !LINE HEOU SFRE
          FACE HFRO
          PINB CDES
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

cara01d.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara01.ali' GARD PSCR
OPTI PRIN
SORT GRAP
AXTE 1.0 'Time [ms]'
COUR 1 'dy_4267' DEPL COMP 2 NOEU LECT 4267 TERM
COUR 2 'dy' MULC 1 -1.0
COUR 3 'fyh' FLIA COMP 2 ZONE LECT noeuds_haut TERM
COUR 4 'fyb' FLIA COMP 2 ZONE LECT noeuds_bas TERM
TRAC 2 AXES 1.0 'DISPL. [MM]' YZER XGRD YGRD
TRAC 3 4 AXES 1.0 'FORCE [N]'
LIST 3 4 AXES 1.0 'FORCE [N]'
TRAC 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
RCOU 44 'fyb' FICH 'car401d.pun' RENA 'fyb_401'
RCOU 54 'fyb' FICH 'car102d.pun' RENA 'fyb_102'
TRAC 4 44 54 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR ROUG VERT
TRAC 4 54 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR VERT
FIN
```

cara01e.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara01.ali' GARD PSCR
OPTI PRIN
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dyh' DEPL COMP 2 NOEU LECT 350 TERM
COUR 2 'dy' MULC 1 -1.0
COUR 3 'fyh' FLIA COMP 2 ZONE LECT noeuds_haut TERM
COUR 4 'fy' MULC 3 -1.0
COUR 5 'fyb' FLIA COMP 2 ZONE LECT noeuds_bas TERM
TRAC 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
LIST 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
TRAC 2 AXES 1.0 'DISPL. [MM]' YZER XGRD YGRD
TRAC 4 5 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR ROUG
FIN
```

cara02.epx

```
CARA02
ECHO
!CONV WIN
CAST mesh
ALE DPLA
DIME NALE 1 NBLE 3180 TERM
GEOM Q42G sur4 TERM
COMP EPAI 1. LECT sur4 TERM
     NGRO 3
       'noeuds_sym'  LECT nodlag TERM COND X GT 14.95
       'noeuds_haut' LECT nodlag TERM COND Y GT 16.95
       'noeuds_bas'  LECT nodlag TERM COND Y LT  0.05
     COUL VERT LECT sur4 TERM
GRIL LAGR LECT nodlag TERM
     AUTO AUTR
MATE VM23 RO 0.00825 YOUN 197600.0 NU 0.29 ELAS 222.35
          TRAC 39
            222.35           0.00112525303643725
            228.192645571222 0.00117982108082602
            230.758344471793 0.001217805387003
            234.450726613396 0.00128649153144431
            239.764555869277 0.00141338337990525
            243.897432663364 0.00153429874829638
            247.411863292444 0.00165208432840306
            250.528021456793 0.00176785435959915
            253.359622970924 0.00188218432677593
            258.417356319849 0.00210778014331907
            262.901922592959 0.00233047531676599
            272.525831528572 0.00287917930935512
            280.709612952488 0.00342059520724944
            306.337249091751 0.00555028972212425
            326.269365384357 0.00765116075599371
            358.247494301277 0.0118129933922129
            390.499112131117 0.0169762100816352
            417.924578503771 0.0221150029276507
            464.338948360747 0.0323498934633641
            503.807844043327 0.0425496348382759
            538.803931461142 0.0527267405438317
            570.604298738599 0.0628876735766123
            599.971697212392 0.0730362940142328
            627.405291846074 0.0831751279951724
            653.253096704044 0.0933059367242108
            677.76931865327  0.103430006673347
            734.395540393597 0.128716576621425
            785.850853879881 0.153976978005465
            833.369446403083 0.179217456712566
            877.759003278812 0.204442100219022
            959.251671749752 0.254854512508855
            1033.30271513801 0.305229264752723
            1165.57077256009 0.405898637512956
            1282.84956691385 0.506492153678714
            1389.41887249881 0.607031472026816
            1579.77020835558 0.807994788503824
            1748.55          1.00884893724696
            2418.75489508018 2.0122406624245
            5336.94734929116 10.0270088428608
          LECT sur4 TERM
LINK COUP SPLT NONE
     BLOQ 12 LECT noeuds_bas TERM
     BLOQ 1  LECT noeuds_sym TERM
     DEPL 2 -1. FONC 1 LECT noeuds_haut TERM
     PINB SELF DMIN 0.1 LECT elepin TERM
FONCT 1 TABLE 4 0. 0. 0.0001 0. 1.0001 1. 100.0001  100.
ECRI DEPL TFRE 0.1 POIN LECT 4460 TERM
     FICH SPLI ALIC TFRE 0.05
REGI 'HAUT' TOUT POIN LECT noeuds_haut TERM
     'BAS'  TOUT POIN LECT noeuds_bas TERM
OPTI PAS AUTO
     PASM 1.0E-12
     LOG 1
     PINS GRID DGRI EQVF CNOR
CALC TINI 0.0 DTMI 1.E-12 DTMA 1.E-04 TFIN 10.0 NMAX 900000000
FIN
```

cara02a.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara02.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

cara02b.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara02.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
          LINE HEOU SFRE
     ISO FILL FIEL ECRO 3 SCAL USER PROG 0.05 PAS 0.05 0.7 TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

cara02c.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara02.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
         !LINE HEOU SFRE
          FACE HFRO
          PINB CDES
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

cara02d.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara02.ali' GARD PSCR
OPTI PRIN
SORT GRAP
AXTE 1.0 'Time [ms]'
COUR 1 'dy_4267' DEPL COMP 2 NOEU LECT 4267 TERM
COUR 2 'dy' MULC 1 -1.0
COUR 3 'fyh' FLIA COMP 2 ZONE LECT noeuds_haut TERM
COUR 4 'fyb' FLIA COMP 2 ZONE LECT noeuds_bas TERM
TRAC 2 AXES 1.0 'DISPL. [MM]' YZER XGRD YGRD
TRAC 3 4 AXES 1.0 'FORCE [N]'
LIST 3 4 AXES 1.0 'FORCE [N]'
TRAC 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
RCOU 44 'fyb' FICH 'car401d.pun' RENA 'fyb_401'
RCOU 54 'fyb' FICH 'car102d.pun' RENA 'fyb_102'
TRAC 4 44 54 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR ROUG VERT
TRAC 4 54 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR VERT
FIN
```

cara02e.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara02.ali' GARD PSCR
OPTI PRIN
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dyh' DEPL COMP 2 NOEU LECT 350 TERM
COUR 2 'dy' MULC 1 -1.0
COUR 3 'fyh' FLIA COMP 2 ZONE LECT noeuds_haut TERM
COUR 4 'fy' MULC 3 -1.0
COUR 5 'fyb' FLIA COMP 2 ZONE LECT noeuds_bas TERM
TRAC 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
LIST 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
RCOU 14 'fy' FICH 'cara01e.pun' RENA 'fy_01'
RCOU 24 'fy' FICH 'cara02e.pun' RENA 'fy_02'
TRAC 14 24 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR ROUG
TRAC 2 AXES 1.0 'DISPL. [MM]' YZER XGRD YGRD
TRAC 4 5 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR ROUG
FIN
```

cara03.epx

```
CARA03
ECHO
!CONV WIN
CAST mesh
ALE DPLA
DIME NALE 1 NBLE 3180 TERM
GEOM Q41N sur4 TERM
COMP EPAI 1. LECT sur4 TERM
     NGRO 3
       'noeuds_sym'  LECT nodlag TERM COND X GT 14.95
       'noeuds_haut' LECT nodlag TERM COND Y GT 16.95
       'noeuds_bas'  LECT nodlag TERM COND Y LT  0.05
     COUL VERT LECT sur4 TERM
GRIL LAGR LECT nodlag TERM
     AUTO AUTR
MATE VM23 RO 0.00825 YOUN 197600.0 NU 0.29 ELAS 222.35
          TRAC 39
            222.35           0.00112525303643725
            228.192645571222 0.00117982108082602
            230.758344471793 0.001217805387003
            234.450726613396 0.00128649153144431
            239.764555869277 0.00141338337990525
            243.897432663364 0.00153429874829638
            247.411863292444 0.00165208432840306
            250.528021456793 0.00176785435959915
            253.359622970924 0.00188218432677593
            258.417356319849 0.00210778014331907
            262.901922592959 0.00233047531676599
            272.525831528572 0.00287917930935512
            280.709612952488 0.00342059520724944
            306.337249091751 0.00555028972212425
            326.269365384357 0.00765116075599371
            358.247494301277 0.0118129933922129
            390.499112131117 0.0169762100816352
            417.924578503771 0.0221150029276507
            464.338948360747 0.0323498934633641
            503.807844043327 0.0425496348382759
            538.803931461142 0.0527267405438317
            570.604298738599 0.0628876735766123
            599.971697212392 0.0730362940142328
            627.405291846074 0.0831751279951724
            653.253096704044 0.0933059367242108
            677.76931865327  0.103430006673347
            734.395540393597 0.128716576621425
            785.850853879881 0.153976978005465
            833.369446403083 0.179217456712566
            877.759003278812 0.204442100219022
            959.251671749752 0.254854512508855
            1033.30271513801 0.305229264752723
            1165.57077256009 0.405898637512956
            1282.84956691385 0.506492153678714
            1389.41887249881 0.607031472026816
            1579.77020835558 0.807994788503824
            1748.55          1.00884893724696
            2418.75489508018 2.0122406624245
            5336.94734929116 10.0270088428608
          LECT sur4 TERM
LINK COUP SPLT NONE
     BLOQ 12 LECT noeuds_bas TERM
     BLOQ 1  LECT noeuds_sym TERM
     DEPL 2 -1. FONC 1 LECT noeuds_haut TERM
     PINB SELF DMIN 0.1 LECT elepin TERM
```

```
FONCT 1 TABLE 4 0. 0. 0.0001 0. 1.0001 1. 100.0001  100.
ECRI DEPL TFRE 0.1 POIN LECT 4460 TERM
     FICH SPLI ALIC TFRE 0.05
REGI 'HAUT' TOUT POIN LECT noeuds_haut TERM
     'BAS'  TOUT POIN LECT noeuds_bas TERM
OPTI PAS AUTO
     PASM 1.0E-12
     LOG 1
     PINS GRID DGRI EQVF CNOR
CALC TINI 0.0 DTMI 1.E-12 DTMA 1.E-04 TFIN 10.0 NMAX 900000000
FIN
```

cara03a.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara03.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

cara03b.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara03.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
          LINE HEOU SFRE
     ISO FILL FIEL ECRO 3 SCAL USER PROG 0.05 PAS 0.05 0.7 TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

cara03c.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara03.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
         !LINE HEOU SFRE
          FACE HFRO
          PINB CDES
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

cara03d.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara03.ali' GARD PSCR
OPTI PRIN
SORT GRAP
AXTE 1.0 'Time [ms]'
COUR 1 'dy_4267' DEPL COMP 2 NOEU LECT 4267 TERM
COUR 2 'dy' MULC 1 -1.0
COUR 3 'fyh' FLIA COMP 2 ZONE LECT noeuds_haut TERM
COUR 4 'fyb' FLIA COMP 2 ZONE LECT noeuds_bas TERM
TRAC 2 AXES 1.0 'DISPL. [MM]' YZER XGRD YGRD
TRAC 3 4 AXES 1.0 'FORCE [N]'
LIST 3 4 AXES 1.0 'FORCE [N]'
TRAC 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
RCOU 44 'fyb' FICH 'car401d.pun' RENA 'fyb_401'
RCOU 54 'fyb' FICH 'car102d.pun' RENA 'fyb_102'
TRAC 4 44 54 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR ROUG VERT
TRAC 4 54 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR VERT
FIN
```

cara03e.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara03.ali' GARD PSCR
OPTI PRIN
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dyh' DEPL COMP 2 NOEU LECT 350 TERM
COUR 2 'dy' MULC 1 -1.0
COUR 3 'fyh' FLIA COMP 2 ZONE LECT noeuds_haut TERM
COUR 4 'fy' MULC 3 -1.0
COUR 5 'fyb' FLIA COMP 2 ZONE LECT noeuds_bas TERM
TRAC 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
LIST 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
RCOU 14 'fy' FICH 'cara01e.pun' RENA 'fy_01'
RCOU 24 'fy' FICH 'cara02e.pun' RENA 'fy_02'
RCOU 34 'fy' FICH 'cara03e.pun' RENA 'fy_03'
TRAC 14 24 34 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR ROUG VERT
TRAC 2 AXES 1.0 'DISPL. [MM]' YZER XGRD YGRD
TRAC 4 5 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR ROUG
FIN
```

cara04.epx

```
CARA04
ECHO
!CONV WIN
CAST mesh
ALE DPLA
DIME NALE 1 NBLE 3180 TERM
GEOM Q42G sur4 TERM
COMP EPAI 1. LECT sur4 TERM
     NGRO 3
       'noeuds_sym'  LECT nodlag TERM COND X GT 14.95
       'noeuds_haut' LECT nodlag TERM COND Y GT 16.95
       'noeuds_bas'  LECT nodlag TERM COND Y LT  0.05
     COUL VERT LECT sur4 TERM
GRIL LAGR LECT nodlag TERM
     AUTO AUTR
MATE VM23 RO 0.00825 YOUN 197600.0 NU 0.29 ELAS 222.35
           TRAC 39
             222.35           0.00112525303643725
             228.192645571222 0.00117982108082602
             230.758344471793 0.001217805387003
             234.450726613396 0.00128649153144431
             239.764555869277 0.00141338337990525
             243.897432663364 0.00153429874829638
             247.411863292444 0.00165208432840306
             250.528021456793 0.00176785435959915
             253.359622970924 0.00188218432677593
             258.417356319849 0.00210778014331907
             262.901922592959 0.00233047531676599
             272.525831528572 0.00287917930935512
             280.709612952488 0.00342059520724944
             306.337249091751 0.00555028972212425
             326.269365384357 0.00765116075599371
             358.247494301277 0.0118129933922129
             390.499112131117 0.0169762100816352
             417.924578503771 0.0221150029276507
             464.338948360747 0.0323498934633641
             503.807844043327 0.0425496348382759
             538.803931461142 0.0527267405438317
             570.604298738599 0.0628876735766123
             599.971697212392 0.0730362940142328
             627.405291846074 0.0831751279951724
             653.253096704044 0.0933059367242108
             677.76931865327  0.103430006673347
             734.395540393597 0.128716576621425
             785.850853879881 0.153976978005465
             833.369446403083 0.179217456712566
             877.759003278812 0.204442100219022
             959.251671749752 0.254854512508855
             1033.30271513801 0.305229264752723
             1165.57077256009 0.405898637512956
             1282.84956691385 0.506492153678714
```

```
           1389.41887249881 0.607031472026816
           1579.77020835558 0.807994788503824
           1748.55          1.00884893724696
           2418.75489508018 2.0122406624245
           5336.94734929116 10.0270088428608
         LECT sur4 TERM
LINK COUP SPLT NONE
     BLOQ 12 LECT noeuds_bas TERM
     BLOQ 1  LECT noeuds_sym TERM
     VITE 2 -10 FONC 1 LECT noeuds_haut TERM
     PINB SELF DMIN 0.1 LECT elepin TERM
FONC 1 TABLE 2 0 1 100 1
INIT VITE 2 -10 LECT noeuds_haut TERM
ECRI DEPL TFRE 0.01 POIN LECT 4460 TERM
     FICH SPLI ALIC TFRE 0.005
REGI 'HAUT' TOUT POIN LECT noeuds_haut TERM
     'BAS'  TOUT POIN LECT noeuds_bas TERM
OPTI PAS AUTO
     LOG 1
     PINS GRID DGRI EQVF CNOR
CALC TINI 0.0 TFIN 1.0
FIN
```

cara04a.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara04.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

cara04b.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara04.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
         LINE HEOU SFRE
     ISO FILL FIEL ECRO 3 SCAL USER PROG 0.05 PAS 0.05 0.7 TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

cara04c.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara04.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
         !LINE HEOU SFRE
          FACE HFRO
          PINB CDES
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

cara04d.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara04.ali' GARD PSCR
OPTI PRIN
SORT GRAP
AXTE 1.0 'Time [ms]'
COUR 1 'dy_4267' DEPL COMP 2 NOEU LECT 4267 TERM
COUR 2 'dy' MULC 1 -1.0
COUR 3 'fyh' FLIA COMP 2 ZONE LECT noeuds_haut TERM
COUR 4 'fyb' FLIA COMP 2 ZONE LECT noeuds_bas TERM
TRAC 2 AXES 1.0 'DISPL. [MM]' YZER XGRD YGRD
TRAC 3 4 AXES 1.0 'FORCE [N]'
LIST 3 4 AXES 1.0 'FORCE [N]'
TRAC 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
RCOU 44 'fyb' FICH 'car401d.pun' RENA 'fyb_401'
RCOU 54 'fyb' FICH 'car102d.pun' RENA 'fyb_102'
TRAC 4 44 54 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR ROUG VERT
TRAC 4 54 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR VERT
FIN
```

cara04e.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara04.ali' GARD PSCR
OPTI PRIN
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dyh' DEPL COMP 2 NOEU LECT 350 TERM
COUR 2 'dy' MULC 1 -1.0
COUR 3 'fyh' FLIA COMP 2 ZONE LECT noeuds_haut TERM
COUR 4 'fy' MULC 3 -1.0
COUR 5 'fyb' FLIA COMP 2 ZONE LECT noeuds_bas TERM
TRAC 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
LIST 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
RCOU 14 'fy' FICH 'cara01e.pun' RENA 'fy_01'
RCOU 24 'fy' FICH 'cara02e.pun' RENA 'fy_02'
RCOU 34 'fy' FICH 'cara03e.pun' RENA 'fy_03'
RCOU 44 'fy' FICH 'cara04e.pun' RENA 'fy_04'
TRAC 14 24 34 44 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR ROUG VERT TURQ
TRAC 2 AXES 1.0 'DISPL. [MM]' YZER XGRD YGRD
TRAC 4 5 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR ROUG
FIN
```

cara05.epx

```
CARA05
ECHO
!CONV WIN
CAST mesh
ALE DPLA
DIME NALE 1 NBLE 3180 TERM
GEOM Q42G sur4 TERM
COMP EPAI 1. LECT sur4 TERM
     NGRO 3
       'noeuds_sym'  LECT nodlag TERM COND X GT 14.95
       'noeuds_haut' LECT nodlag TERM COND Y GT 16.95
       'noeuds_bas'  LECT nodlag TERM COND Y LT  0.05
     COUL VERT LECT sur4 TERM
GRIL LAGR LECT nodlag TERM
     AUTO AUTR
MATE VM23 RO 0.825 YOUN 197600.0 NU 0.29 ELAS 222.35
           TRAC 39
             222.35           0.00112525303643725
             228.192645571222 0.00117982108082602
             230.758344471793 0.001217805387003
             234.450726613396 0.00128649153144431
             239.764555869277 0.00141338337990525
             243.897432663364 0.00153429874829638
             247.411863292444 0.00165208432840306
             250.528021456793 0.00176785435959915
             253.359622970924 0.00188218432677593
             258.417356319849 0.00210778014331907
             262.901922592959 0.00233047531676599
             272.525831528572 0.00287917930935512
             280.709612952488 0.00342059520724944
             306.337249091751 0.00555028972212425
             326.269365384357 0.00765116075599371
             358.247494301277 0.0118129933922129
             390.499112131117 0.0169762100816352
             417.924578503771 0.0221150029276507
             464.338948360747 0.0323498934633641
             503.807844043327 0.0425496348382759
             538.803931461142 0.0527267405438317
             570.604298738599 0.0628876735766123
```

```
           599.971697212392 0.0730362940142328
           627.405291846074 0.0831751279951724
           653.253096704044 0.0933059367242108
           677.76931865327  0.103430006673347
           734.395540393597 0.128716576621425
           785.850853879881 0.153976978005465
           833.369446403083 0.179217456712566
           877.759003278812 0.204442100219022
           959.251671749752 0.254854512508855
           1033.30271513801 0.305229264752723
           1165.57077256009 0.405898637512956
           1282.84956691385 0.506492153678714
           1389.41887249881 0.607031472026816
           1579.77020835558 0.807994788503824
           1748.55          1.00884893724696
           2418.75489508018 2.0122406624245
           5336.94734929116 10.0270088428608
         LECT sur4 TERM
LINK COUP SPLT NONE
     BLOQ 12 LECT noeuds_bas TERM
     BLOQ 1  LECT noeuds_sym TERM
     VITE 2 -1 FONC 1 LECT noeuds_haut TERM
     PINB SELF DMIN 0.1 LECT elepin TERM
FONC 1 TABLE 2 0 1 100 1
INIT VITE 2 -1 LECT noeuds_haut TERM
ECRI DEPL TFRE 0.1 POIN LECT 4460 TERM
     FICH SPLI ALIC TFRE 0.05
REGI 'HAUT' TOUT POIN LECT noeuds_haut TERM
     'BAS'  TOUT POIN LECT noeuds_bas TERM
OPTI PAS AUTO
     LOG 1
     PINS GRID DGRI EQVF CNOR
CALC TINI 0.0 TFIN 10.0
FIN
```

cara05a.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara05.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

cara05b.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara05.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
          LINE HEOU SFRE
     ISO FILL FIEL ECRO 3 SCAL USER PROG 0.05 PAS 0.05 0.7 TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

cara05c.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara05.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
         !LINE HEOU SFRE
          FACE HFRO
          PINB CDES
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

cara05d.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara05.ali' GARD PSCR
OPTI PRIN
SORT GRAP
AXTE 1.0 'Time [ms]'
COUR 1 'dy_4267' DEPL COMP 2 NOEU LECT 4267 TERM
COUR 2 'dy' MULC 1 -1.0
COUR 3 'fyh' FLIA COMP 2 ZONE LECT noeuds_haut TERM
COUR 4 'fyb' FLIA COMP 2 ZONE LECT noeuds_bas TERM
TRAC 2 AXES 1.0 'DISPL. [MM]' YZER XGRD YGRD
TRAC 3 4 AXES 1.0 'FORCE [N]'
LIST 3 4 AXES 1.0 'FORCE [N]'
TRAC 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
RCOU 44 'fyb' FICH 'car401d.pun' RENA 'fyb_401'
RCOU 54 'fyb' FICH 'car102d.pun' RENA 'fyb_102'
TRAC 4 44 54 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR ROUG VERT
TRAC 4 54 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR VERT
FIN
```

cara05e.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara05.ali' GARD PSCR
OPTI PRIN
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dyh' DEPL COMP 2 NOEU LECT 350 TERM
COUR 2 'dy' MULC 1 -1.0
COUR 3 'fyh' FLIA COMP 2 ZONE LECT noeuds_haut TERM
COUR 4 'fy' MULC 3 -1.0
COUR 5 'fyb' FLIA COMP 2 ZONE LECT noeuds_bas TERM
TRAC 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
LIST 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
RCOU 14 'fy' FICH 'cara01e.pun' RENA 'fy_01'
RCOU 24 'fy' FICH 'cara02e.pun' RENA 'fy_02'
RCOU 34 'fy' FICH 'cara03e.pun' RENA 'fy_03'
RCOU 44 'fy' FICH 'cara04e.pun' RENA 'fy_04'
RCOU 54 'fy' FICH 'cara05e.pun' RENA 'fy_05'
TRAC 14 24 34 44 54 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR ROUG VERT TURQ ROSE
TRAC 2 AXES 1.0 'DISPL. [MM]' YZER XGRD YGRD
TRAC 4 5 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR ROUG
FIN
```

cara06.epx

```
CARA06
ECHO
!CONV WIN
CAST mesh
ALE DPLA
DIME NALE 1 NBLE 3180 TERM
GEOM Q42N sur4 TERM
COMP EPAI 1. LECT sur4 TERM
     NGRO 3
       'noeuds_sym'  LECT nodlag TERM COND X GT 14.95
       'noeuds_haut' LECT nodlag TERM COND Y GT 16.95
       'noeuds_bas'  LECT nodlag TERM COND Y LT  0.05
     COUL VERT LECT sur4 TERM
GRIL LAGR LECT nodlag TERM
     AUTO AUTR
MATE VM23 RO 0.00825 YOUN 197600.0 NU 0.29 ELAS 222.35
          TRAC 39
            222.35           0.00112525303643725
            228.192645571222 0.00117982108082602
            230.758344471793 0.001217805387003
            234.450726613396 0.00128649153144431
            239.764555869277 0.00141338337990525
            243.897432663364 0.00153429874829638
            247.411863292444 0.00165208432840306
            250.528021456793 0.00176785435959915
            253.359622970924 0.00188218432677593
```

```
           258.417356319849 0.00210778014331907
           262.901922592959 0.00233047531676599
           272.525831528572 0.00287917930935512
           280.709612952488 0.00342059520724944
           306.337249091751 0.00555028972212425
           326.269365384357 0.00765116075599371
           358.247494301277 0.0118129933922129
           390.499112131117 0.0169762100816352
           417.924578503771 0.0221150029276507
           464.338948360747 0.0323498934633641
           503.807844043327 0.0425496348382759
           538.803931461142 0.0527267405438317
           570.604298738599 0.0628876735766123
           599.971697212392 0.0730362940142328
           627.405291846074 0.0831751279951724
           653.253096704044 0.0933059367242108
           677.76931865327  0.103430006673347
           734.395540393597 0.128716576621425
           785.850853879881 0.153976978005465
           833.369446403083 0.179217456712566
           877.759003278812 0.204442100219022
           959.251671749752 0.254854512508855
           1033.30271513801 0.305229264752723
           1165.57077256009 0.405898637512956
           1282.84956691385 0.506492153678714
           1389.41887249881 0.607031472026816
           1579.77020835558 0.807994788503824
           1748.55          1.00884893724696
           2418.75489508018 2.0122406624245
           5336.94734929116 10.0270088428608
         LECT sur4 TERM
LINK COUP SPLT NONE
     BLOQ 12 LECT noeuds_bas TERM
     BLOQ 1  LECT noeuds_sym TERM
     VITE 2 -10 FONC 1 LECT noeuds_haut TERM
     PINB SELF DMIN 0.1 LECT elepin TERM
FONC 1 TABLE 2 0 1 100 1
INIT VITE 2 -10 LECT noeuds_haut TERM
ECRI DEPL TFRE 0.01 POIN LECT 4460 TERM
     FICH SPLI ALIC TFRE 0.005
REGI 'HAUT' TOUT POIN LECT noeuds_haut TERM
     'BAS'  TOUT POIN LECT noeuds_bas TERM
OPTI PAS AUTO
     LOG 1
     PINS GRID DGRI EQVF CNOR
CALC TINI 0.0 TFIN 1.0
FIN
```

cara06a.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara06.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

cara06b.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara06.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
          LINE HEOU SFRE
     ISO FILL FIEL ECRO 3 SCAL USER PROG 0.05 PAS 0.05 0.7 TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

cara06c.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara06.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
         !LINE HEOU SFRE
          FACE HFRO
          PINB CDES
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

cara06d.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara06.ali' GARD PSCR
OPTI PRIN
SORT GRAP
AXTE 1.0 'Time [ms]'
COUR 1 'dy_4267' DEPL COMP 2 NOEU LECT 4267 TERM
COUR 2 'dy' MULC 1 -1.0
COUR 3 'fyh' FLIA COMP 2 ZONE LECT noeuds_haut TERM
COUR 4 'fyb' FLIA COMP 2 ZONE LECT noeuds_bas TERM
TRAC 2 AXES 1.0 'DISPL. [MM]' YZER XGRD YGRD
TRAC 3 4 AXES 1.0 'FORCE [N]'
LIST 3 4 AXES 1.0 'FORCE [N]'
TRAC 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
RCOU 44 'fyb' FICH 'car401d.pun' RENA 'fyb_401'
RCOU 54 'fyb' FICH 'car102d.pun' RENA 'fyb_102'
TRAC 4 44 54 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR ROUG VERT
TRAC 4 54 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR VERT
FIN
```

cara06e.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara06.ali' GARD PSCR
OPTI PRIN
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dyh' DEPL COMP 2 NOEU LECT 350 TERM
COUR 2 'dy' MULC 1 -1.0
COUR 3 'fyh' FLIA COMP 2 ZONE LECT noeuds_haut TERM
COUR 4 'fy' MULC 3 -1.0
COUR 5 'fyb' FLIA COMP 2 ZONE LECT noeuds_bas TERM
TRAC 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
LIST 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
RCOU 24 'fy' FICH 'cara02e.pun' RENA 'fy_02'
RCOU 44 'fy' FICH 'cara04e.pun' RENA 'fy_04'
RCOU 54 'fy' FICH 'cara05e.pun' RENA 'fy_05'
RCOU 64 'fy' FICH 'cara06e.pun' RENA 'fy_06'
TRAC 24 44 54 64 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR ROUG VERT TURQ
TRAC 2 AXES 1.0 'DISPL. [MM]' YZER XGRD YGRD
TRAC 4 5 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR ROUG
FIN
```

cara07.epx

```
CARA07
ECHO
!CONV WIN
CAST mesh
ALE DPLA
DIME NALE 1 NBLE 3180 TERM
GEOM Q42 sur4 TERM
COMP EPAI 1. LECT sur4 TERM
     NGRO 3
       'noeuds_sym'  LECT nodlag TERM COND X GT 14.95
       'noeuds_haut' LECT nodlag TERM COND Y GT 16.95
       'noeuds_bas'  LECT nodlag TERM COND Y LT  0.05
     COUL VERT LECT sur4 TERM
GRIL LAGR LECT nodlag TERM
```

```
     AUTO AUTR
MATE VM23 RO 0.00825 YOUN 197600.0 NU 0.29 ELAS 222.35
          TRAC 39
            222.35           0.00112525303643725
            228.192645571222 0.00117982108082602
            230.758344471793 0.001217805387003
            234.450726613396 0.00128649153144431
            239.764555869277 0.00141338337990525
            243.897432663364 0.00153429874829638
            247.411863292444 0.00165208432840306
            250.528021456793 0.00176785435959915
            253.359622970924 0.00188218432677593
            258.417356319849 0.00210778014331907
            262.901922592959 0.00233047531676599
            272.525831528572 0.00287917930935512
            280.709612952488 0.00342059520724944
            306.337249091751 0.00555028972212425
            326.269365384357 0.00765116075599371
            358.247494301277 0.0118129933922129
            390.499112131117 0.0169762100816352
            417.924578503771 0.0221150029276507
            464.338948360747 0.0323498934633641
            503.807844043327 0.0425496348382759
            538.803931461142 0.0527267405438317
            570.604298738599 0.0628876735766123
            599.971697212392 0.0730362940142328
            627.405291846074 0.0831751279951724
            653.253096704044 0.0933059367242108
            677.76931865327  0.103430006673347
            734.395540393597 0.128716576621425
            785.850853879881 0.153976978005465
            833.369446403083 0.179217456712566
            877.759003278812 0.204442100219022
            959.251671749752 0.254854512508855
            1033.30271513801 0.305229264752723
            1165.57077256009 0.405898637512956
            1282.84956691385 0.506492153678714
            1389.41887249881 0.607031472026816
            1579.77020835558 0.807994788503824
            1748.55          1.00884893724696
            2418.75489508018 2.0122406624245
            5336.94734929116 10.0270088428608
          LECT sur4 TERM
LINK COUP SPLT NONE
     BLOQ 12 LECT noeuds_bas TERM
     BLOQ 1  LECT noeuds_sym TERM
     VITE 2 -10 FONC 1 LECT noeuds_haut TERM
     PINB SELF DMIN 0.1 LECT elepin TERM
FONC 1 TABLE 2 0 1 100 1
INIT VITE 2 -10 LECT noeuds_haut TERM
ECRI DEPL TFRE 0.01 POIN LECT 4460 TERM
     FICH SPLI ALIC TFRE 0.005
REGI 'HAUT' TOUT POIN LECT noeuds_haut TERM
     'BAS'  TOUT POIN LECT noeuds_bas TERM
OPTI PAS AUTO
     LOG 1
     PINS GRID DGRI EQVF CNOR
CALC TINI 0.0 TFIN 1.0
FIN
```

cara07a.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara07.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

cara07b.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara07.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
     LINE HEOU SFRE
     ISO FILL FIEL ECRO 3 SCAL USER PROG 0.05 PAS 0.05 0.7 TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

cara07c.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara07.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
         !LINE HEOU SFRE
          FACE HFRO
          PINB CDES
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

cara07d.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara07.ali' GARD PSCR
OPTI PRIN
SORT GRAP
AXTE 1.0 'Time [ms]'
COUR 1 'dy_4267' DEPL COMP 2 NOEU LECT 4267 TERM
COUR 2 'dy' MULC 1 -1.0
COUR 3 'fyh' FLIA COMP 2 ZONE LECT noeuds_haut TERM
COUR 4 'fyb' FLIA COMP 2 ZONE LECT noeuds_bas TERM
TRAC 2 AXES 1.0 'DISPL. [MM]' YZER XGRD YGRD
TRAC 3 4 AXES 1.0 'FORCE [N]'
LIST 3 4 AXES 1.0 'FORCE [N]'
TRAC 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
RCOU 44 'fyb' FICH 'car401d.pun' RENA 'fyb_401'
RCOU 54 'fyb' FICH 'car102d.pun' RENA 'fyb_102'
TRAC 4 44 54 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR ROUG VERT
TRAC 4 54 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR VERT
FIN
```

cara07e.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara07.ali' GARD PSCR
OPTI PRIN
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dyh' DEPL COMP 2 NOEU LECT 350 TERM
COUR 2 'dy' MULC 1 -1.0
COUR 3 'fyh' FLIA COMP 2 ZONE LECT noeuds_haut TERM
COUR 4 'fy' MULC 3 -1.0
COUR 5 'fyb' FLIA COMP 2 ZONE LECT noeuds_bas TERM
TRAC 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
LIST 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
RCOU 24 'fy' FICH 'cara02e.pun' RENA 'fy_02'
RCOU 44 'fy' FICH 'cara04e.pun' RENA 'fy_04'
RCOU 54 'fy' FICH 'cara05e.pun' RENA 'fy_05'
RCOU 64 'fy' FICH 'cara06e.pun' RENA 'fy_06'
RCOU 74 'fy' FICH 'cara07e.pun' RENA 'fy_07'
TRAC 24 44 54 64 74 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR ROUG VERT TURQ ROSE
TRAC 2 AXES 1.0 'DISPL. [MM]' YZER XGRD YGRD
TRAC 4 5 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR ROUG
FIN
```

cara08.epx

```
CARA08
```

```
ECHO
!CONV WIN
CAST mesh
ALE DPLA
DIME NALE 1 NBLE 3180 TERM
GEOM Q41 sur4 TERM
COMP EPAI 1. LECT sur4 TERM
     NGRO 3
       'noeuds_sym'  LECT nodlag TERM COND X GT 14.95
       'noeuds_haut' LECT nodlag TERM COND Y GT 16.95
       'noeuds_bas'  LECT nodlag TERM COND Y LT  0.05
     COUL VERT LECT sur4 TERM
GRIL LAGR LECT nodlag TERM
     AUTO AUTR
MATE VM23 RO 0.00825 YOUN 197600.0 NU 0.29 ELAS 222.35
          TRAC 39
            222.35           0.00112525303643725
            228.192645571222 0.00117982108082602
            230.758344471793 0.001217805387003
            234.450726613396 0.00128649153144431
            239.764555869277 0.00141338337990525
            243.897432663364 0.00153429874829638
            247.411863292444 0.00165208432840306
            250.528021456793 0.00176785435959915
            253.359622970924 0.00188218432677593
            258.417356319849 0.00210778014331907
            262.901922592959 0.00233047531676599
            272.525831528572 0.00287917930935512
            280.709612952488 0.00342059520724944
            306.337249091751 0.00555028972212425
            326.269365384357 0.00765116075599371
            358.247494301277 0.0118129933922129
            390.499112131117 0.0169762100816352
            417.924578503771 0.0221150029276507
            464.338948360747 0.0323498934633641
            503.807844043327 0.0425496348382759
            538.803931461142 0.0527267405438317
            570.604298738599 0.0628876735766123
            599.971697212392 0.0730362940142328
            627.405291846074 0.0831751279951724
            653.253096704044 0.0933059367242108
            677.76931865327  0.103430006673347
            734.395540393597 0.128716576621425
            785.850853879881 0.153976978005465
            833.369446403083 0.179217456712566
            877.759003278812 0.204442100219022
            959.251671749752 0.254854512508855
            1033.30271513801 0.305229264752723
            1165.57077256009 0.405898637512956
            1282.84956691385 0.506492153678714
            1389.41887249881 0.607031472026816
            1579.77020835558 0.807994788503824
            1748.55          1.00884893724696
            2418.75489508018 2.0122406624245
            5336.94734929116 10.0270088428608
          LECT sur4 TERM
LINK COUP SPLT NONE
     BLOQ 12 LECT noeuds_bas TERM
     BLOQ 1  LECT noeuds_sym TERM
     VITE 2 -10 FONC 1 LECT noeuds_haut TERM
     PINB SELF DMIN 0.1 LECT elepin TERM
FONC 1 TABLE 2 0 1 100 1
INIT VITE 2 -10 LECT noeuds_haut TERM
ECRI DEPL TFRE 0.01 POIN LECT 4460 TERM
     FICH SPLI ALIC TFRE 0.005
REGI 'HAUT' TOUT POIN LECT noeuds_haut TERM
     'BAS'  TOUT POIN LECT noeuds_bas TERM
OPTI PAS AUTO
     LOG 1
     PINS GRID DGRI EQVF CNOR
CALC TINI 0.0 TFIN 1.0
FIN
```

cara08a.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara08.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

cara08b.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara08.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
          LINE HEOU SFRE
     ISO FILL FIEL ECRO 3 SCAL USER PROG 0.05 PAS 0.05 0.7 TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

cara08c.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara08.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
         !LINE HEOU SFRE
          FACE HFRO
          PINB CDES
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

cara08d.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara08.ali' GARD PSCR
OPTI PRIN
SORT GRAP
AXTE 1.0 'Time [ms]'
COUR 1 'dy_4267' DEPL COMP 2 NOEU LECT 4267 TERM
COUR 2 'dy' MULC 1 -1.0
COUR 3 'fyh' FLIA COMP 2 ZONE LECT noeuds_haut TERM
COUR 4 'fyb' FLIA COMP 2 ZONE LECT noeuds_bas TERM
TRAC 2 AXES 1.0 'DISPL. [MM]' YZER XGRD YGRD
TRAC 3 4 AXES 1.0 'FORCE [N]'
LIST 3 4 AXES 1.0 'FORCE [N]'
TRAC 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
RCOU 44 'fyb' FICH 'car401d.pun' RENA 'fyb_401'
RCOU 54 'fyb' FICH 'car102d.pun' RENA 'fyb_102'
TRAC 4 44 54 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR ROUG VERT
TRAC 4 54 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR VERT
FIN
```

cara08e.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'cara08.ali' GARD PSCR
OPTI PRIN
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dyh' DEPL COMP 2 NOEU LECT 350 TERM
COUR 2 'dy' MULC 1 -1.0
COUR 3 'fyh' FLIA COMP 2 ZONE LECT noeuds_haut TERM
COUR 4 'fy' MULC 3 -1.0
COUR 5 'fyb' FLIA COMP 2 ZONE LECT noeuds_bas TERM
TRAC 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
LIST 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
RCOU 14 'fy' FICH 'cara01e.pun' RENA 'fy_01'
RCOU 24 'fy' FICH 'cara02e.pun' RENA 'fy_02'
RCOU 34 'fy' FICH 'cara03e.pun' RENA 'fy_03'
RCOU 44 'fy' FICH 'cara08e.pun' RENA 'fy_04'
```

```
TRAC 14 24 34 44 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR ROUG VERT TURQ
TRAC 2 AXES 1.0 'DISPL. [MM]' YZER XGRD YGRD
TRAC 4 5 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR ROUG
FIN
```

carm01.epx

```
CARM01
ECHO
!CONV WIN
CAST MESH
DPLA
GEOM CAR1 sur41 CAR4 sur42 TERM
COMP NGRO 3
      'noeuds_sym'  LECT elpeau4 TERM COND X GT 14.95
      'noeuds_haut' LECT elpeau4 TERM COND Y GT 16.95
      'noeuds_bas'  LECT elpeau4 TERM COND Y LT  0.05
     COUL VERT LECT sur41 TERM
          ROUG LECT sur42 TERM
MATE VMIS ISOT RO 0.00825 YOUN 197600.0 NU 0.29 ELAS 222.35
          TRAC 39
            222.35           0.00112525303643725
            228.192645571222 0.00117982108082602
            230.758344471793 0.001217805387003
            234.450726613396 0.00128649153144431
            239.764555869277 0.00141338337990525
            243.897432663364 0.00153429874829638
            247.411863292444 0.00165208432840306
            250.528021456793 0.00176785435959915
            253.359622970924 0.00188218432677593
            258.417356319849 0.00201778014331907
            262.901922592959 0.00233047531676599
            272.525831528572 0.00287917930935512
            280.709612952488 0.00342059520724944
            306.337249091751 0.00555028972212425
            326.269365384357 0.00765116075599371
            358.247494301277 0.0118129933922129
            390.499112131117 0.0169762100816352
            417.924578503771 0.0221150029276507
            464.338948360747 0.0323498934633641
            503.807844043327 0.0425496348382759
            538.803931461142 0.0527267405438317
            570.604298738599 0.0628876735766123
            599.971697212392 0.0730362940142328
            627.405291846074 0.0831751279951724
            653.253096704044 0.0933059367242108
            677.76931865327  0.103430006673347
            734.395540393597 0.128716576621425
            785.850853879881 0.153976978005465
            833.369446403083 0.179217456712566
            877.759003278812 0.204442100219022
            959.251671749752 0.254854512508855
            1033.30271513801 0.305229264752723
            1165.57077256009 0.405898637512956
            1282.84956691385 0.506492153678714
            1389.41887249881 0.607031472026816
            1579.77020835558 0.807994788503824
            1748.55          1.00884893724696
            2418.75489508018 2.0122406624245
            5336.94734929116 10.0270088428608
          LECT sur4 TERM
LINK COUP SPLT NONE
     BLOQ 2 LECT noeuds_bas TERM
     BLOQ 1 LECT noeuds_sym TERM
     DEPL 2 -1. FONCT 1 LECT noeuds_haut TERM
     PINB SELF DMIN 0.1 LECT elpeau4 TERM
FONC 1 TABL 4 0. 0. 0.0001 0. 1.0001 1. 100.0001  100.
ECRI DEPL TFRE 0.1 POIN LECT 4460 TERM
    FICH SPLI ALICE TFRE 0.05
OPTI PAS AUTO
     LOG 1
     PINS GRID DGRI EQVF
CALC TINI 0.00 TFIN 10.0 NMAX 900000000
FIN
```

carm01a.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'carm01.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

carm01b.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'carm01.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
          LINE HEOU SFRE
     ISO FILL FIEL ECRO 3 SCAL USER PROG 0.05 PAS 0.05 0.7 TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

carm01c.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'carm01.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
          !LINE HEOU SFRE
           FACE HFRO
           PINB CDES
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

carm01d.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'carm01.ali' GARD PSCR
OPTI PRIN
SORT GRAP
AXTE 1.0 'Time [ms]'
COUR 1 'dy_4267' DEPL COMP 2 NOEU LECT 4267 TERM
COUR 2 'dy' MULC 1 -1.0
COUR 3 'fyh' FLIA COMP 2 ZONE LECT noeuds_haut TERM
COUR 4 'fyb' FLIA COMP 2 ZONE LECT noeuds_bas TERM
TRAC 2 AXES 1.0 'DISPL. [MM]' YZER XGRD YGRD
TRAC 3 4 AXES 1.0 'FORCE [N]'
LIST 3 4 AXES 1.0 'FORCE [N]'
TRAC 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
FIN
```

carm02.epx

```
CARM02
ECHO
!CONV WIN
CAST MESH
DPLA
GEOM CAR1 sur41 CAR4 sur42 TERM
COMP NGRO 3
      'noeuds_sym'  LECT elpeau4 TERM COND X GT 14.95
      'noeuds_haut' LECT elpeau4 TERM COND Y GT 16.95
      'noeuds_bas'  LECT elpeau4 TERM COND Y LT  0.05
     COUL VERT LECT sur41 TERM
          ROUG LECT sur42 TERM
MATE VMIS ISOT RO 0.00825 YOUN 197600.0 NU 0.29 ELAS 222.35
          TRAC 39
            222.35           0.00112525303643725
```

```
           228.192645571222 0.00117982108082602
           230.758344471793 0.001217805387003
           234.450726613396 0.00128649153144431
           239.764555869277 0.00141338337990525
           243.897432663364 0.00153429874829638
           247.411863292444 0.00165208432840306
           250.528021456793 0.00176785435959915
           253.359622970924 0.00188218432677593
           258.417356319849 0.00210778014331907
           262.901922592959 0.00233047531676599
           272.525831528572 0.00287917930935512
           280.709612952488 0.00342059520724944
           306.337249091751 0.00555028972212425
           326.269365384357 0.00765116075599371
           358.247494301277 0.0118129933922129
           390.499112131117 0.0169762100816352
           417.924578503771 0.0221150029276507
           464.338948360747 0.0323498934633641
           503.807844043327 0.0425496348382759
           538.803931461142 0.0527267405438317
           570.604298738599 0.0628876735766123
           599.971697212392 0.0730362940142328
           627.405291846074 0.0831751279951724
           653.253096704044 0.0933059367242108
           677.76931865327  0.103430006673347
           734.395540393597 0.128716576621425
           785.850853879881 0.153976978005465
           833.369446403083 0.179217456712566
           877.759003278812 0.204442100219022
           959.251671749752 0.254854512508855
           1033.30271513801 0.305229264752723
           1165.57077256009 0.405898637512956
           1282.84956691385 0.506492153678714
           1389.41887249881 0.607031472026816
           1579.77020835558 0.807994788503824
           1748.55          1.00884893724696
           2418.75489508018 2.0122406624245
           5336.94734929116 10.0270088428608
         LECT sur4 TERM
LINK COUP SPLT NONE
     BLOQ 2 LECT noeuds_bas TERM
     BLOQ 1 LECT noeuds_sym TERM
     DEPL 2 -1. FONCT 1 LECT noeuds_haut TERM
     PINB SELF DMIN 0.1 LECT elpeau4 TERM
FONC 1 TABL 4 0. 0. 0.0001 0. 1.0001 1. 100.0001  100.
ECRI DEPL TFRE 0.1 POIN LECT 4460 TERM
    FICH SPLI ALICE TFRE 0.05
OPTI PAS AUTO CSTA 0.5
     LOG 1
     PINS GRID DGRI EQVF
CALC TINI 0.00 TFIN 10.0 NMAX 900000000
FIN
```

carm02a.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'carm02.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

carm02b.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'carm02.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
          LINE HEOU SFRE
     ISO FILL FIEL ECRO 3 SCAL USER PROG 0.05 PAS 0.05 0.7 TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

carm02c.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'carm02.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
          !LINE HEOU SFRE
           FACE HFRO
           PINB CDES
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

carm02d.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'carm02.ali' GARD PSCR
OPTI PRIN
SORT GRAP
AXTE 1.0 'Time [ms]'
COUR 1 'dy_4267' DEPL COMP 2 NOEU LECT 4267 TERM
COUR 2 'dy' MULC 1 -1.0
COUR 3 'fyh' FLIA COMP 2 ZONE LECT noeuds_haut TERM
COUR 4 'fyb' FLIA COMP 2 ZONE LECT noeuds_bas TERM
TRAC 2 AXES 1.0 'DISPL. [MM]' YZER XGRD YGRD
TRAC 3 4 AXES 1.0 'FORCE [N]'
LIST 3 4 AXES 1.0 'FORCE [N]'
TRAC 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
RCOU 44 'fyb' FICH 'car401d.pun' RENA 'fyb_401'
RCOU 54 'fyb' FICH 'car102d.pun' RENA 'fyb_102'
TRAC 4 44 54 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR ROUG VERT
TRAC 4 54 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR VERT
FIN
```

pbc201.epx

```
PBC201
ECHO
!CONV WIN
LAGR TRID
GEOM LIBR POIN 54 C272 2 TERM
 0 0 0 1 0 0 1 1 0 0 1 0
 0 0 1 1 0 1 1 1 1 0 1 1
 0.5 0.5 0 0.5 0 0.5 1 0.5 0.5 0.5 1 0.5 0 0.5 0.5 0.5 0.5 1
 0.5 0 0 1 0.5 0 0.5 1 0 0 0.5 0 0 0 0.5 1 0 0.5 1 1 0.5 0 1 0.5
 0.5 0 1 1 0.5 1 0.5 1 1 0 0.5 1 0.5 0.5 0.5
 0 0 1 1 0 1 1 1 1 0 1 1
 0 0 2 1 0 2 1 1 2 0 1 2
 0.5 0.5 1 0.5 0 1.5 1 0.5 1.5 0.5 1 1.5 0 0.5 1.5 0.5 0.5 2
 0.5 0 1 1 0.5 1 0.5 1 1 0 0.5 1 0 0 1.5 1 0 1.5 1 1 1.5 0 1 1.5
 0.5 0 2 1 0.5 2 0.5 1 2 0 0.5 2 0.5 0.5 1.5
 1 2 3 4 5 6 7 8 9 10 11 12 13
 14 15 16 17 18 19 20 21 22 23 24 25 26 27
 28 29 30 31 32 33 34 35 36 37 38 39 40
 41 42 43 44 45 46 47 48 49 50 51 52 53 54
OPTI DUMP DPMA
MATE VM23 RO 8000. YOUN 1.D11 NU 0.3 ELAS 2.D8
          TRAC 3 2.D8 2.D-3 3.D8 1. 3.1D8 2.
          LECT tous TERM
LINK COUP
     PINB BODY LECT 1 TERM
          BODY LECT 2 TERM
INIT VITE 3  100 LECT  1 PAS 1 27 TERM
     VITE 3 -100 LECT 28 PAS 1 54 TERM
ECRI DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO FREQ 1
     FICH ALIC FREQ 1
OPTI PAS AUTO NOTE LOG 1
     PINS DUMP STAT
     LNKS STAT DIAG DUMP
CALC TINI 0. TEND 0.1D0 NMAX 100
*=============================================================
PLAY
CAME   1 EYE  -1.77482E+00 -5.99653E+00  3.54494E+00
```

```
!        Q     8.06707E-01  5.64863E-01 -8.68241E-02 -1.50384E-01
         VIEW  3.09976E-01  8.85244E-01 -3.46784E-01
         RIGH  9.39693E-01 -3.40719E-01 -2.98090E-02
         UP    1.44544E-01  3.16630E-01  9.37471E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.00000E-01  5.00000E-01  1.00000E+00
!RSPHERE:  1.83467E+00
!RADIUS :  7.33869E+00
!ASPECT :  1.00000E+00
!NEAR   :  5.50402E+00
!FAR    :  1.10080E+01
SCEN GEOM NAVI FREE
          FACE HFRO
          PINB CDES JOIN
     VECT SCCO FIEL VITE SCAL USER PROG 7 PAS 7 98 TERM
     TEXT VSCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 15 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*================================================================
SUIT
Post-treatment from Alice file
ECHO
RESU ALIC GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dz_27' DEPL COMP 3 NOEU LECT 27 TERM
COUR 2 'dz_54' DEPL COMP 3 NOEU LECT 54 TERM
TRAC 1 2 AXES 1.0 'DISPL. [M]'
LIST 1 2 AXES 1.0 'DISPL. [M]'
*================================================================
FIN
```

pbc202.epx

```
PBC202
ECHO
!CONV WIN
LAGR TRID
GEOM LIBR POIN 54 C272 2 TERM
 0 0 0 1 0 0 1 1 0 0 1 0
 0 0 1 1 0 1 1 1 1 0 1 1
 0.5 0.5 0 0.5 0 0.5 1 0.5 0.5 0.5 1 0.5 0 0.5 0.5 0.5 0.5 1
 0.5 0 0 1 0.5 0 0.5 1 0 0 0.5 0 0 0 0.5 1 0 0.5 1 1 0.5 0 1 0.5
 0.5 0 1 1 0.5 1 0.5 1 1 0 0.5 1 0.5 0.5 0.5
 0 0 1 1 0 1 1 1 1 0 1 1
 0 0 2 1 0 2 1 1 2 0 1 2
 0.5 0.5 1 0.5 0 1.5 1 0.5 1.5 0.5 1 1.5 0 0.5 1.5 0.5 0.5 2
 0.5 0 1 1 0.5 1 0.5 1 1 0 0.5 1 0 0 1.5 1 0 1.5 1 1 1.5 0 1 1.5
 0.5 0 2 1 0.5 2 0.5 1 2 0 0.5 2 0.5 0.5 1.5
 1 2 3 4 5 6 7 8 9 10 11 12 13
 14 15 16 17 18 19 20 21 22 23 24 25 26 27
 28 29 30 31 32 33 34 35 36 37 38 39 40
 41 42 43 44 45 46 47 48 49 50 51 52 53 54
OPTI DUMP DPMA
MATE VM23 RO 8000. YOUN 1.D11 NU 0.3 ELAS 2.D8
          TRAC 3 2.D8 2.D-3 3.D8 1. 3.1D8 2.
          LECT tous TERM
LINK COUP
     PINB BODY MLEV 1 LECT 1 TERM
          BODY MLEV 1 LECT 2 TERM
INIT VITE 3  100 LECT  1 PAS 1 27 TERM
     VITE 3 -100 LECT 28 PAS 1 54 TERM
ECRI DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO FREQ 1
     FICH ALIC FREQ 1
OPTI PAS AUTO NOTE LOG 1
     PINS DUMP STAT EQVF
     LNKS STAT DIAG DUMP
CALC TINI 0. TEND 0.1D0 NMAX 15
*================================================================
PLAY
CAME   1 EYE  -1.77482E+00 -5.99653E+00  3.54494E+00
!        Q     8.06707E-01  5.64863E-01 -8.68241E-02 -1.50384E-01
         VIEW  3.09976E-01  8.85244E-01 -3.46784E-01
         RIGH  9.39693E-01 -3.40719E-01 -2.98090E-02
         UP    1.44544E-01  3.16630E-01  9.37471E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.00000E-01  5.00000E-01  1.00000E+00
!RSPHERE:  1.83467E+00
!RADIUS :  7.33869E+00
!ASPECT :  1.00000E+00
!NEAR   :  5.50402E+00
!FAR    :  1.10080E+01
SCEN GEOM NAVI FREE
          FACE HFRO
          PINB CDES JOIN
     VECT SCCO FIEL VITE SCAL USER PROG 7 PAS 7 98 TERM
     TEXT VSCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 16 FPS 15 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 14 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*================================================================
SUIT
Post-treatment from Alice file
ECHO
RESU ALIC GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dz_27' DEPL COMP 3 NOEU LECT 27 TERM
COUR 2 'dz_54' DEPL COMP 3 NOEU LECT 54 TERM
TRAC 1 2 AXES 1.0 'DISPL. [M]'
LIST 1 2 AXES 1.0 'DISPL. [M]'
*================================================================
FIN
```

pbc203.epx

```
PBC203
ECHO
!CONV WIN
LAGR TRID
GEOM LIBR POIN 54 C272 2 TERM
 0 0 0 1 0 0 1 1 0 0 1 0
 0 0 1 1 0 1 1 1 1 0 1 1
 0.5 0.5 0 0.5 0 0.5 1 0.5 0.5 0.5 1 0.5 0 0.5 0.5 0.5 0.5 1
 0.5 0 0 1 0.5 0 0.5 1 0 0 0.5 0 0 0 0.5 1 0 0.5 1 1 0.5 0 1 0.5
 0.5 0 1 1 0.5 1 0.5 1 1 0 0.5 1 0.5 0.5 0.5
 0 0 1 1 0 1 1 1 1 0 1 1
 0 0 2 1 0 2 1 1 2 0 1 2
 0.5 0.5 1 0.5 0 1.5 1 0.5 1.5 0.5 1 1.5 0 0.5 1.5 0.5 0.5 2
 0.5 0 1 1 0.5 1 0.5 1 1 0 0.5 1 0 0 1.5 1 0 1.5 1 1 1.5 0 1 1.5
 0.5 0 2 1 0.5 2 0.5 1 2 0 0.5 2 0.5 0.5 1.5
 1 2 3 4 5 6 7 8 9 10 11 12 13
 14 15 16 17 18 19 20 21 22 23 24 25 26 27
 28 29 30 31 32 33 34 35 36 37 38 39 40
 41 42 43 44 45 46 47 48 49 50 51 52 53 54
OPTI DUMP DPMA
MATE VM23 RO 8000. YOUN 1.D11 NU 0.3 ELAS 2.D8
          TRAC 3 2.D8 2.D-3 3.D8 1. 3.1D8 2.
          LECT tous TERM
LINK COUP
     PINB BODY MLEV 2 LECT 1 TERM
          BODY MLEV 2 LECT 2 TERM
INIT VITE 3  100 LECT  1 PAS 1 27 TERM
     VITE 3 -100 LECT 28 PAS 1 54 TERM
ECRI DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO FREQ 1
     FICH ALIC FREQ 1
OPTI PAS AUTO NOTE LOG 1
     PINS DUMP STAT EQVF
     LNKS STAT DIAG DUMP
CALC TINI 0. TEND 0.1D0 NMAX 19
*================================================================
PLAY
CAME   1 EYE  -1.77482E+00 -5.99653E+00  3.54494E+00
!        Q     8.06707E-01  5.64863E-01 -8.68241E-02 -1.50384E-01
         VIEW  3.09976E-01  8.85244E-01 -3.46784E-01
         RIGH  9.39693E-01 -3.40719E-01 -2.98090E-02
         UP    1.44544E-01  3.16630E-01  9.37471E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.00000E-01  5.00000E-01  1.00000E+00
!RSPHERE:  1.83467E+00
!RADIUS :  7.33869E+00
!ASPECT :  1.00000E+00
!NEAR   :  5.50402E+00
!FAR    :  1.10080E+01
SCEN GEOM NAVI FREE
          FACE HFRO
          PINB CDES JOIN
     VECT SCCO FIEL VITE SCAL USER PROG 7 PAS 7 98 TERM
     TEXT VSCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 20 FPS 15 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 18 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*================================================================
SUIT
Post-treatment from Alice file
ECHO
RESU ALIC GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dz_27' DEPL COMP 3 NOEU LECT 27 TERM
COUR 2 'dz_54' DEPL COMP 3 NOEU LECT 54 TERM
TRAC 1 2 AXES 1.0 'DISPL. [M]'
LIST 1 2 AXES 1.0 'DISPL. [M]'
*================================================================
FIN
```

pbc204.epx

```
PBC204
ECHO
!CONV WIN
LAGR TRID
GEOM LIBR POIN 54 C272 2 TERM
 0 0 0 1 0 0 1 1 0 0 1 0
 0 0 1 1 0 1 1 1 1 0 1 1
 0.5 0.5 0 0.5 0 0.5 1 0.5 0.5 0.5 1 0.5 0 0.5 0.5 0.5 0.5 1
 0.5 0 0 1 0.5 0 0.5 1 0 0 0.5 0 0 0 0.5 1 0 0.5 1 1 0.5 0 1 0.5
 0.5 0 1 1 0.5 1 0.5 1 1 0 0.5 1 0.5 0.5 0.5
 0 0 1 1 0 1 1 1 1 0 1 1
 0 0 2 1 0 2 1 1 2 0 1 2
 0.5 0.5 1 0.5 0 1.5 1 0.5 1.5 0.5 1 1.5 0 0.5 1.5 0.5 0.5 2
 0.5 0 1 1 0.5 1 0.5 1 1 0 0.5 1 0 0 1.5 1 0 1.5 1 1 1.5 0 1 1.5
 0.5 0 2 1 0.5 2 0.5 1 2 0 0.5 2 0.5 0.5 1.5
 1 2 3 4 5 6 7 8 9 10 11 12 13
 14 15 16 17 18 19 20 21 22 23 24 25 26 27
 28 29 30 31 32 33 34 35 36 37 38 39 40
 41 42 43 44 45 46 47 48 49 50 51 52 53 54
OPTI DUMP DPMA
MATE VM23 RO 8000. YOUN 1.D11 NU 0.3 ELAS 2.D8
          TRAC 3 2.D8 2.D-3 3.D8 1. 3.1D8 2.
          LECT tous TERM
LINK COUP
     PINB BODY MLEV 3 LECT 1 TERM
          BODY MLEV 3 LECT 2 TERM
INIT VITE 3  100 LECT  1 PAS 1 27 TERM
     VITE 3 -100 LECT 28 PAS 1 54 TERM
ECRI DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO FREQ 1
     FICH ALIC FREQ 1
OPTI PAS AUTO NOTE LOG 1
     PINS DUMP STAT
     LNKS STAT DIAG DUMP
CALC TINI 0. TEND 0.1D0 NMAX 100
```

```
*=============================================================
PLAY
CAME   1 EYE  -1.77482E+00 -5.99653E+00  3.54494E+00
!        Q     8.06707E-01  5.64863E-01 -8.68241E-02 -1.50384E-01
         VIEW  3.09976E-01  8.85244E-01 -3.46784E-01
         RIGH  9.39693E-01 -3.40719E-01 -2.98090E-02
         UP    1.44544E-01  3.16630E-01  9.37471E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.00000E-01  5.00000E-01  1.00000E+00
!RSPHERE:  1.83467E+00
!RADIUS :  7.33869E+00
!ASPECT :  1.00000E+00
!NEAR   :  5.50402E+00
!FAR    :  1.10080E+01
SCEN GEOM NAVI FREE
          FACE HFRO
          PINB CDES JOIN
     VECT SCCO FIEL VITE SCAL USER PROG 101 PAS 7 98 TERM
     TEXT VSCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 99 FPS 15 KFRE 5 COMP -1 REND
FREQ 1
GOTR LOOP 7 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=============================================================
SUIT
Post-treatment from Alice file
ECHO
RESU ALIC GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dz_27' DEPL COMP 3 NOEU LECT 27 TERM
COUR 2 'dz_54' DEPL COMP 3 NOEU LECT 54 TERM
TRAC 1 2 AXES 1.0 'DISPL. [M]'
LIST 1 2 AXES 1.0 'DISPL. [M]'
*=============================================================
FIN
```

pbc231.epx

```
PBC231
ECHO
!CONV WIN
LAGR TRID
GEOM LIBR POIN 54 C273 2 TERM
 0 0 0 1 0 0 1 1 0 0 1 0
 0 0 1 1 0 1 1 1 1 0 1 1
 0.5 0.5 0 0.5 0 0.5 1 0.5 0.5 0.5 1 0.5 0 0.5 0.5 0.5 0.5 1
 0.5 0 0 1 0.5 0 0.5 1 0 0 0.5 0 0 0 0.5 1 0 0.5 1 1 0.5 0 1 0.5
 0.5 0 1 1 0.5 1 0.5 1 1 0 0.5 1 0.5 0.5 0.5
 0 0 1 1 0 1 1 1 1 0 1 1
 0 0 2 1 0 2 1 1 2 0 1 2
 0.5 0.5 1 0.5 0 1.5 1 0.5 1.5 0.5 1 1.5 0 0.5 1.5 0.5 0.5 2
 0.5 0 1 1 0.5 1 0.5 1 1 0 0.5 1 0 0 1.5 1 0 1.5 1 1 1.5 0 1 1.5
 0.5 0 2 1 0.5 2 0.5 1 2 0 0.5 2 0.5 0.5 1.5
 1 2 3 4 5 6 7 8 9 10 11 12 13
 14 15 16 17 18 19 20 21 22 23 24 25 26 27
 28 29 30 31 32 33 34 35 36 37 38 39 40
 41 42 43 44 45 46 47 48 49 50 51 52 53 54
OPTI DUMP DPMA
MATE VM23 RO 8000. YOUN 1.D11 NU 0.3 ELAS 2.D8
          TRAC 3 2.D8 2.D-3 3.D8 1. 3.1D8 2.
          LECT tous TERM
LINK COUP
     PINB BODY LECT 1 TERM
          BODY LECT 2 TERM
INIT VITE 3  100 LECT  1 PAS 1 27 TERM
     VITE 3 -100 LECT 28 PAS 1 54 TERM
ECRI DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO FREQ 1
     FICH ALIC FREQ 1
OPTI PAS AUTO NOTE LOG 1
     PINS DUMP STAT
     LNKS STAT DIAG DUMP
CALC TINI 0. TEND 0.1D0 NMAX 17
*=============================================================
PLAY
CAME   1 EYE  -1.77482E+00 -5.99653E+00  3.54494E+00
!        Q     8.06707E-01  5.64863E-01 -8.68241E-02 -1.50384E-01
         VIEW  3.09976E-01  8.85244E-01 -3.46784E-01
         RIGH  9.39693E-01 -3.40719E-01 -2.98090E-02
         UP    1.44544E-01  3.16630E-01  9.37471E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.00000E-01  5.00000E-01  1.00000E+00
!RSPHERE:  1.83467E+00
!RADIUS :  7.33869E+00
!ASPECT :  1.00000E+00
!NEAR   :  5.50402E+00
!FAR    :  1.10080E+01
SCEN GEOM NAVI FREE
          FACE HFRO
          PINB CDES JOIN
     VECT SCCO FIEL VITE SCAL USER PROG 7 PAS 7 98 TERM
     TEXT VSCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 18 FPS 15 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 16 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=============================================================
SUIT
Post-treatment from Alice file
ECHO
RESU ALIC GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dz_27' DEPL COMP 3 NOEU LECT 27 TERM
COUR 2 'dz_54' DEPL COMP 3 NOEU LECT 54 TERM
TRAC 1 2 AXES 1.0 'DISPL. [M]'
LIST 1 2 AXES 1.0 'DISPL. [M]'
*=============================================================
FIN
```

pbc232.epx

```
PBC232
ECHO
!CONV WIN
LAGR TRID
GEOM LIBR POIN 54 C273 2 TERM
 0 0 0 1 0 0 1 1 0 0 1 0
 0 0 1 1 0 1 1 1 1 0 1 1
 0.5 0.5 0 0.5 0 0.5 1 0.5 0.5 0.5 1 0.5 0 0.5 0.5 0.5 0.5 1
 0.5 0 0 1 0.5 0 0.5 1 0 0 0.5 0 0 0 0.5 1 0 0.5 1 1 0.5 0 1 0.5
 0.5 0 1 1 0.5 1 0.5 1 1 0 0.5 1 0.5 0.5 0.5
 0 0 1 1 0 1 1 1 1 0 1 1
 0 0 2 1 0 2 1 1 2 0 1 2
 0.5 0.5 1 0.5 0 1.5 1 0.5 1.5 0.5 1 1.5 0 0.5 1.5 0.5 0.5 2
 0.5 0 1 1 0.5 1 0.5 1 1 0 0.5 1 0 0 1.5 1 0 1.5 1 1 1.5 0 1 1.5
 0.5 0 2 1 0.5 2 0.5 1 2 0 0.5 2 0.5 0.5 1.5
 1 2 3 4 5 6 7 8 9 10 11 12 13
 14 15 16 17 18 19 20 21 22 23 24 25 26 27
 28 29 30 31 32 33 34 35 36 37 38 39 40
 41 42 43 44 45 46 47 48 49 50 51 52 53 54
OPTI DUMP DPMA
MATE VM23 RO 8000. YOUN 1.D11 NU 0.3 ELAS 2.D8
          TRAC 3 2.D8 2.D-3 3.D8 1. 3.1D8 2.
          LECT tous TERM
LINK COUP
     PINB BODY MLEV 1 LECT 1 TERM
          BODY MLEV 1 LECT 2 TERM
INIT VITE 3  100 LECT  1 PAS 1 27 TERM
     VITE 3 -100 LECT 28 PAS 1 54 TERM
ECRI DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO FREQ 1
     FICH ALIC FREQ 1
OPTI PAS AUTO NOTE LOG 1
     PINS DUMP STAT
     LNKS STAT DIAG DUMP
CALC TINI 0. TEND 0.1D0 NMAX 16
*=============================================================
PLAY
CAME   1 EYE  -1.77482E+00 -5.99653E+00  3.54494E+00
!        Q     8.06707E-01  5.64863E-01 -8.68241E-02 -1.50384E-01
         VIEW  3.09976E-01  8.85244E-01 -3.46784E-01
         RIGH  9.39693E-01 -3.40719E-01 -2.98090E-02
         UP    1.44544E-01  3.16630E-01  9.37471E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.00000E-01  5.00000E-01  1.00000E+00
!RSPHERE:  1.83467E+00
!RADIUS :  7.33869E+00
!ASPECT :  1.00000E+00
!NEAR   :  5.50402E+00
!FAR    :  1.10080E+01
SCEN GEOM NAVI FREE
          FACE HFRO
          PINB CDES JOIN
     VECT SCCO FIEL VITE SCAL USER PROG 7 PAS 7 98 TERM
     TEXT VSCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 17 FPS 15 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 15 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=============================================================
SUIT
Post-treatment from Alice file
ECHO
RESU ALIC GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dz_27' DEPL COMP 3 NOEU LECT 27 TERM
COUR 2 'dz_54' DEPL COMP 3 NOEU LECT 54 TERM
TRAC 1 2 AXES 1.0 'DISPL. [M]'
LIST 1 2 AXES 1.0 'DISPL. [M]'
*=============================================================
FIN
```

pbc233.epx

```
PBC233
ECHO
!CONV WIN
LAGR TRID
GEOM LIBR POIN 54 C273 2 TERM
 0 0 0 1 0 0 1 1 0 0 1 0
 0 0 1 1 0 1 1 1 1 0 1 1
 0.5 0.5 0 0.5 0 0.5 1 0.5 0.5 0.5 1 0.5 0 0.5 0.5 0.5 0.5 1
 0.5 0 0 1 0.5 0 0.5 1 0 0 0.5 0 0 0 0.5 1 0 0.5 1 1 0.5 0 1 0.5
 0.5 0 1 1 0.5 1 0.5 1 1 0 0.5 1 0.5 0.5 0.5
 0 0 1 1 0 1 1 1 1 0 1 1
 0 0 2 1 0 2 1 1 2 0 1 2
 0.5 0.5 1 0.5 0 1.5 1 0.5 1.5 0.5 1 1.5 0 0.5 1.5 0.5 0.5 2
 0.5 0 1 1 0.5 1 0.5 1 1 0 0.5 1 0 0 1.5 1 0 1.5 1 1 1.5 0 1 1.5
 0.5 0 2 1 0.5 2 0.5 1 2 0 0.5 2 0.5 0.5 1.5
 1 2 3 4 5 6 7 8 9 10 11 12 13
 14 15 16 17 18 19 20 21 22 23 24 25 26 27
 28 29 30 31 32 33 34 35 36 37 38 39 40
 41 42 43 44 45 46 47 48 49 50 51 52 53 54
OPTI DUMP DPMA
MATE VM23 RO 8000. YOUN 1.D11 NU 0.3 ELAS 2.D8
          TRAC 3 2.D8 2.D-3 3.D8 1. 3.1D8 2.
          LECT tous TERM
LINK COUP
     PINB BODY MLEV 2 LECT 1 TERM
          BODY MLEV 2 LECT 2 TERM
INIT VITE 3  100 LECT  1 PAS 1 27 TERM
     VITE 3 -100 LECT 28 PAS 1 54 TERM
ECRI DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO FREQ 1
```

```
     FICH ALIC FREQ 1
OPTI PAS AUTO NOTE LOG 1
     PINS DUMP STAT
     LNKS STAT DIAG DUMP
CALC TINI 0. TEND 0.1D0 NMAX 20
*=============================================================
PLAY
CAME   1 EYE  -1.77482E+00 -5.99653E+00  3.54494E+00
!        Q     8.06707E-01  5.64863E-01 -8.68241E-02 -1.50384E-01
         VIEW  3.09976E-01  8.85244E-01 -3.46784E-01
         RIGH  9.39693E-01 -3.40719E-01 -2.98090E-02
         UP    1.44544E-01  3.16630E-01  9.37471E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.00000E-01  5.00000E-01  1.00000E+00
!RSPHERE:  1.83467E+00
!RADIUS :  7.33869E+00
!ASPECT :  1.00000E+00
!NEAR   :  5.50402E+00
!FAR    :  1.10080E+01
SCEN GEOM NAVI FREE
          FACE HFRO
          PINB CDES JOIN
     VECT SCCO FIEL VITE SCAL USER PROG 7 PAS 7 98 TERM
     TEXT VSCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 21 FPS 15 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 19 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=============================================================
SUIT
Post-treatment from Alice file
ECHO
RESU ALIC GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dz_27' DEPL COMP 3 NOEU LECT 27 TERM
COUR 2 'dz_54' DEPL COMP 3 NOEU LECT 54 TERM
TRAC 1 2 AXES 1.0 'DISPL. [M]'
LIST 1 2 AXES 1.0 'DISPL. [M]'
*=============================================================
FIN
```

pbc234.epx

```
PBC234
ECHO
!CONV WIN
LAGR TRID
GEOM LIBR POIN 54 C273 2 TERM
 0 0 0 1 0 0 1 1 0 0 1 0
 0 0 1 1 0 1 1 1 1 0 1 1
 0.5 0.5 0 0.5 0 0.5 1 0.5 0.5 0.5 1 0.5 0 0.5 0.5 0.5 0.5 1
 0.5 0 0 1 0.5 0 0.5 1 0 0 0.5 0 0 0 0.5 1 0 0.5 1 1 0.5 0 1 0.5
 0.5 0 1 1 0.5 1 0.5 1 1 0 0.5 1 0.5 0.5 0.5
 0 0 1 1 0 1 1 1 1 0 1 1
 0 0 2 1 0 2 1 1 2 0 1 2
 0.5 0.5 1 0.5 0 1.5 1 0.5 1.5 0.5 1 1.5 0 0.5 1.5 0.5 0.5 2
 0.5 0 1 1 0.5 1 0.5 1 1 0 0.5 1 0 0 1.5 1 0 1.5 1 1 1.5 0 1 1.5
 0.5 0 2 1 0.5 2 0.5 1 2 0 0.5 2 0.5 0.5 1.5
 1 2 3 4 5 6 7 8 9 10 11 12 13
 14 15 16 17 18 19 20 21 22 23 24 25 26 27
 28 29 30 31 32 33 34 35 36 37 38 39 40
 41 42 43 44 45 46 47 48 49 50 51 52 53 54
OPTI DUMP DPMA
MATE VM23 RO 8000. YOUN 1.D11 NU 0.3 ELAS 2.D8
          TRAC 3 2.D8 2.D-3 3.D8 1. 3.1D8 2.
          LECT tous TERM
LINK COUP
     PINB BODY MLEV 3 LECT 1 TERM
          BODY MLEV 3 LECT 2 TERM
INIT VITE 3  100 LECT  1 PAS 1 27 TERM
     VITE 3 -100 LECT 28 PAS 1 54 TERM
ECRI DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO FREQ 1
     FICH ALIC FREQ 1
OPTI PAS AUTO NOTE LOG 1
     PINS DUMP STAT
     LNKS STAT DIAG DUMP
CALC TINI 0. TEND 0.1D0 NMAX 100
*=============================================================
PLAY
CAME   1 EYE  -1.77482E+00 -5.99653E+00  3.54494E+00
!        Q     8.06707E-01  5.64863E-01 -8.68241E-02 -1.50384E-01
         VIEW  3.09976E-01  8.85244E-01 -3.46784E-01
         RIGH  9.39693E-01 -3.40719E-01 -2.98090E-02
         UP    1.44544E-01  3.16630E-01  9.37471E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.00000E-01  5.00000E-01  1.00000E+00
!RSPHERE:  1.83467E+00
!RADIUS :  7.33869E+00
!ASPECT :  1.00000E+00
!NEAR   :  5.50402E+00
!FAR    :  1.10080E+01
SCEN GEOM NAVI FREE
          FACE HFRO
          PINB CDES JOIN
     VECT SCCO FIEL VITE SCAL USER PROG 7 PAS 7 98 TERM
     TEXT VSCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 15 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=============================================================
SUIT
Post-treatment from Alice file
ECHO
RESU ALIC GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dz_27' DEPL COMP 3 NOEU LECT 27 TERM
COUR 2 'dz_54' DEPL COMP 3 NOEU LECT 54 TERM
TRAC 1 2 AXES 1.0 'DISPL. [M]'
LIST 1 2 AXES 1.0 'DISPL. [M]'
*=============================================================
FIN
```

pbc2all.epx

```
Comparison of results with C272/C273
ECHO
RESU ALIC 'pbc233.ali' GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 331 'dz_27_33' DEPL COMP 2 NOEU LECT 27 TERM
COUR 332 'dz_54_33' DEPL COMP 2 NOEU LECT 54 TERM
RCOU  11 'dz_27' FICH 'pbc201.pun' RENA 'dz_27_01'
RCOU  12 'dz_54' FICH 'pbc201.pun' RENA 'dz_54_01'
RCOU  21 'dz_27' FICH 'pbc202.pun' RENA 'dz_27_02'
RCOU  22 'dz_54' FICH 'pbc202.pun' RENA 'dz_54_02'
RCOU  31 'dz_27' FICH 'pbc203.pun' RENA 'dz_27_03'
RCOU  32 'dz_54' FICH 'pbc203.pun' RENA 'dz_54_03'
RCOU 311 'dz_27' FICH 'pbc231.pun' RENA 'dz_27_31'
RCOU 312 'dz_54' FICH 'pbc231.pun' RENA 'dz_54_31'
RCOU 321 'dz_27' FICH 'pbc232.pun' RENA 'dz_27_32'
RCOU 322 'dz_54' FICH 'pbc232.pun' RENA 'dz_54_32'
TRAC 11 21 31 311 321 331 AXES 1.0 'DISPL. [M]' YZER
TRAC 12 22 32 312 322 332 AXES 1.0 'DISPL. [M]' YZER
*=============================================================
FIN
```

pbc801.epx

```
PBC801
ECHO
!CONV WIN
LAGR TRID
GEOM LIBR POIN 16 CUB8 2 TERM
 0 0 0 1 0 0 1 1 0 0 1 0
 0 0 1 1 0 1 1 1 1 0 1 1
 0 0 1 1 0 1 1 1 1 0 1 1
 0 0 2 1 0 2 1 1 2 0 1 2
 1 2 3 4 5 6 7 8
 9 10 11 12 13 14 15 16
OPTI DUMP DPMA
MATE VM23 RO 8000. YOUN 1.D11 NU 0.3 ELAS 2.D8
          TRAC 3 2.D8 2.D-3 3.D8 1. 3.1D8 2.
          LECT tous TERM
LINK COUP
     PINB BODY LECT 1 TERM
          BODY LECT 2 TERM
INIT VITE 3  100 LECT  1 PAS 1  8 TERM
     VITE 3 -100 LECT  9 PAS 1 16 TERM
ECRI DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO FREQ 1
     FICH ALIC FREQ 1
OPTI PAS AUTO NOTE LOG 1
     PINS DUMP STAT
     LNKS STAT DIAG DUMP
CALC TINI 0. TEND 0.1D0 NMAX 100
*=============================================================
PLAY
CAME   1 EYE  -1.77482E+00 -5.99653E+00  3.54494E+00
!        Q     8.06707E-01  5.64863E-01 -8.68241E-02 -1.50384E-01
         VIEW  3.09976E-01  8.85244E-01 -3.46784E-01
         RIGH  9.39693E-01 -3.40719E-01 -2.98090E-02
         UP    1.44544E-01  3.16630E-01  9.37471E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.00000E-01  5.00000E-01  1.00000E+00
!RSPHERE:  1.83467E+00
!RADIUS :  7.33869E+00
!ASPECT :  1.00000E+00
!NEAR   :  5.50402E+00
!FAR    :  1.10080E+01
SCEN GEOM NAVI FREE
          FACE HFRO
          PINB CDES JOIN
     VECT SCCO FIEL VITE SCAL USER PROG 7 PAS 7 98 TERM
     TEXT VSCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 15 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=============================================================
SUIT
Post-treatment from Alice file
ECHO
RESU ALIC GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dz_1' DEPL COMP 3 NOEU LECT 1 TERM
COUR 2 'dz_13' DEPL COMP 3 NOEU LECT 13 TERM
TRAC 1 2 AXES 1.0 'DISPL. [M]'
LIST 1 2 AXES 1.0 'DISPL. [M]'
*=============================================================
FIN
```

pbc802.epx

```
PBC802
ECHO
!CONV WIN
LAGR TRID
GEOM LIBR POIN 16 CUB8 2 TERM
 0 0 0 1 0 0 1 1 0 0 1 0
```

```
 0 0 1 1 0 1 1 1 1 0 1 1
 0 0 1 1 0 1 1 1 1 0 1 1
 0 0 2 1 0 2 1 1 2 0 1 2
 1 2 3 4 5 6 7 8
 9 10 11 12 13 14 15 16
OPTI DUMP DPMA
MATE VM23 RO 8000. YOUN 1.D11 NU 0.3 ELAS 2.D8
          TRAC 3 2.D8 2.D-3 3.D8 1. 3.1D8 2.
          LECT tous TERM
LINK COUP
     PINB BODY MLEV 1 LECT 1 TERM
          BODY MLEV 1 LECT 2 TERM
INIT VITE 3  100 LECT  1 PAS 1  8 TERM
     VITE 3 -100 LECT  9 PAS 1 16 TERM
ECRI DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO FREQ 1
     FICH ALIC FREQ 1
OPTI PAS AUTO NOTE LOG 1
     PINS DUMP STAT EQVF
     LNKS STAT DIAG DUMP
CALC TINI 0. TEND 0.1D0 NMAX 9
*================================================================
PLAY
CAME   1 EYE  -1.77482E+00 -5.99653E+00  3.54494E+00
!        Q     8.06707E-01  5.64863E-01 -8.68241E-02 -1.50384E-01
         VIEW  3.09976E-01  8.85244E-01 -3.46784E-01
         RIGH  9.39693E-01 -3.40719E-01 -2.98090E-02
         UP    1.44544E-01  3.16630E-01  9.37471E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.00000E-01  5.00000E-01  1.00000E+00
!RSPHERE:  1.83467E+00
!RADIUS :  7.33869E+00
!ASPECT :  1.00000E+00
!NEAR   :  5.50402E+00
!FAR    :  1.10080E+01
SCEN GEOM NAVI FREE
          FACE HFRO
          PINB CDES JOIN
     VECT SCCO FIEL VITE SCAL USER PROG 7 PAS 7 98 TERM
     TEXT VSCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 10 FPS 15 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 8 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*================================================================
SUIT
Post-treatment from Alice file
ECHO
RESU ALIC GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dz_1' DEPL COMP 3 NOEU LECT 1 TERM
COUR 2 'dz_13' DEPL COMP 3 NOEU LECT 13 TERM
TRAC 1 2 AXES 1.0 'DISPL. [M]'
LIST 1 2 AXES 1.0 'DISPL. [M]'
*================================================================
FIN
```

pbc803.epx

```
PBC803
ECHO
!CONV WIN
LAGR TRID
GEOM LIBR POIN 16 CUB8 2 TERM
 0 0 0 1 0 0 1 1 0 0 1 0
 0 0 1 1 0 1 1 1 1 0 1 1
 0 0 1 1 0 1 1 1 1 0 1 1
 0 0 2 1 0 2 1 1 2 0 1 2
 1 2 3 4 5 6 7 8
 9 10 11 12 13 14 15 16
OPTI DUMP DPMA
MATE VM23 RO 8000. YOUN 1.D11 NU 0.3 ELAS 2.D8
          TRAC 3 2.D8 2.D-3 3.D8 1. 3.1D8 2.
          LECT tous TERM
LINK COUP
     PINB BODY MLEV 2 LECT 1 TERM
          BODY MLEV 2 LECT 2 TERM
INIT VITE 3  100 LECT  1 PAS 1  8 TERM
     VITE 3 -100 LECT  9 PAS 1 16 TERM
ECRI DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO FREQ 1
     FICH ALIC FREQ 1
OPTI PAS AUTO NOTE LOG 1
     PINS DUMP STAT EQVF
     LNKS STAT DIAG DUMP
CALC TINI 0. TEND 0.1D0 NMAX 11
*================================================================
PLAY
CAME   1 EYE  -1.77482E+00 -5.99653E+00  3.54494E+00
!        Q     8.06707E-01  5.64863E-01 -8.68241E-02 -1.50384E-01
         VIEW  3.09976E-01  8.85244E-01 -3.46784E-01
         RIGH  9.39693E-01 -3.40719E-01 -2.98090E-02
         UP    1.44544E-01  3.16630E-01  9.37471E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.00000E-01  5.00000E-01  1.00000E+00
!RSPHERE:  1.83467E+00
!RADIUS :  7.33869E+00
!ASPECT :  1.00000E+00
!NEAR   :  5.50402E+00
!FAR    :  1.10080E+01
SCEN GEOM NAVI FREE
          FACE HFRO
          PINB CDES JOIN
     VECT SCCO FIEL VITE SCAL USER PROG 7 PAS 7 98 TERM
     TEXT VSCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 12 FPS 15 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 10 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*================================================================
SUIT
Post-treatment from Alice file
ECHO
RESU ALIC GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dz_1' DEPL COMP 3 NOEU LECT 1 TERM
COUR 2 'dz_13' DEPL COMP 3 NOEU LECT 13 TERM
TRAC 1 2 AXES 1.0 'DISPL. [M]'
LIST 1 2 AXES 1.0 'DISPL. [M]'
*================================================================
FIN
```

pbc804.epx

```
PBC804
ECHO
!CONV WIN
LAGR TRID
GEOM LIBR POIN 16 CUB8 2 TERM
 0 0 0 1 0 0 1 1 0 0 1 0
 0 0 1 1 0 1 1 1 1 0 1 1
 0 0 1 1 0 1 1 1 1 0 1 1
 0 0 2 1 0 2 1 1 2 0 1 2
 1 2 3 4 5 6 7 8
 9 10 11 12 13 14 15 16
OPTI DUMP DPMA
MATE VM23 RO 8000. YOUN 1.D11 NU 0.3 ELAS 2.D8
          TRAC 3 2.D8 2.D-3 3.D8 1. 3.1D8 2.
          LECT tous TERM
LINK COUP
     PINB BODY MLEV 3 LECT 1 TERM
          BODY MLEV 3 LECT 2 TERM
INIT VITE 3  100 LECT  1 PAS 1  8 TERM
     VITE 3 -100 LECT  9 PAS 1 16 TERM
ECRI DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO FREQ 1
     FICH ALIC FREQ 1
OPTI PAS AUTO NOTE LOG 1
     PINS DUMP STAT EQVF
     LNKS STAT DIAG DUMP
CALC TINI 0. TEND 0.1D0 NMAX 100
*================================================================
PLAY
CAME   1 EYE  -1.77482E+00 -5.99653E+00  3.54494E+00
!        Q     8.06707E-01  5.64863E-01 -8.68241E-02 -1.50384E-01
         VIEW  3.09976E-01  8.85244E-01 -3.46784E-01
         RIGH  9.39693E-01 -3.40719E-01 -2.98090E-02
         UP    1.44544E-01  3.16630E-01  9.37471E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.00000E-01  5.00000E-01  1.00000E+00
!RSPHERE:  1.83467E+00
!RADIUS :  7.33869E+00
!ASPECT :  1.00000E+00
!NEAR   :  5.50402E+00
!FAR    :  1.10080E+01
SCEN GEOM NAVI FREE
          FACE HFRO
          PINB CDES JOIN
     VECT SCCO FIEL VITE SCAL USER PROG 7 PAS 7 98 TERM
     TEXT VSCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 15 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*================================================================
SUIT
Post-treatment from Alice file
ECHO
RESU ALIC GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dz_1' DEPL COMP 3 NOEU LECT 1 TERM
COUR 2 'dz_13' DEPL COMP 3 NOEU LECT 13 TERM
TRAC 1 2 AXES 1.0 'DISPL. [M]'
LIST 1 2 AXES 1.0 'DISPL. [M]'
*================================================================
FIN
```

pbcu01.epx

```
PBCU01
ECHO
!CONV WIN
LAGR TRID
GEOM LIBR POIN 16 CUBE 2 TERM
 0 0 0 1 0 0 1 1 0 0 1 0
 0 0 1 1 0 1 1 1 1 0 1 1
 0 0 1 1 0 1 1 1 1 0 1 1
 0 0 2 1 0 2 1 1 2 0 1 2
 1 2 3 4 5 6 7 8
 9 10 11 12 13 14 15 16
OPTI DUMP DPMA
MATE VM23 RO 8000. YOUN 1.D11 NU 0.3 ELAS 2.D8
          TRAC 3 2.D8 2.D-3 3.D8 1. 3.1D8 2.
          LECT tous TERM
LINK COUP
     PINB BODY LECT 1 TERM
          BODY LECT 2 TERM
INIT VITE 3  100 LECT  1 PAS 1  8 TERM
     VITE 3 -100 LECT  9 PAS 1 16 TERM
ECRI DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO FREQ 1
     FICH ALIC FREQ 1
OPTI PAS AUTO NOTE LOG 1
     PINS DUMP STAT
     LNKS STAT DIAG DUMP
```

```
CALC TINI 0. TEND 0.1D0 NMAX 100
*=============================================================
PLAY
CAME   1 EYE  -1.77482E+00 -5.99653E+00  3.54494E+00
!        Q     8.06707E-01  5.64863E-01 -8.68241E-02 -1.50384E-01
         VIEW  3.09976E-01  8.85244E-01 -3.46784E-01
         RIGH  9.39693E-01 -3.40719E-01 -2.98090E-02
         UP    1.44544E-01  3.16630E-01  9.37471E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.00000E-01  5.00000E-01  1.00000E+00
!RSPHERE:  1.83467E+00
!RADIUS :  7.33869E+00
!ASPECT :  1.00000E+00
!NEAR   :  5.50402E+00
!FAR    :  1.10080E+01
SCEN GEOM NAVI FREE
          FACE HFRO
          PINB CDES JOIN
     VECT SCCO FIEL VITE SCAL USER PROG 7 PAS 7 98 TERM
     TEXT VSCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 15 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=============================================================
SUIT
Post-treatment from Alice file
ECHO
RESU ALIC GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dz_1' DEPL COMP 3 NOEU LECT 1 TERM
COUR 2 'dz_13' DEPL COMP 3 NOEU LECT 13 TERM
TRAC 1 2 AXES 1.0 'DISPL. [M]'
LIST 1 2 AXES 1.0 'DISPL. [M]'
*=============================================================
FIN
```

pbcu02.epx

```
PBCU02
ECHO
!CONV WIN
LAGR TRID
GEOM LIBR POIN 16 CUBE 2 TERM
 0 0 0 1 0 0 1 1 0 0 1 0
 0 0 1 1 0 1 1 1 1 0 1 1
 0 0 1 1 0 1 1 1 1 0 1 1
 0 0 2 1 0 2 1 1 2 0 1 2
 1 2 3 4 5 6 7 8
 9 10 11 12 13 14 15 16
OPTI DUMP DPMA
MATE VM23 RO 8000. YOUN 1.D11 NU 0.3 ELAS 2.D8
          TRAC 3 2.D8 2.D-3 3.D8 1. 3.1D8 2.
          LECT tous TERM
LINK COUP
     PINB BODY MLEV 1 LECT 1 TERM
          BODY MLEV 1 LECT 2 TERM
INIT VITE 3  100 LECT  1 PAS 1  8 TERM
     VITE 3 -100 LECT  9 PAS 1 16 TERM
ECRI DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO FREQ 1
     FICH ALIC FREQ 1
OPTI PAS AUTO NOTE LOG 1
     PINS DUMP STAT EQVF
     LNKS STAT DIAG DUMP
CALC TINI 0. TEND 0.1D0 NMAX 100
*=============================================================
PLAY
CAME   1 EYE  -1.77482E+00 -5.99653E+00  3.54494E+00
!        Q     8.06707E-01  5.64863E-01 -8.68241E-02 -1.50384E-01
         VIEW  3.09976E-01  8.85244E-01 -3.46784E-01
         RIGH  9.39693E-01 -3.40719E-01 -2.98090E-02
         UP    1.44544E-01  3.16630E-01  9.37471E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.00000E-01  5.00000E-01  1.00000E+00
!RSPHERE:  1.83467E+00
!RADIUS :  7.33869E+00
!ASPECT :  1.00000E+00
!NEAR   :  5.50402E+00
!FAR    :  1.10080E+01
SCEN GEOM NAVI FREE
          FACE HFRO
          PINB CDES JOIN
     VECT SCCO FIEL VITE SCAL USER PROG 7 PAS 7 98 TERM
     TEXT VSCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 15 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=============================================================
SUIT
Post-treatment from Alice file
ECHO
RESU ALIC GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dz_1' DEPL COMP 3 NOEU LECT 1 TERM
COUR 2 'dz_13' DEPL COMP 3 NOEU LECT 13 TERM
TRAC 1 2 AXES 1.0 'DISPL. [M]'
LIST 1 2 AXES 1.0 'DISPL. [M]'
*=============================================================
FIN
```

pbcu03.epx

```
PBCU03
ECHO
!CONV WIN
LAGR TRID
GEOM LIBR POIN 16 CUBE 2 TERM
 0 0 0 1 0 0 1 1 0 0 1 0
 0 0 1 1 0 1 1 1 1 0 1 1
 0 0 1 1 0 1 1 1 1 0 1 1
 0 0 2 1 0 2 1 1 2 0 1 2
 1 2 3 4 5 6 7 8
 9 10 11 12 13 14 15 16
OPTI DUMP DPMA
MATE VM23 RO 8000. YOUN 1.D11 NU 0.3 ELAS 2.D8
          TRAC 3 2.D8 2.D-3 3.D8 1. 3.1D8 2.
          LECT tous TERM
LINK COUP
     PINB BODY MLEV 2 LECT 1 TERM
          BODY MLEV 2 LECT 2 TERM
INIT VITE 3  100 LECT  1 PAS 1  8 TERM
     VITE 3 -100 LECT  9 PAS 1 16 TERM
ECRI DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO FREQ 1
     FICH ALIC FREQ 1
OPTI PAS AUTO NOTE LOG 1
     PINS DUMP STAT EQVF
     LNKS STAT DIAG DUMP
CALC TINI 0. TEND 0.1D0 NMAX 100
*=============================================================
PLAY
CAME   1 EYE  -1.77482E+00 -5.99653E+00  3.54494E+00
!        Q     8.06707E-01  5.64863E-01 -8.68241E-02 -1.50384E-01
         VIEW  3.09976E-01  8.85244E-01 -3.46784E-01
         RIGH  9.39693E-01 -3.40719E-01 -2.98090E-02
         UP    1.44544E-01  3.16630E-01  9.37471E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.00000E-01  5.00000E-01  1.00000E+00
!RSPHERE:  1.83467E+00
!RADIUS :  7.33869E+00
!ASPECT :  1.00000E+00
!NEAR   :  5.50402E+00
!FAR    :  1.10080E+01
SCEN GEOM NAVI FREE
          FACE HFRO
          PINB CDES JOIN
     VECT SCCO FIEL VITE SCAL USER PROG 7 PAS 7 98 TERM
     TEXT VSCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 15 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=============================================================
SUIT
Post-treatment from Alice file
ECHO
RESU ALIC GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dz_1' DEPL COMP 3 NOEU LECT 1 TERM
COUR 2 'dz_13' DEPL COMP 3 NOEU LECT 13 TERM
TRAC 1 2 AXES 1.0 'DISPL. [M]'
LIST 1 2 AXES 1.0 'DISPL. [M]'
*=============================================================
FIN
```

pbcu04.epx

```
PBCU04
ECHO
!CONV WIN
LAGR TRID
GEOM LIBR POIN 16 CUBE 2 TERM
 0 0 0 1 0 0 1 1 0 0 1 0
 0 0 1 1 0 1 1 1 1 0 1 1
 0 0 1 1 0 1 1 1 1 0 1 1
 0 0 2 1 0 2 1 1 2 0 1 2
 1 2 3 4 5 6 7 8
 9 10 11 12 13 14 15 16
OPTI DUMP DPMA
MATE VM23 RO 8000. YOUN 1.D11 NU 0.3 ELAS 2.D8
          TRAC 3 2.D8 2.D-3 3.D8 1. 3.1D8 2.
          LECT tous TERM
LINK COUP
     PINB BODY MLEV 3 LECT 1 TERM
          BODY MLEV 3 LECT 2 TERM
INIT VITE 3  100 LECT  1 PAS 1  8 TERM
     VITE 3 -100 LECT  9 PAS 1 16 TERM
ECRI DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO FREQ 1
     FICH ALIC FREQ 1
OPTI PAS AUTO NOTE LOG 1
     PINS DUMP STAT EQVF
     LNKS STAT DIAG DUMP
CALC TINI 0. TEND 0.1D0 NMAX 100
*=============================================================
PLAY
CAME   1 EYE  -1.77482E+00 -5.99653E+00  3.54494E+00
!        Q     8.06707E-01  5.64863E-01 -8.68241E-02 -1.50384E-01
         VIEW  3.09976E-01  8.85244E-01 -3.46784E-01
         RIGH  9.39693E-01 -3.40719E-01 -2.98090E-02
         UP    1.44544E-01  3.16630E-01  9.37471E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.00000E-01  5.00000E-01  1.00000E+00
!RSPHERE:  1.83467E+00
!RADIUS :  7.33869E+00
!ASPECT :  1.00000E+00
!NEAR   :  5.50402E+00
!FAR    :  1.10080E+01
SCEN GEOM NAVI FREE
```

```
          FACE HFRO
          PINB CDES JOIN
     VECT SCCO FIEL VITE SCAL USER PROG 7 PAS 7 98 TERM
     TEXT VSCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 15 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=============================================================
SUIT
Post-treatment from Alice file
ECHO
RESU ALIC GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dz_1' DEPL COMP 3 NOEU LECT 1 TERM
COUR 2 'dz_13' DEPL COMP 3 NOEU LECT 13 TERM
TRAC 1 2 AXES 1.0 'DISPL. [M]'
LIST 1 2 AXES 1.0 'DISPL. [M]'
*=============================================================
FIN
```

pbcuall.epx

```
Comparison of results with CUBE/CUB8
ECHO
RESU ALIC 'pbc803.ali' GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 331 'dz_1_33' DEPL COMP 2 NOEU LECT 1 TERM
COUR 332 'dz_13_33' DEPL COMP 2 NOEU LECT 13 TERM
RCOU  11 'dz_1' FICH 'pbcu01.pun' RENA 'dz_1_01'
RCOU  12 'dz_13' FICH 'pbcu01.pun' RENA 'dz_13_01'
RCOU  21 'dz_1' FICH 'pbcu02.pun' RENA 'dz_1_02'
RCOU  22 'dz_13' FICH 'pbcu02.pun' RENA 'dz_13_02'
RCOU  31 'dz_1' FICH 'pbcu03.pun' RENA 'dz_1_03'
RCOU  32 'dz_13' FICH 'pbcu03.pun' RENA 'dz_13_03'
RCOU 311 'dz_1' FICH 'pbc801.pun' RENA 'dz_1_31'
RCOU 312 'dz_13' FICH 'pbc801.pun' RENA 'dz_13_31'
RCOU 321 'dz_1' FICH 'pbc802.pun' RENA 'dz_1_32'
RCOU 322 'dz_13' FICH 'pbc802.pun' RENA 'dz_13_32'
TRAC 11 21 31 311 321 331 AXES 1.0 'DISPL. [M]' YZER
TRAC 12 22 32 312 322 332 AXES 1.0 'DISPL. [M]' YZER
*=============================================================
FIN
```

pbq401.epx

```
PBQ401
ECHO
!CONV WIN
LAGR CPLA
GEOM LIBR POIN 8 Q41L 2 TERM
  0 0  2 0
  0 2  2 2
  0 2  2 2
  0 4  2 4
 1 2 4 3
 5 6 8 7
OPTI DUMP DPMA
COMP EPAI 1. LECT tous TERM
MATE VM23 RO 8000. YOUN 1.D11 NU 0.3 ELAS 2.D8
          TRAC 3 2.D8 2.D-3 3.D8 1. 3.1D8 2.
          LECT tous TERM
LINK COUP
     PINB BODY LECT 1 TERM
          BODY LECT 2 TERM
INIT VITE 2  100 LECT 1 PAS 1 4 TERM
     VITE 2 -100 LECT 5 PAS 1 8 TERM
ECRI DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO FREQ 1
     FICH ALIC FREQ 1
OPTI PAS AUTO NOTE LOG 1
     PINS DUMP STAT
     LNKS STAT DIAG DUMP
CALC TINI 0. TEND 0.1D0 NMAX 100
*=============================================================
PLAY
CAME   1 EYE   1.00000E+00  2.00000E+00  1.56752E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  1.00000E+00  2.00000E+00  0.00000E+00
!RSPHERE:  3.13503E+00
!RADIUS :  1.56752E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.22266E+01
!FAR    :  2.19452E+01
SCEN GEOM NAVI FREE
          FACE HFRO
          PINB CDES JOIN
     VECT SCCO FIEL VITE SCAL USER PROG 7 PAS 7 98 TERM
     TEXT VSCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 15 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=============================================================
SUIT
Post-treatment from Alice file
ECHO
RESU ALIC GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dy_1' DEPL COMP 2 NOEU LECT 1 TERM
COUR 2 'dy_7' DEPL COMP 2 NOEU LECT 7 TERM
TRAC 1 2 AXES 1.0 'DISPL. [M]'
LIST 1 2 AXES 1.0 'DISPL. [M]'
*=============================================================
FIN
```

pbq402.epx

```
PBQ402
ECHO
!CONV WIN
LAGR CPLA
GEOM LIBR POIN 8 Q41L 2 TERM
  0 0  2 0
  0 2  2 2
  0 2  2 2
  0 4  2 4
 1 2 4 3
 5 6 8 7
OPTI DUMP DPMA
COMP EPAI 1. LECT tous TERM
MATE VM23 RO 8000. YOUN 1.D11 NU 0.3 ELAS 2.D8
          TRAC 3 2.D8 2.D-3 3.D8 1. 3.1D8 2.
          LECT tous TERM
LINK COUP
     PINB BODY MLEV 1 LECT 1 TERM
          BODY MLEV 1 LECT 2 TERM
INIT VITE 2  100 LECT 1 PAS 1 4 TERM
     VITE 2 -100 LECT 5 PAS 1 8 TERM
ECRI DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO FREQ 1
     FICH ALIC FREQ 1
OPTI PAS AUTO NOTE LOG 1
     PINS DUMP STAT EQVF
     LNKS STAT DIAG DUMP
CALC TINI 0. TEND 0.1D0 NMAX 100
*=============================================================
PLAY
CAME   1 EYE   1.00000E+00  2.00000E+00  1.56752E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  1.00000E+00  2.00000E+00  0.00000E+00
!RSPHERE:  3.13503E+00
!RADIUS :  1.56752E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.22266E+01
!FAR    :  2.19452E+01
SCEN GEOM NAVI FREE
          FACE HFRO
          PINB CDES JOIN
     VECT SCCO FIEL VITE SCAL USER PROG 7 PAS 7 98 TERM
     TEXT VSCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 15 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=============================================================
SUIT
Post-treatment from Alice file
ECHO
RESU ALIC GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dy_1' DEPL COMP 2 NOEU LECT 1 TERM
COUR 2 'dy_7' DEPL COMP 2 NOEU LECT 7 TERM
TRAC 1 2 AXES 1.0 'DISPL. [M]'
LIST 1 2 AXES 1.0 'DISPL. [M]'
*=============================================================
FIN
```

pbq403.epx

```
PBQ403
ECHO
!CONV WIN
LAGR CPLA
GEOM LIBR POIN 8 Q41L 2 TERM
  0 0  2 0
  0 2  2 2
  0 2  2 2
  0 4  2 4
 1 2 4 3
 5 6 8 7
OPTI DUMP DPMA
COMP EPAI 1. LECT tous TERM
MATE VM23 RO 8000. YOUN 1.D11 NU 0.3 ELAS 2.D8
          TRAC 3 2.D8 2.D-3 3.D8 1. 3.1D8 2.
          LECT tous TERM
LINK COUP
     PINB BODY MLEV 2 LECT 1 TERM
          BODY MLEV 2 LECT 2 TERM
INIT VITE 2  100 LECT 1 PAS 1 4 TERM
     VITE 2 -100 LECT 5 PAS 1 8 TERM
ECRI DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO FREQ 1
     FICH ALIC FREQ 1
OPTI PAS AUTO NOTE LOG 1
     PINS DUMP STAT EQVF
     LNKS STAT DIAG DUMP
CALC TINI 0. TEND 0.1D0 NMAX 100
*=============================================================
PLAY
CAME   1 EYE   1.00000E+00  2.00000E+00  1.56752E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
```

```
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  1.00000E+00  2.00000E+00  0.00000E+00
!RSPHERE:  3.13503E+00
!RADIUS :  1.56752E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.22266E+01
!FAR    :  2.19452E+01
SCEN GEOM NAVI FREE
          FACE HFRO
          PINB CDES JOIN
     VECT SCCO FIEL VITE SCAL USER PROG 7 PAS 7 98 TERM
     TEXT VSCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 15 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*================================================================
SUIT
Post-treatment from Alice file
ECHO
RESU ALIC GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dy_1' DEPL COMP 2 NOEU LECT 1 TERM
COUR 2 'dy_7' DEPL COMP 2 NOEU LECT 7 TERM
TRAC 1 2 AXES 1.0 'DISPL. [M]'
LIST 1 2 AXES 1.0 'DISPL. [M]'
*================================================================
FIN
```

pbq404.epx

```
PBQ404
ECHO
!CONV WIN
LAGR CPLA
GEOM LIBR POIN 8 Q41L 2 TERM
  0 0  2 0
  0 2  2 2
  0 2  2 2
  0 4  2 4
 1 2 4 3
 5 6 8 7
OPTI DUMP DPMA
COMP EPAI 1. LECT tous TERM
MATE VM23 RO 8000. YOUN 1.D11 NU 0.3 ELAS 2.D8
          TRAC 3 2.D8 2.D-3 3.D8 1. 3.1D8 2.
          LECT tous TERM
LINK COUP
     PINB BODY MLEV 3 LECT 1 TERM
          BODY MLEV 3 LECT 2 TERM
INIT VITE 2  100 LECT 1 PAS 1 4 TERM
     VITE 2 -100 LECT 5 PAS 1 8 TERM
ECRI DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO FREQ 1
     FICH ALIC FREQ 1
OPTI PAS AUTO NOTE LOG 1
     PINS DUMP STAT EQVF
     LNKS STAT DIAG DUMP
CALC TINI 0. TEND 0.1D0 NMAX 100
*================================================================
PLAY
CAME   1 EYE   1.00000E+00  2.00000E+00  1.56752E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  1.00000E+00  2.00000E+00  0.00000E+00
!RSPHERE:  3.13503E+00
!RADIUS :  1.56752E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.22266E+01
!FAR    :  2.19452E+01
SCEN GEOM NAVI FREE
          FACE HFRO
          PINB CDES JOIN
     VECT SCCO FIEL VITE SCAL USER PROG 7 PAS 7 98 TERM
     TEXT VSCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 15 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*================================================================
SUIT
Post-treatment from Alice file
ECHO
RESU ALIC GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dy_1' DEPL COMP 2 NOEU LECT 1 TERM
COUR 2 'dy_7' DEPL COMP 2 NOEU LECT 7 TERM
TRAC 1 2 AXES 1.0 'DISPL. [M]'
LIST 1 2 AXES 1.0 'DISPL. [M]'
*================================================================
FIN
```

pbq421.epx

```
PBQ421
ECHO
!CONV WIN
LAGR CPLA
GEOM LIBR POIN 8 Q42L 2 TERM
  0 0  2 0
  0 2  2 2
  0 2  2 2
  0 4  2 4
 1 2 4 3
 5 6 8 7
OPTI DUMP DPMA
COMP EPAI 1. LECT tous TERM
MATE VM23 RO 8000. YOUN 1.D11 NU 0.3 ELAS 2.D8
          TRAC 3 2.D8 2.D-3 3.D8 1. 3.1D8 2.
          LECT tous TERM
LINK COUP
     PINB BODY LECT 1 TERM
          BODY LECT 2 TERM
INIT VITE 2  100 LECT 1 PAS 1 4 TERM
     VITE 2 -100 LECT 5 PAS 1 8 TERM
ECRI DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO FREQ 1
     FICH ALIC FREQ 1
OPTI PAS AUTO NOTE LOG 1
     PINS DUMP STAT
     LNKS STAT DIAG DUMP
CALC TINI 0. TEND 0.1D0 NMAX 100
*================================================================
PLAY
CAME   1 EYE   1.00000E+00  2.00000E+00  1.56752E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  1.00000E+00  2.00000E+00  0.00000E+00
!RSPHERE:  3.13503E+00
!RADIUS :  1.56752E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.22266E+01
!FAR    :  2.19452E+01
SCEN GEOM NAVI FREE
          FACE HFRO
          PINB CDES JOIN
     VECT SCCO FIEL VITE SCAL USER PROG 7 PAS 7 98 TERM
     TEXT VSCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 15 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*================================================================
SUIT
Post-treatment from Alice file
ECHO
RESU ALIC GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dy_1' DEPL COMP 2 NOEU LECT 1 TERM
COUR 2 'dy_7' DEPL COMP 2 NOEU LECT 7 TERM
TRAC 1 2 AXES 1.0 'DISPL. [M]'
LIST 1 2 AXES 1.0 'DISPL. [M]'
*================================================================
FIN
```

pbq422.epx

```
PBQ422
ECHO
!CONV WIN
LAGR CPLA
GEOM LIBR POIN 8 Q42L 2 TERM
  0 0  2 0
  0 2  2 2
  0 2  2 2
  0 4  2 4
 1 2 4 3
 5 6 8 7
OPTI DUMP DPMA
COMP EPAI 1. LECT tous TERM
MATE VM23 RO 8000. YOUN 1.D11 NU 0.3 ELAS 2.D8
          TRAC 3 2.D8 2.D-3 3.D8 1. 3.1D8 2.
          LECT tous TERM
LINK COUP
     PINB BODY MLEV 1 LECT 1 TERM
          BODY MLEV 1 LECT 2 TERM
INIT VITE 2  100 LECT 1 PAS 1 4 TERM
     VITE 2 -100 LECT 5 PAS 1 8 TERM
ECRI DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO FREQ 1
     FICH ALIC FREQ 1
OPTI PAS AUTO NOTE LOG 1
     PINS DUMP STAT EQVF
     LNKS STAT DIAG DUMP
CALC TINI 0. TEND 0.1D0 NMAX 100
*================================================================
PLAY
CAME   1 EYE   1.00000E+00  2.00000E+00  1.56752E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  1.00000E+00  2.00000E+00  0.00000E+00
!RSPHERE:  3.13503E+00
!RADIUS :  1.56752E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.22266E+01
!FAR    :  2.19452E+01
SCEN GEOM NAVI FREE
          FACE HFRO
          PINB CDES JOIN
     VECT SCCO FIEL VITE SCAL USER PROG 7 PAS 7 98 TERM
     TEXT VSCA
     COLO PAPE
```

```
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 15 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=============================================================
SUIT
Post-treatment from Alice file
ECHO
RESU ALIC GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dy_1' DEPL COMP 2 NOEU LECT 1 TERM
COUR 2 'dy_7' DEPL COMP 2 NOEU LECT 7 TERM
TRAC 1 2 AXES 1.0 'DISPL. [M]'
LIST 1 2 AXES 1.0 'DISPL. [M]'
*=============================================================
FIN
```

pbq423.epx

```
PBQ423
ECHO
!CONV WIN
LAGR CPLA
GEOM LIBR POIN 8 Q42L 2 TERM
  0 0  2 0
  0 2  2 2
  0 2  2 2
  0 4  2 4
 1 2 4 3
 5 6 8 7
OPTI DUMP DPMA
COMP EPAI 1. LECT tous TERM
MATE VM23 RO 8000. YOUN 1.D11 NU 0.3 ELAS 2.D8
          TRAC 3 2.D8 2.D-3 3.D8 1. 3.1D8 2.
          LECT tous TERM
LINK COUP
     PINB BODY MLEV 2 LECT 1 TERM
          BODY MLEV 2 LECT 2 TERM
INIT VITE 2  100 LECT 1 PAS 1 4 TERM
     VITE 2 -100 LECT 5 PAS 1 8 TERM
ECRI DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO FREQ 1
     FICH ALIC FREQ 1
OPTI PAS AUTO NOTE LOG 1
     PINS DUMP STAT EQVF
     LNKS STAT DIAG DUMP
CALC TINI 0. TEND 0.1D0 NMAX 100
*=============================================================
PLAY
CAME   1 EYE   1.00000E+00  2.00000E+00  1.56752E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  1.00000E+00  2.00000E+00  0.00000E+00
!RSPHERE:  3.13503E+00
!RADIUS :  1.56752E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.22266E+01
!FAR    :  2.19452E+01
SCEN GEOM NAVI FREE
          FACE HFRO
          PINB CDES JOIN
     VECT SCCO FIEL VITE SCAL USER PROG 7 PAS 7 98 TERM
     TEXT VSCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 15 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=============================================================
SUIT
Post-treatment from Alice file
ECHO
RESU ALIC GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dy_1' DEPL COMP 2 NOEU LECT 1 TERM
COUR 2 'dy_7' DEPL COMP 2 NOEU LECT 7 TERM
TRAC 1 2 AXES 1.0 'DISPL. [M]'
LIST 1 2 AXES 1.0 'DISPL. [M]'
*=============================================================
FIN
```

pbq424.epx

```
PBQ424
ECHO
!CONV WIN
LAGR CPLA
GEOM LIBR POIN 8 Q42L 2 TERM
  0 0  2 0
  0 2  2 2
  0 2  2 2
  0 4  2 4
 1 2 4 3
 5 6 8 7
OPTI DUMP DPMA
COMP EPAI 1. LECT tous TERM
MATE VM23 RO 8000. YOUN 1.D11 NU 0.3 ELAS 2.D8
          TRAC 3 2.D8 2.D-3 3.D8 1. 3.1D8 2.
          LECT tous TERM
LINK COUP
     PINB BODY MLEV 3 LECT 1 TERM
          BODY MLEV 3 LECT 2 TERM
INIT VITE 2  100 LECT 1 PAS 1 4 TERM
     VITE 2 -100 LECT 5 PAS 1 8 TERM
ECRI DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO FREQ 1
     FICH ALIC FREQ 1
OPTI PAS AUTO NOTE LOG 1
     PINS DUMP STAT EQVF
     LNKS STAT DIAG DUMP
CALC TINI 0. TEND 0.1D0 NMAX 100
*=============================================================
PLAY
CAME   1 EYE   1.00000E+00  2.00000E+00  1.56752E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  1.00000E+00  2.00000E+00  0.00000E+00
!RSPHERE:  3.13503E+00
!RADIUS :  1.56752E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.22266E+01
!FAR    :  2.19452E+01
SCEN GEOM NAVI FREE
          FACE HFRO
          PINB CDES JOIN
     VECT SCCO FIEL VITE SCAL USER PROG 7 PAS 7 98 TERM
     TEXT VSCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 15 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=============================================================
SUIT
Post-treatment from Alice file
ECHO
RESU ALIC GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dy_1' DEPL COMP 2 NOEU LECT 1 TERM
COUR 2 'dy_7' DEPL COMP 2 NOEU LECT 7 TERM
TRAC 1 2 AXES 1.0 'DISPL. [M]'
LIST 1 2 AXES 1.0 'DISPL. [M]'
*=============================================================
FIN
```

pbq4all.epx

```
Comparison of results with Q41L/Q42L
ECHO
RESU ALIC 'pbq424.ali' GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 341 'dy_1_34' DEPL COMP 2 NOEU LECT 1 TERM
COUR 342 'dy_7_34' DEPL COMP 2 NOEU LECT 7 TERM
RCOU  11 'dy_1' FICH 'pbq401.pun' RENA 'dy_1_01'
RCOU  12 'dy_7' FICH 'pbq401.pun' RENA 'dy_7_01'
RCOU  21 'dy_1' FICH 'pbq402.pun' RENA 'dy_1_02'
RCOU  22 'dy_7' FICH 'pbq402.pun' RENA 'dy_7_02'
RCOU  31 'dy_1' FICH 'pbq403.pun' RENA 'dy_1_03'
RCOU  32 'dy_7' FICH 'pbq403.pun' RENA 'dy_7_03'
RCOU  41 'dy_1' FICH 'pbq404.pun' RENA 'dy_1_04'
RCOU  42 'dy_7' FICH 'pbq404.pun' RENA 'dy_7_04'
RCOU 311 'dy_1' FICH 'pbq421.pun' RENA 'dy_1_31'
RCOU 312 'dy_7' FICH 'pbq421.pun' RENA 'dy_7_31'
RCOU 321 'dy_1' FICH 'pbq422.pun' RENA 'dy_1_32'
RCOU 322 'dy_7' FICH 'pbq422.pun' RENA 'dy_7_32'
RCOU 331 'dy_1' FICH 'pbq423.pun' RENA 'dy_1_33'
RCOU 332 'dy_7' FICH 'pbq423.pun' RENA 'dy_7_33'
TRAC 11 21 31 41 311 321 331 341 AXES 1.0 'DISPL. [M]' YZER
TRAC 12 22 32 42 312 322 332 342 AXES 1.0 'DISPL. [M]' YZER
*=============================================================
FIN
```

pbq901.epx

```
PBQ901
ECHO
!CONV WIN
LAGR CPLA
GEOM LIBR POIN 18 Q92 2 TERM
  0 0  1 0  2 0
  0 1  1 1  2 1
  0 2  1 2  2 2
  0 2  1 2  2 2
  0 3  1 3  2 3
  0 4  1 4  2 4
 1 2 3 6 9 8 7 4 5
 10 11 12 15 18 17 16 13 14
OPTI DUMP DPMA
COMP EPAI 1. LECT tous TERM
MATE VM23 RO 8000. YOUN 1.D11 NU 0.3 ELAS 2.D8
          TRAC 3 2.D8 2.D-3 3.D8 1. 3.1D8 2.
          LECT tous TERM
LINK COUP
     PINB BODY LECT 1 TERM
          BODY LECT 2 TERM
INIT VITE 2  100 LECT 1 PAS 1 9 TERM
     VITE 2 -100 LECT 10 PAS 1 18 TERM
ECRI DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO FREQ 1
     FICH ALIC FREQ 1
OPTI PAS AUTO NOTE LOG 1
     PINS DUMP STAT
     LNKS STAT DIAG DUMP
CALC TINI 0. TEND 0.1D0 NMAX 100
*=============================================================
PLAY
CAME   1 EYE   1.00000E+00  2.00000E+00  1.56752E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
```

```
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  1.00000E+00  2.00000E+00  0.00000E+00
!RSPHERE:  3.13503E+00
!RADIUS :  1.56752E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.22266E+01
!FAR    :  2.19452E+01
SCEN GEOM NAVI FREE
          FACE HFRO
          PINB CDES JOIN
     VECT SCCO FIEL VITE SCAL USER PROG 7 PAS 7 98 TERM
     TEXT VSCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 15 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*================================================================
SUIT
Post-treatment from Alice file
ECHO
RESU ALIC GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dy_05' DEPL COMP 2 NOEU LECT  5 TERM
COUR 2 'dy_14' DEPL COMP 2 NOEU LECT 14 TERM
TRAC 1 2 AXES 1.0 'DISPL. [M]'
LIST 1 2 AXES 1.0 'DISPL. [M]'
*================================================================
FIN
```

pbq902.epx

```
PBQ902
ECHO
!CONV WIN
LAGR CPLA
GEOM LIBR POIN 18 Q92 2 TERM
  0 0  1 0  2 0
  0 1  1 1  2 1
  0 2  1 2  2 2
  0 2  1 2  2 2
  0 3  1 3  2 3
  0 4  1 4  2 4
 1 2 3 6 9 8 7 4 5
 10 11 12 15 18 17 16 13 14
OPTI DUMP DPMA
COMP EPAI 1. LECT tous TERM
MATE VM23 RO 8000. YOUN 1.D11 NU 0.3 ELAS 2.D8
          TRAC 3 2.D8 2.D-3 3.D8 1. 3.1D8 2.
          LECT tous TERM
LINK COUP
     PINB BODY MLEV 1 LECT 1 TERM
          BODY MLEV 1 LECT 2 TERM
INIT VITE 2  100 LECT 1 PAS 1 9 TERM
     VITE 2 -100 LECT 10 PAS 1 18 TERM
ECRI DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO FREQ 1
     FICH ALIC FREQ 1
OPTI PAS AUTO NOTE LOG 1
     PINS DUMP STAT EQVF
     LNKS STAT DIAG DUMP
CALC TINI 0. TEND 0.1D0 NMAX 100
*================================================================
PLAY
CAME   1 EYE   1.00000E+00  2.00000E+00  1.56752E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  1.00000E+00  2.00000E+00  0.00000E+00
!RSPHERE:  3.13503E+00
!RADIUS :  1.56752E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.22266E+01
!FAR    :  2.19452E+01
SCEN GEOM NAVI FREE
          FACE HFRO
          PINB CDES JOIN
     VECT SCCO FIEL VITE SCAL USER PROG 7 PAS 7 98 TERM
     TEXT VSCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 15 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*================================================================
SUIT
Post-treatment from Alice file
ECHO
RESU ALIC GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dy_05' DEPL COMP 2 NOEU LECT  5 TERM
COUR 2 'dy_14' DEPL COMP 2 NOEU LECT 14 TERM
TRAC 1 2 AXES 1.0 'DISPL. [M]'
LIST 1 2 AXES 1.0 'DISPL. [M]'
*================================================================
FIN
```

pbq903.epx

```
PBQ903
ECHO
!CONV WIN
LAGR CPLA
GEOM LIBR POIN 18 Q92 2 TERM
  0 0  1 0  2 0
  0 1  1 1  2 1
  0 2  1 2  2 2
  0 2  1 2  2 2
  0 3  1 3  2 3
  0 4  1 4  2 4
 1 2 3 6 9 8 7 4 5
 10 11 12 15 18 17 16 13 14
OPTI DUMP DPMA
COMP EPAI 1. LECT tous TERM
MATE VM23 RO 8000. YOUN 1.D11 NU 0.3 ELAS 2.D8
          TRAC 3 2.D8 2.D-3 3.D8 1. 3.1D8 2.
          LECT tous TERM
LINK COUP
     PINB BODY MLEV 2 LECT 1 TERM
          BODY MLEV 2 LECT 2 TERM
INIT VITE 2  100 LECT 1 PAS 1 9 TERM
     VITE 2 -100 LECT 10 PAS 1 18 TERM
ECRI DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO FREQ 1
     FICH ALIC FREQ 1
OPTI PAS AUTO NOTE LOG 1
     PINS DUMP STAT EQVF
     LNKS STAT DIAG DUMP
CALC TINI 0. TEND 0.1D0 NMAX 100
*================================================================
PLAY
CAME   1 EYE   1.00000E+00  2.00000E+00  1.56752E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  1.00000E+00  2.00000E+00  0.00000E+00
!RSPHERE:  3.13503E+00
!RADIUS :  1.56752E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.22266E+01
!FAR    :  2.19452E+01
SCEN GEOM NAVI FREE
          FACE HFRO
          PINB CDES JOIN
     VECT SCCO FIEL VITE SCAL USER PROG 7 PAS 7 98 TERM
     TEXT VSCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 15 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*================================================================
SUIT
Post-treatment from Alice file
ECHO
RESU ALIC GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dy_05' DEPL COMP 2 NOEU LECT  5 TERM
COUR 2 'dy_14' DEPL COMP 2 NOEU LECT 14 TERM
TRAC 1 2 AXES 1.0 'DISPL. [M]'
LIST 1 2 AXES 1.0 'DISPL. [M]'
*================================================================
FIN
```

pbq904.epx

```
PBQ904
ECHO
!CONV WIN
LAGR CPLA
GEOM LIBR POIN 18 Q92 2 TERM
  0 0  1 0  2 0
  0 1  1 1  2 1
  0 2  1 2  2 2
  0 2  1 2  2 2
  0 3  1 3  2 3
  0 4  1 4  2 4
 1 2 3 6 9 8 7 4 5
 10 11 12 15 18 17 16 13 14
OPTI DUMP DPMA
COMP EPAI 1. LECT tous TERM
MATE VM23 RO 8000. YOUN 1.D11 NU 0.3 ELAS 2.D8
          TRAC 3 2.D8 2.D-3 3.D8 1. 3.1D8 2.
          LECT tous TERM
LINK COUP
     PINB BODY MLEV 3 LECT 1 TERM
          BODY MLEV 3 LECT 2 TERM
INIT VITE 2  100 LECT 1 PAS 1 9 TERM
     VITE 2 -100 LECT 10 PAS 1 18 TERM
ECRI DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO FREQ 1
     FICH ALIC FREQ 1
OPTI PAS AUTO NOTE LOG 1
     PINS DUMP STAT EQVF
     LNKS STAT DIAG DUMP
CALC TINI 0. TEND 0.1D0 NMAX 100
*================================================================
PLAY
CAME   1 EYE   1.00000E+00  2.00000E+00  1.56752E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  1.00000E+00  2.00000E+00  0.00000E+00
```

```
!RSPHERE:  3.13503E+00
!RADIUS :  1.56752E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.22266E+01
!FAR    :  2.19452E+01
SCEN GEOM NAVI FREE
          FACE HFRO
          PINB CDES JOIN
     VECT SCCO FIEL VITE SCAL USER PROG 7 PAS 7 98 TERM
     TEXT VSCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 15 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*================================================================
SUIT
Post-treatment from Alice file
ECHO
RESU ALIC GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dy_05' DEPL COMP 2 NOEU LECT  5 TERM
COUR 2 'dy_14' DEPL COMP 2 NOEU LECT 14 TERM
TRAC 1 2 AXES 1.0 'DISPL. [M]'
LIST 1 2 AXES 1.0 'DISPL. [M]'
*================================================================
FIN
```

pbq931.epx

```
PBQ931
ECHO
!CONV WIN
LAGR CPLA
GEOM LIBR POIN 18 Q93 2 TERM
  0 0  1 0  2 0
  0 1  1 1  2 1
  0 2  1 2  2 2
  0 2  1 2  2 2
  0 3  1 3  2 3
  0 4  1 4  2 4
 1 2 3 6 9 8 7 4 5
 10 11 12 15 18 17 16 13 14
OPTI DUMP DPMA
COMP EPAI 1. LECT tous TERM
MATE VM23 RO 8000. YOUN 1.D11 NU 0.3 ELAS 2.D8
          TRAC 3 2.D8 2.D-3 3.D8 1. 3.1D8 2.
          LECT tous TERM
LINK COUP
     PINB BODY LECT 1 TERM
          BODY LECT 2 TERM
INIT VITE 2  100 LECT 1 PAS 1 9 TERM
     VITE 2 -100 LECT 10 PAS 1 18 TERM
ECRI DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO FREQ 1
     FICH ALIC FREQ 1
OPTI PAS AUTO NOTE LOG 1
     PINS DUMP STAT
     LNKS STAT DIAG DUMP
CALC TINI 0. TEND 0.1D0 NMAX 100
*================================================================
PLAY
CAME   1 EYE   1.00000E+00  2.00000E+00  1.56752E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  1.00000E+00  2.00000E+00  0.00000E+00
!RSPHERE:  3.13503E+00
!RADIUS :  1.56752E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.22266E+01
!FAR    :  2.19452E+01
SCEN GEOM NAVI FREE
          FACE HFRO
          PINB CDES JOIN
     VECT SCCO FIEL VITE SCAL USER PROG 7 PAS 7 98 TERM
     TEXT VSCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 15 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*================================================================
SUIT
Post-treatment from Alice file
ECHO
RESU ALIC GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dy_05' DEPL COMP 2 NOEU LECT  5 TERM
COUR 2 'dy_14' DEPL COMP 2 NOEU LECT 14 TERM
TRAC 1 2 AXES 1.0 'DISPL. [M]'
LIST 1 2 AXES 1.0 'DISPL. [M]'
*================================================================
FIN
```

pbq932.epx

```
PBQ932
ECHO
!CONV WIN
LAGR CPLA
GEOM LIBR POIN 18 Q93 2 TERM
  0 0  1 0  2 0
  0 1  1 1  2 1
  0 2  1 2  2 2
  0 2  1 2  2 2
  0 3  1 3  2 3
  0 4  1 4  2 4
 1 2 3 6 9 8 7 4 5
 10 11 12 15 18 17 16 13 14
OPTI DUMP DPMA
COMP EPAI 1. LECT tous TERM
MATE VM23 RO 8000. YOUN 1.D11 NU 0.3 ELAS 2.D8
          TRAC 3 2.D8 2.D-3 3.D8 1. 3.1D8 2.
          LECT tous TERM
LINK COUP
     PINB BODY MLEV 1 LECT 1 TERM
          BODY MLEV 1 LECT 2 TERM
INIT VITE 2  100 LECT 1 PAS 1 9 TERM
     VITE 2 -100 LECT 10 PAS 1 18 TERM
ECRI DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO FREQ 1
     FICH ALIC FREQ 1
OPTI PAS AUTO NOTE LOG 1
     PINS DUMP STAT EQVF
     LNKS STAT DIAG DUMP
CALC TINI 0. TEND 0.1D0 NMAX 93 !100
*================================================================
PLAY
CAME   1 EYE   1.00000E+00  2.00000E+00  1.56752E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  1.00000E+00  2.00000E+00  0.00000E+00
!RSPHERE:  3.13503E+00
!RADIUS :  1.56752E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.22266E+01
!FAR    :  2.19452E+01
SCEN GEOM NAVI FREE
          FACE HFRO
          PINB CDES JOIN
     VECT SCCO FIEL VITE SCAL USER PROG 7 PAS 7 98 TERM
     TEXT VSCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 94 FPS 15 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 92 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*================================================================
SUIT
Post-treatment from Alice file
ECHO
RESU ALIC GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dy_05' DEPL COMP 2 NOEU LECT  5 TERM
COUR 2 'dy_14' DEPL COMP 2 NOEU LECT 14 TERM
TRAC 1 2 AXES 1.0 'DISPL. [M]'
LIST 1 2 AXES 1.0 'DISPL. [M]'
*================================================================
FIN
```

pbq933.epx

```
PBQ933
ECHO
!CONV WIN
LAGR CPLA
GEOM LIBR POIN 18 Q93 2 TERM
  0 0  1 0  2 0
  0 1  1 1  2 1
  0 2  1 2  2 2
  0 2  1 2  2 2
  0 3  1 3  2 3
  0 4  1 4  2 4
 1 2 3 6 9 8 7 4 5
 10 11 12 15 18 17 16 13 14
OPTI DUMP DPMA
COMP EPAI 1. LECT tous TERM
MATE VM23 RO 8000. YOUN 1.D11 NU 0.3 ELAS 2.D8
          TRAC 3 2.D8 2.D-3 3.D8 1. 3.1D8 2.
          LECT tous TERM
LINK COUP
     PINB BODY MLEV 2 LECT 1 TERM
          BODY MLEV 2 LECT 2 TERM
INIT VITE 2  100 LECT 1 PAS 1 9 TERM
     VITE 2 -100 LECT 10 PAS 1 18 TERM
ECRI DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO FREQ 1
     FICH ALIC FREQ 1
OPTI PAS AUTO NOTE LOG 1
     PINS DUMP STAT EQVF
     LNKS STAT DIAG DUMP
CALC TINI 0. TEND 0.1D0 NMAX 100
*================================================================
PLAY
CAME   1 EYE   1.00000E+00  2.00000E+00  1.56752E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  1.00000E+00  2.00000E+00  0.00000E+00
!RSPHERE:  3.13503E+00
!RADIUS :  1.56752E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.22266E+01
!FAR    :  2.19452E+01
SCEN GEOM NAVI FREE
          FACE HFRO
          PINB CDES JOIN
     VECT SCCO FIEL VITE SCAL USER PROG 7 PAS 7 98 TERM
     TEXT VSCA
```

```
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 15 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=============================================================
SUIT
Post-treatment from Alice file
ECHO
RESU ALIC GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dy_05' DEPL COMP 2 NOEU LECT  5 TERM
COUR 2 'dy_14' DEPL COMP 2 NOEU LECT 14 TERM
TRAC 1 2 AXES 1.0 'DISPL. [M]'
LIST 1 2 AXES 1.0 'DISPL. [M]'
*=============================================================
FIN
```

pbq934.epx

```
PBQ934
ECHO
!CONV WIN
LAGR CPLA
GEOM LIBR POIN 18 Q93 2 TERM
  0 0  1 0  2 0
  0 1  1 1  2 1
  0 2  1 2  2 2
  0 2  1 2  2 2
  0 3  1 3  2 3
  0 4  1 4  2 4
 1 2 3 6 9 8 7 4 5
 10 11 12 15 18 17 16 13 14
OPTI DUMP DPMA
COMP EPAI 1. LECT tous TERM
MATE VM23 RO 8000. YOUN 1.D11 NU 0.3 ELAS 2.D8
          TRAC 3 2.D8 2.D-3 3.D8 1. 3.1D8 2.
          LECT tous TERM
LINK COUP
     PINB BODY MLEV 3 LECT 1 TERM
          BODY MLEV 3 LECT 2 TERM
INIT VITE 2  100 LECT 1 PAS 1 9 TERM
     VITE 2 -100 LECT 10 PAS 1 18 TERM
ECRI DEPL VITE ACCE FINT FEXT FLIA FDEC CONT ECRO FREQ 1
     FICH ALIC FREQ 1
OPTI PAS AUTO NOTE LOG 1
     PINS DUMP STAT EQVF
     LNKS STAT DIAG DUMP
CALC TINI 0. TEND 0.1D0 NMAX 44 !100
*=============================================================
PLAY
CAME   1 EYE   1.00000E+00  2.00000E+00  1.56752E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  1.00000E+00  2.00000E+00  0.00000E+00
!RSPHERE:  3.13503E+00
!RADIUS :  1.56752E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.22266E+01
!FAR    :  2.19452E+01
SCEN GEOM NAVI FREE
          FACE HFRO
          PINB CDES JOIN
     VECT SCCO FIEL VITE SCAL USER PROG 7 PAS 7 98 TERM
     TEXT VSCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 45 FPS 15 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 43 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=============================================================
SUIT
Post-treatment from Alice file
ECHO
RESU ALIC GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'dy_05' DEPL COMP 2 NOEU LECT  5 TERM
COUR 2 'dy_14' DEPL COMP 2 NOEU LECT 14 TERM
TRAC 1 2 AXES 1.0 'DISPL. [M]'
LIST 1 2 AXES 1.0 'DISPL. [M]'
*=============================================================
FIN
```

pbq9all.epx

```
Comparison of results with Q92/Q93
ECHO
RESU ALIC 'pbq934.ali' GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 341 'dy_05_34' DEPL COMP 2 NOEU LECT  5 TERM
COUR 342 'dy_14_34' DEPL COMP 2 NOEU LECT 14 TERM
RCOU  11 'dy_05' FICH 'pbq901.pun' RENA 'dy_05_01'
RCOU  12 'dy_14' FICH 'pbq901.pun' RENA 'dy_14_01'
RCOU  21 'dy_05' FICH 'pbq902.pun' RENA 'dy_05_02'
RCOU  22 'dy_14' FICH 'pbq902.pun' RENA 'dy_14_02'
RCOU  31 'dy_05' FICH 'pbq903.pun' RENA 'dy_05_03'
RCOU  32 'dy_14' FICH 'pbq903.pun' RENA 'dy_14_03'
RCOU  41 'dy_05' FICH 'pbq904.pun' RENA 'dy_05_04'
RCOU  42 'dy_14' FICH 'pbq904.pun' RENA 'dy_14_04'
RCOU 311 'dy_05' FICH 'pbq931.pun' RENA 'dy_05_31'
RCOU 312 'dy_14' FICH 'pbq931.pun' RENA 'dy_14_31'
RCOU 321 'dy_05' FICH 'pbq932.pun' RENA 'dy_05_32'
RCOU 322 'dy_14' FICH 'pbq932.pun' RENA 'dy_14_32'
RCOU 331 'dy_05' FICH 'pbq933.pun' RENA 'dy_05_33'
RCOU 332 'dy_14' FICH 'pbq933.pun' RENA 'dy_14_33'
TRAC 11 21 31 41 311 321 331 341 AXES 1.0 'DISPL. [M]' YZER
TRAC 12 22 32 42 312 322 332 342 AXES 1.0 'DISPL. [M]' YZER
*=============================================================
FIN
```

pxq42q92.proc

```
'DEBPROC' pxq42q92 q4*'MAILLAGE';
*
*-------------------------------------------------
* Transforms a q4 (in 2d !!!) into a q9 by creating:
* - 4 new mid-side nodes
* - 1 new central  node
*
* Input :
* -----
*     q4 : a mesh containing just one q4 (in 2d)
* Output :
* ------
*     q9 : mesh containing one q9 (in 3d: meshed as qua9)
*-------------------------------------------------
*
hh = chan poi1 q4;
*
p01 = hh poin 1;
p02 = hh poin 2;
p03 = hh poin 3;
p04 = hh poin 4;
*
n01 = noeu p01;
n02 = noeu p02;
n03 = noeu p03;
n04 = noeu p04;
*
x01 y01 = coor p01;
x02 y02 = coor p02;
x03 y03 = coor p03;
x04 y04 = coor p04;
*
x05 = (x01 + x02) / 2.0;
y05 = (y01 + y02) / 2.0;
p05 = x05 y05;
n05 = noeu p05;
*
x06 = (x02 + x03) / 2.0;
y06 = (y02 + y03) / 2.0;
p06 = x06 y06;
n06 = noeu p06;
*
x07 = (x03 + x04) / 2.0;
y07 = (y03 + y04) / 2.0;
p07 = x07 y07;
n07 = noeu p07;
*
x08 = (x01 + x04) / 2.0;
y08 = (y01 + y04) / 2.0;
p08 = x08 y08;
n08 = noeu p08;
*
x09 = (x01 + x02 + x03 + x04) / 4.0;
y09 = (y01 + y02 + y03 + y04) / 4.0;
p09 = x09 y09;
n09 = noeu p09;
*
* Q9 element in 2D (meshed as a "qua9")
*
*q9 = manu qua9 p01 p02 p03 p04 p05 p06 p07 p08 p09;
q9 = manu qua9 p01 p05 p02 p06 p03 p07 p04 p08 p09;
*
finproc q9;
```

pxq92q4.proc

```
'DEBPROC' pxq92q4 q9*'MAILLAGE';
*
*-------------------------------------------------
* Transforms a q9 (in 2d !!!) into four q4, one for each
* "quadrant" of the q9
*
* Input :
* -----
*     q9 : a mesh containing just one q9 (in 2d)
* Output :
* ------
*     q4 : mesh containing four q4 (in 2d: meshed as qua4)
*-------------------------------------------------
*
hh = chan poi1 q9;
*
p01 = hh poin 1;
p02 = hh poin 2;
p03 = hh poin 3;
p04 = hh poin 4;
p05 = hh poin 5;
p06 = hh poin 6;
p07 = hh poin 7;
p08 = hh poin 8;
p09 = hh poin 9;
*
q41 = manu qua4 p01 p02 p09 p08;
q42 = manu qua4 p02 p03 p04 p09;
q43 = manu qua4 p09 p04 p05 p06;
q44 = manu qua4 p08 p09 p06 p07;
*
q4 = q41 et q42 et q43 et q44;
*
finproc q4;
```

q92_03.epx

```
Q92_03
ECHO
!CONV WIN
CAST mesh
DPLA
GEOM Q92 sur9 TERM
COMP EPAI 1. LECT sur9 TERM
     NGRO 3
       'noeuds_sym'  LECT elpeau9 TERM COND X GT 14.95
       'noeuds_haut' LECT elpeau9 TERM COND Y GT 16.95
       'noeuds_bas'  LECT elpeau9 TERM COND Y LT  0.05
     COUL VERT LECT sur9 TERM
MATE VM23 RO 0.00825 YOUN 197600.0 NU 0.29 ELAS 222.35
          TRAC 39
            222.35           0.00112525303643725
            228.192645571222 0.00117982108082602
            230.758344471793 0.001217805387003
            234.450726613396 0.00128649153144431
            239.764555869277 0.00141338337990525
            243.897432663364 0.00153429874829638
            247.411863292444 0.00165208432840306
            250.528021456793 0.00176785435959915
            253.359622970924 0.00188218432677593
            258.417356319849 0.00210778014331907
            262.901922592959 0.00233047531676599
            272.525831528572 0.00287917930935512
            280.709612952488 0.00342059520724944
            306.337249091751 0.00555028972212425
            326.269365384357 0.00765116075599371
            358.247494301277 0.0118129933922129
            390.499112131117 0.0169762100816352
            417.924578503771 0.0221150029276507
            464.338948360747 0.0323498934633641
            503.807844043327 0.0425496348382759
            538.803931461142 0.0527267405438317
            570.604298738599 0.0628876735766123
            599.971697212392 0.0730362940142328
            627.405291846074 0.0831751279951724
            653.253096704044 0.0933059367242108
            677.76931865327  0.103430006673347
            734.395540393597 0.128716576621425
            785.850853879881 0.153976978005465
            833.369446403083 0.179217456712566
            877.759003278812 0.204442100219022
            959.251671749752 0.254854512508855
            1033.30271513801 0.305229264752723
            1165.57077256009 0.405898637512956
            1282.84956691385 0.506492153678714
            1389.41887249881 0.607031472026816
            1579.77020835558 0.807994788503824
            1748.55          1.00884893724696
            2418.75489508018 2.0122406624245
            5336.94734929116 10.0270088428608
          LECT sur9 TERM
LINK COUP SPLT NONE
     BLOQ 2 LECT noeuds_bas TERM
     BLOQ 1 LECT noeuds_sym TERM
     DEPLA 2 -1. FONC 1 LECT noeuds_haut TERM
     PINB SELF DMIN 0.1 LECT elpeau9 TERM
FONC 1 TABL 4 0. 0. 0.0001 0. 1.0001 1. 100.0001  100.
ECRI DEPL TFRE 0.1 POIN LECT 4460 TERM
     FICH SPLI ALIC TFRE 0.05
REGI 'HAUT' TOUT POIN LECT noeuds_haut TERM
     'BAS'  TOUT POIN LECT noeuds_bas TERM
OPTI PAS AUTO
     PASM 1.0E-12
     LOG 1
     PINS GRID DGRI EQVF
CALC TINI 0.0 DTMI 1.E-12 DTMA 1.E-04 TFIN 10.0 NMAX 900000000
FIN
```

q92_03a.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'q92_03.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 27 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 25 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

q92_03b.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'q92_03.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 27 FPS 25 KFRE 10 COMP -1
     OBJE LECT sur9 TERM REND
FREQ 1
GOTR LOOP 25 OFFS FICH AVI CONT NOCL
     OBJE LECT sur9 TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT sur9 TERM REND
ENDPLAY
*=====================================================================
FIN
```

q92_03c.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'q92_03.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
         !LINE HEOU SFRE
          FACE HFRO
          PINB CDES
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 27 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 25 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

q92_03d.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'q92_03.ali' GARD PSCR
OPTI PRIN
SORT GRAP
AXTE 1.0 'Time [ms]'
COUR 1 'dy_1226' DEPL COMP 2 NOEU LECT 1226 TERM
COUR 2 'dy' MULC 1 -1.0
COUR 3 'fyh' FLIA COMP 2 ZONE LECT noeuds_haut TERM
COUR 4 'fyb' FLIA COMP 2 ZONE LECT noeuds_bas TERM
TRAC 2 AXES 1.0 'DISPL. [MM]' YZER XGRD YGRD
TRAC 3 4 AXES 1.0 'FORCE [N]'
LIST 3 4 AXES 1.0 'FORCE [N]'
TRAC 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
RCOU 14 'fyb' FICH 'car401d.pun' RENA 'fyb_q4'
RCOU 24 'fyb' FICH 'q93_02d.pun' RENA 'fyb_q9q4'
RCOU 34 'fyb' FICH 'q93_03d.pun' RENA 'fyb_q93'
TRAC 4 14 24 34 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR ROUG VERT TURQ
TRAC 4 14 24 34 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
     XMIN 0 XMAX 2 DX 0.2 YMIN 0 YMAX 800 DY 100
COLO NOIR ROUG VERT TURQ
FIN
```

q93_02.epx

```
Q93_02
ECHO
!CONV WIN
CAST mesh
DPLA
GEOM Q93 sur9 Q41L sur4p TERM
COMP EPAI 1. LECT sur9 sur4p TERM
     NGRO 3
       'noeuds_sym'  LECT sur4p TERM COND X GT 14.95
       'noeuds_haut' LECT sur4p TERM COND Y GT 16.95
```

```
       'noeuds_bas'  LECT sur4p TERM COND Y LT  0.05
     COUL VERT LECT sur9 TERM
          TURQ LECT sur4p TERM
MATE VM23 RO 0.00825 YOUN 197600.0 NU 0.29 ELAS 222.35
          TRAC 39
            222.35           0.00112525303643725
            228.192645571222 0.00117982108082602
            230.758344471793 0.001217805387003
            234.450726613396 0.00128649153144431
            239.764555869277 0.00141338337990525
            243.897432663364 0.00153429874829638
            247.411863292444 0.00165208432840306
            250.528021456793 0.00176785435959915
            253.359622970924 0.00188218432677593
            258.417356319849 0.00210778014331907
            262.901922592959 0.00233047531676599
            272.525831528572 0.00287917930935512
            280.709612952488 0.00342059520724944
            306.337249091751 0.00555028972212425
            326.269365384357 0.00765116075599371
            358.247494301277 0.0118129933922129
            390.499112131117 0.0169762100816352
            417.924578503771 0.0221150029276507
            464.338948360747 0.0323498934633641
            503.807844043327 0.0425496348382759
            538.803931461142 0.0527267405438317
            570.604298738599 0.0628876735766123
            599.971697212392 0.0730362940142328
            627.405291846074 0.0831751279951724
            653.253096704044 0.0933059367242108
            677.76931865327  0.103430006673347
            734.395540393597 0.128716576621425
            785.850853879881 0.153976978005465
            833.369446403083 0.179217456712566
            877.759003278812 0.204442100219022
            959.251671749752 0.254854512508855
            1033.30271513801 0.305229264752723
            1165.57077256009 0.405898637512956
            1282.84956691385 0.506492153678714
            1389.41887249881 0.607031472026816
            1579.77020835558 0.807994788503824
            1748.55          1.00884893724696
            2418.75489508018 2.012240662424 5
            5336.94734929116 10.0270088428608
          LECT sur9 TERM
     FANT 0.0
          LECT sur4p TERM
LINK COUP SPLT NONE
     BLOQ 2 LECT noeuds_bas TERM
     BLOQ 1 LECT noeuds_sym TERM
     DEPLA 2 -1. FONC 1 LECT noeuds_haut TERM
     PINB SELF DMIN 0.1 LECT sur4p TERM
FONC 1 TABL 4 0. 0. 0.0001 0. 1.0001 1. 100.0001  100.
ECRI DEPL TFRE 0.1 POIN LECT 4460 TERM
     FICH SPLI ALIC TFRE 0.05
REGI 'HAUT' TOUT POIN LECT noeuds_haut TERM
     'BAS'  TOUT POIN LECT noeuds_bas TERM
OPTI PAS AUTO
     PASM 1.0E-12
     LOG 1
     PINS GRID DGRI EQVF CNOR
CALC TINI 0.0 DTMI 1.E-12 DTMA 1.E-04 TFIN 10.0 NMAX 900000000
FIN
```

q93_02a.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'q93_02.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 183 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 181 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

q93_02b.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'q93_02.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 183 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 181 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

q93_02c.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'q93_02.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
         !LINE HEOU SFRE
          FACE HFRO
          PINB CDES
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 183 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 181 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

q93_02d.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'q93_02.ali' GARD PSCR
OPTI PRIN
SORT GRAP
AXTE 1.0 'Time [ms]'
COUR 1 'dy_1226' DEPL COMP 2 NOEU LECT 1226 TERM
COUR 2 'dy' MULC 1 -1.0
COUR 3 'fyh' FLIA COMP 2 ZONE LECT noeuds_haut TERM
COUR 4 'fyb' FLIA COMP 2 ZONE LECT noeuds_bas TERM
TRAC 2 AXES 1.0 'DISPL. [MM]' YZER XGRD YGRD
TRAC 3 4 AXES 1.0 'FORCE [N]'
LIST 3 4 AXES 1.0 'FORCE [N]'
TRAC 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
RCOU 14 'fyb' FICH 'car401d.pun' RENA 'fyb_q4'
TRAC 4 14 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR ROUG
FIN
```

q93_03.epx

```
Q93_03
ECHO
!CONV WIN
CAST mesh
DPLA
GEOM Q93 sur9 TERM
COMP EPAI 1. LECT sur9 TERM
     NGRO 3
       'noeuds_sym'  LECT elpeau9 TERM COND X GT 14.95
       'noeuds_haut' LECT elpeau9 TERM COND Y GT 16.95
       'noeuds_bas'  LECT elpeau9 TERM COND Y LT  0.05
     COUL VERT LECT sur9 TERM
MATE VM23 RO 0.00825 YOUN 197600.0 NU 0.29 ELAS 222.35
          TRAC 39
            222.35           0.00112525303643725
            228.192645571222 0.00117982108082602
            230.758344471793 0.001217805387003
            234.450726613396 0.00128649153144431
            239.764555869277 0.00141338337990525
            243.897432663364 0.00153429874829638
            247.411863292444 0.00165208432840306
            250.528021456793 0.00176785435959915
            253.359622970924 0.00188218432677593
            258.417356319849 0.00210778014331907
            262.901922592959 0.00233047531676599
```

```
           272.525831528572 0.00287917930935512
           280.709612952488 0.00342059520724944
           306.337249091751 0.00555028972212425
           326.269365384357 0.00765116075599371
           358.247494301277 0.0118129933922129
           390.499112131117 0.0169762100816352
           417.924578503771 0.0221150029276507
           464.338948360747 0.0323498934633641
           503.807844043327 0.0425496348382759
           538.803931461142 0.0527267405438317
           570.604298738599 0.0628876735766123
           599.971697212392 0.0730362940142328
           627.405291846074 0.0831751279951724
           653.253096704044 0.0933059367242108
           677.76931865327  0.103430006673347
           734.395540393597 0.128716576621425
           785.850853879881 0.153976978005465
           833.369446403083 0.179217456712566
           877.759003278812 0.204442100219022
           959.251671749752 0.254854512508855
           1033.30271513801 0.305229264752723
           1165.57077256009 0.405898637512956
           1282.84956691385 0.506492153678714
           1389.41887249881 0.607031472026816
           1579.77020835558 0.807994788503824
           1748.55          1.00884893724696
           2418.75489508018 2.0122406624245
           5336.94734929116 10.0270088428608
         LECT sur9 TERM
LINK COUP SPLT NONE
     BLOQ 2 LECT noeuds_bas TERM
     BLOQ 1 LECT noeuds_sym TERM
     DEPLA 2 -1. FONC 1 LECT noeuds_haut TERM
     PINB SELF DMIN 0.1 LECT elpeau9 TERM
FONC 1 TABL 4 0. 0. 0.0001 0. 1.0001 1. 100.0001  100.
ECRI DEPL TFRE 0.1 POIN LECT 4460 TERM
     FICH SPLI ALIC TFRE 0.05
REGI 'HAUT' TOUT POIN LECT noeuds_haut TERM
     'BAS'  TOUT POIN LECT noeuds_bas TERM
OPTI PAS AUTO
     PASM 1.0E-12
     LOG 1
     PINS GRID DGRI EQVF
CALC TINI 0.0 DTMI 1.E-12 DTMA 1.E-04 TFIN 10.0 NMAX 900000000
FIN
```

q93_03a.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'q93_03.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

q93_03b.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'q93_03.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
          LINE HEOU SFRE
     ISO FILL FIEL ECRO 3 SCAL USER PROG 0.05 PAS 0.05 0.7 TERM
         SUPP LECT sur9 TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1
     OBJE LECT sur9 TERM REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL
     OBJE LECT sur9 TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT sur9 TERM REND
ENDPLAY
*=====================================================================
FIN
```

q93_03c.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'q93_03.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
         !LINE HEOU SFRE
          FACE HFRO
          PINB CDES
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

q93_03d.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'q93_03.ali' GARD PSCR
OPTI PRIN
SORT GRAP
AXTE 1.0 'Time [ms]'
COUR 1 'dy_1226' DEPL COMP 2 NOEU LECT 1226 TERM
COUR 2 'dy' MULC 1 -1.0
COUR 3 'fyh' FLIA COMP 2 ZONE LECT noeuds_haut TERM
COUR 4 'fyb' FLIA COMP 2 ZONE LECT noeuds_bas TERM
TRAC 2 AXES 1.0 'DISPL. [MM]' YZER XGRD YGRD
TRAC 3 4 AXES 1.0 'FORCE [N]'
LIST 3 4 AXES 1.0 'FORCE [N]'
TRAC 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
RCOU 14 'fyb' FICH 'car401d.pun' RENA 'fyb_q4'
RCOU 24 'fyb' FICH 'q93_02d.pun' RENA 'fyb_q9q4'
TRAC 4 14 24 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR ROUG VERT
COUR 5 'dt' DT1
TRAC 5 AXES 1.0 'DELTAT [S]' YZER XGRD YGRD
LIST 5 AXES 1.0 'DELTAT [S]' YZER XGRD YGRD
FIN
```

q93_03e.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'q93_03.ali' GARD PSCR
OPTI PRIN
SORT GRAP
AXTE 1.0 'Time [ms]'
COUR  1 'ecr1_gp1' ECRO COMP 1 GAUS 1 ELEM LECT 4071 TERM
COUR  2 'ecr1_gp2' ECRO COMP 1 GAUS 2 ELEM LECT 4071 TERM
COUR  3 'ecr1_gp3' ECRO COMP 1 GAUS 3 ELEM LECT 4071 TERM
COUR  4 'ecr1_gp4' ECRO COMP 1 GAUS 4 ELEM LECT 4071 TERM
COUR  5 'ecr1_gp5' ECRO COMP 1 GAUS 5 ELEM LECT 4071 TERM
COUR  6 'ecr1_gp6' ECRO COMP 1 GAUS 6 ELEM LECT 4071 TERM
COUR  7 'ecr1_gp7' ECRO COMP 1 GAUS 7 ELEM LECT 4071 TERM
COUR  8 'ecr1_gp8' ECRO COMP 1 GAUS 8 ELEM LECT 4071 TERM
COUR  9 'ecr1_gp9' ECRO COMP 1 GAUS 9 ELEM LECT 4071 TERM
TRAC  1  2  3  4  5  6  7  8  9 AXES 1.0 'HYDR [PA]' YZER

COUR 21 'ecr2_gp1' ECRO COMP 2 GAUS 1 ELEM LECT 4071 TERM
COUR 22 'ecr2_gp2' ECRO COMP 2 GAUS 2 ELEM LECT 4071 TERM
COUR 23 'ecr2_gp3' ECRO COMP 2 GAUS 3 ELEM LECT 4071 TERM
COUR 24 'ecr2_gp4' ECRO COMP 2 GAUS 4 ELEM LECT 4071 TERM
COUR 25 'ecr2_gp5' ECRO COMP 2 GAUS 5 ELEM LECT 4071 TERM
COUR 26 'ecr2_gp6' ECRO COMP 2 GAUS 6 ELEM LECT 4071 TERM
COUR 27 'ecr2_gp7' ECRO COMP 2 GAUS 7 ELEM LECT 4071 TERM
COUR 28 'ecr2_gp8' ECRO COMP 2 GAUS 8 ELEM LECT 4071 TERM
COUR 29 'ecr2_gp9' ECRO COMP 2 GAUS 9 ELEM LECT 4071 TERM
TRAC 21 22 23 24 25 26 27 28 29 AXES 1.0 'VMIS [PA]' YZER

COUR 31 'ecr3_gp1' ECRO COMP 3 GAUS 1 ELEM LECT 4071 TERM
COUR 32 'ecr3_gp2' ECRO COMP 3 GAUS 2 ELEM LECT 4071 TERM
COUR 33 'ecr3_gp3' ECRO COMP 3 GAUS 3 ELEM LECT 4071 TERM
COUR 34 'ecr3_gp4' ECRO COMP 3 GAUS 4 ELEM LECT 4071 TERM
COUR 35 'ecr3_gp5' ECRO COMP 3 GAUS 5 ELEM LECT 4071 TERM
COUR 36 'ecr3_gp6' ECRO COMP 3 GAUS 6 ELEM LECT 4071 TERM
COUR 37 'ecr3_gp7' ECRO COMP 3 GAUS 7 ELEM LECT 4071 TERM
COUR 38 'ecr3_gp8' ECRO COMP 3 GAUS 8 ELEM LECT 4071 TERM
COUR 39 'ecr3_gp9' ECRO COMP 3 GAUS 9 ELEM LECT 4071 TERM
TRAC 31 32 33 34 35 36 37 38 39 AXES 1.0 'PL.STR. [-]' YZER
```

```
COUR 41 'ecr4_gp1' ECRO COMP 4 GAUS 1 ELEM LECT 4071 TERM
COUR 42 'ecr4_gp2' ECRO COMP 4 GAUS 2 ELEM LECT 4071 TERM
COUR 43 'ecr4_gp3' ECRO COMP 4 GAUS 3 ELEM LECT 4071 TERM
COUR 44 'ecr4_gp4' ECRO COMP 4 GAUS 4 ELEM LECT 4071 TERM
COUR 45 'ecr4_gp5' ECRO COMP 4 GAUS 5 ELEM LECT 4071 TERM
COUR 46 'ecr4_gp6' ECRO COMP 4 GAUS 6 ELEM LECT 4071 TERM
COUR 47 'ecr4_gp7' ECRO COMP 4 GAUS 7 ELEM LECT 4071 TERM
COUR 48 'ecr4_gp8' ECRO COMP 4 GAUS 8 ELEM LECT 4071 TERM
COUR 49 'ecr4_gp9' ECRO COMP 4 GAUS 9 ELEM LECT 4071 TERM
TRAC 41 42 43 44 45 46 47 48 49 AXES 1.0 'EPSX [-]' YZER

COUR 51 'ecr5_gp1' ECRO COMP 5 GAUS 1 ELEM LECT 4071 TERM
COUR 52 'ecr5_gp2' ECRO COMP 5 GAUS 2 ELEM LECT 4071 TERM
COUR 53 'ecr5_gp3' ECRO COMP 5 GAUS 3 ELEM LECT 4071 TERM
COUR 54 'ecr5_gp4' ECRO COMP 5 GAUS 4 ELEM LECT 4071 TERM
COUR 55 'ecr5_gp5' ECRO COMP 5 GAUS 5 ELEM LECT 4071 TERM
COUR 56 'ecr5_gp6' ECRO COMP 5 GAUS 6 ELEM LECT 4071 TERM
COUR 57 'ecr5_gp7' ECRO COMP 5 GAUS 7 ELEM LECT 4071 TERM
COUR 58 'ecr5_gp8' ECRO COMP 5 GAUS 8 ELEM LECT 4071 TERM
COUR 59 'ecr5_gp9' ECRO COMP 5 GAUS 9 ELEM LECT 4071 TERM
TRAC 51 52 53 54 55 56 57 58 59 AXES 1.0 'EPSY [-]' YZER

COUR 61 'ecr6_gp1' ECRO COMP 6 GAUS 1 ELEM LECT 4071 TERM
COUR 62 'ecr6_gp2' ECRO COMP 6 GAUS 2 ELEM LECT 4071 TERM
COUR 63 'ecr6_gp3' ECRO COMP 6 GAUS 3 ELEM LECT 4071 TERM
COUR 64 'ecr6_gp4' ECRO COMP 6 GAUS 4 ELEM LECT 4071 TERM
COUR 65 'ecr6_gp5' ECRO COMP 6 GAUS 5 ELEM LECT 4071 TERM
COUR 66 'ecr6_gp6' ECRO COMP 6 GAUS 6 ELEM LECT 4071 TERM
COUR 67 'ecr6_gp7' ECRO COMP 6 GAUS 7 ELEM LECT 4071 TERM
COUR 68 'ecr6_gp8' ECRO COMP 6 GAUS 8 ELEM LECT 4071 TERM
COUR 69 'ecr6_gp9' ECRO COMP 6 GAUS 9 ELEM LECT 4071 TERM
TRAC 61 62 63 64 65 66 67 68 69 AXES 1.0 'EPSXY [-]' YZER

COUR 71 'ecr7_gp1' ECRO COMP 7 GAUS 1 ELEM LECT 4071 TERM
COUR 72 'ecr7_gp2' ECRO COMP 7 GAUS 2 ELEM LECT 4071 TERM
COUR 73 'ecr7_gp3' ECRO COMP 7 GAUS 3 ELEM LECT 4071 TERM
COUR 74 'ecr7_gp4' ECRO COMP 7 GAUS 4 ELEM LECT 4071 TERM
COUR 75 'ecr7_gp5' ECRO COMP 7 GAUS 5 ELEM LECT 4071 TERM
COUR 76 'ecr7_gp6' ECRO COMP 7 GAUS 6 ELEM LECT 4071 TERM
COUR 77 'ecr7_gp7' ECRO COMP 7 GAUS 7 ELEM LECT 4071 TERM
COUR 78 'ecr7_gp8' ECRO COMP 7 GAUS 8 ELEM LECT 4071 TERM
COUR 79 'ecr7_gp9' ECRO COMP 7 GAUS 9 ELEM LECT 4071 TERM
TRAC 71 72 73 74 75 76 77 78 79 AXES 1.0 'YIELD [PA]' YZER

COUR 81 'ecr8_gp1' ECRO COMP 8 GAUS 1 ELEM LECT 4071 TERM
COUR 82 'ecr8_gp2' ECRO COMP 8 GAUS 2 ELEM LECT 4071 TERM
COUR 83 'ecr8_gp3' ECRO COMP 8 GAUS 3 ELEM LECT 4071 TERM
COUR 84 'ecr8_gp4' ECRO COMP 8 GAUS 4 ELEM LECT 4071 TERM
COUR 85 'ecr8_gp5' ECRO COMP 8 GAUS 5 ELEM LECT 4071 TERM
COUR 86 'ecr8_gp6' ECRO COMP 8 GAUS 6 ELEM LECT 4071 TERM
COUR 87 'ecr8_gp7' ECRO COMP 8 GAUS 7 ELEM LECT 4071 TERM
COUR 88 'ecr8_gp8' ECRO COMP 8 GAUS 8 ELEM LECT 4071 TERM
COUR 89 'ecr8_gp9' ECRO COMP 8 GAUS 9 ELEM LECT 4071 TERM
TRAC 81 82 83 84 85 86 87 88 89 AXES 1.0 'EPSZ [-]' YZER

COUR 111 'con1_gp1' CONT COMP 1 GAUS 1 ELEM LECT 4071 TERM
COUR 112 'con1_gp2' CONT COMP 1 GAUS 2 ELEM LECT 4071 TERM
COUR 113 'con1_gp3' CONT COMP 1 GAUS 3 ELEM LECT 4071 TERM
COUR 114 'con1_gp4' CONT COMP 1 GAUS 4 ELEM LECT 4071 TERM
COUR 115 'con1_gp5' CONT COMP 1 GAUS 5 ELEM LECT 4071 TERM
COUR 116 'con1_gp6' CONT COMP 1 GAUS 6 ELEM LECT 4071 TERM
COUR 117 'con1_gp7' CONT COMP 1 GAUS 7 ELEM LECT 4071 TERM
COUR 118 'con1_gp8' CONT COMP 1 GAUS 8 ELEM LECT 4071 TERM
COUR 119 'con1_gp9' CONT COMP 1 GAUS 9 ELEM LECT 4071 TERM
TRAC 111 112 113 114 115 116 117 118 119 AXES 1.0 'SX [PA]' YZER

COUR 121 'con2_gp1' CONT COMP 2 GAUS 1 ELEM LECT 4071 TERM
COUR 122 'con2_gp2' CONT COMP 2 GAUS 2 ELEM LECT 4071 TERM
COUR 123 'con2_gp3' CONT COMP 2 GAUS 3 ELEM LECT 4071 TERM
COUR 124 'con2_gp4' CONT COMP 2 GAUS 4 ELEM LECT 4071 TERM
COUR 125 'con2_gp5' CONT COMP 2 GAUS 5 ELEM LECT 4071 TERM
COUR 126 'con2_gp6' CONT COMP 2 GAUS 6 ELEM LECT 4071 TERM
COUR 127 'con2_gp7' CONT COMP 2 GAUS 7 ELEM LECT 4071 TERM
COUR 128 'con2_gp8' CONT COMP 2 GAUS 8 ELEM LECT 4071 TERM
COUR 129 'con2_gp9' CONT COMP 2 GAUS 9 ELEM LECT 4071 TERM
TRAC 121 122 123 124 125 126 127 128 129 AXES 1.0 'SY [PA]' YZER

COUR 131 'con3_gp1' CONT COMP 3 GAUS 1 ELEM LECT 4071 TERM
COUR 132 'con3_gp2' CONT COMP 3 GAUS 2 ELEM LECT 4071 TERM
COUR 133 'con3_gp3' CONT COMP 3 GAUS 3 ELEM LECT 4071 TERM
COUR 134 'con3_gp4' CONT COMP 3 GAUS 4 ELEM LECT 4071 TERM
COUR 135 'con3_gp5' CONT COMP 3 GAUS 5 ELEM LECT 4071 TERM
COUR 136 'con3_gp6' CONT COMP 3 GAUS 6 ELEM LECT 4071 TERM
COUR 137 'con3_gp7' CONT COMP 3 GAUS 7 ELEM LECT 4071 TERM
COUR 138 'con3_gp8' CONT COMP 3 GAUS 8 ELEM LECT 4071 TERM
COUR 139 'con3_gp9' CONT COMP 3 GAUS 9 ELEM LECT 4071 TERM
TRAC 131 132 133 134 135 136 137 138 139 AXES 1.0 'SXY [PA]' YZER

COUR 141 'con4_gp1' CONT COMP 4 GAUS 1 ELEM LECT 4071 TERM
COUR 142 'con4_gp2' CONT COMP 4 GAUS 2 ELEM LECT 4071 TERM
COUR 143 'con4_gp3' CONT COMP 4 GAUS 3 ELEM LECT 4071 TERM
COUR 144 'con4_gp4' CONT COMP 4 GAUS 4 ELEM LECT 4071 TERM
COUR 145 'con4_gp5' CONT COMP 4 GAUS 5 ELEM LECT 4071 TERM
COUR 146 'con4_gp6' CONT COMP 4 GAUS 6 ELEM LECT 4071 TERM
COUR 147 'con4_gp7' CONT COMP 4 GAUS 7 ELEM LECT 4071 TERM
COUR 148 'con4_gp8' CONT COMP 4 GAUS 8 ELEM LECT 4071 TERM
COUR 149 'con4_gp9' CONT COMP 4 GAUS 9 ELEM LECT 4071 TERM
TRAC 141 142 143 144 145 146 147 148 149 AXES 1.0 'SZ [PA]' YZER

FIN
```

q95_03.epx

```
Q95_03
ECHO
!CONV WIN
CAST mesh
DPLA
GEOM Q95 sur9 TERM
COMP EPAI 1. LECT sur9 TERM
     NGRO 3
       'noeuds_sym'  LECT elpeau9 TERM COND X GT 14.95
       'noeuds_haut' LECT elpeau9 TERM COND Y GT 16.95
       'noeuds_bas'  LECT elpeau9 TERM COND Y LT  0.05
     COUL VERT LECT sur9 TERM
MATE VM23 RO 0.00825 YOUN 197600.0 NU 0.29 ELAS 222.35
          TRAC 39
            222.35          0.00112525303643725
            228.192645571222 0.00117982108082602
            230.758344471793 0.001217805387003
            234.450726613396 0.00128649153144431
            239.764555869277 0.00141338337990525
            243.897432663364 0.00153429874829638
            247.411863292444 0.00165208432840306
            250.528021456793 0.00176785435959915
            253.359622970924 0.00188218432677593
            258.417356319849 0.00210778014331907
            262.901922592959 0.00233047531676599
            272.525831528572 0.00287917930935512
            280.709612952488 0.00342059520724944
            306.337249091751 0.00555028972212425
            326.269365384357 0.00765116075599371
            358.247494301277 0.0118129933922129
            390.499112131117 0.0169762100816352
            417.924578503771 0.0221150029276507
            464.338948360747 0.0323498934633641
            503.807844043327 0.0425496348382759
            538.803931461142 0.0527267405438317
            570.604298738599 0.0628876735766123
            599.971697212392 0.0730362940142328
            627.405291846074 0.0831751279951724
            653.253096704044 0.0933059367242108
            677.76931865327  0.103430006673347
            734.395540393597 0.128716576621425
            785.850853879881 0.153976978005465
            833.369446403083 0.179217456712566
            877.759003278812 0.204442100219022
            959.251671749752 0.254854512508855
            1033.30271513801 0.305229264752723
            1165.57077256009 0.405898637512956
            1282.84956691385 0.506492153678714
            1389.41887249881 0.607031472026816
            1579.77020835558 0.807994788503824
            1748.55          1.00884893724696
            2418.75489508018 2.0122406624245
            5336.94734929116 10.0270088428608
          LECT sur9 TERM
LINK COUP SPLT NONE
     BLOQ 2 LECT noeuds_bas TERM
     BLOQ 1 LECT noeuds_sym TERM
     DEPLA 2 -1. FONC 1 LECT noeuds_haut TERM
     PINB SELF DMIN 0.1 LECT elpeau9 TERM
FONC 1 TABL 4 0. 0. 0.0001 0. 1.0001 1. 100.0001  100.
ECRI DEPL TFRE 0.1 POIN LECT 4460 TERM
     FICH SPLI ALIC TFRE 0.05
REGI 'HAUT' TOUT POIN LECT noeuds_haut TERM
     'BAS'  TOUT POIN LECT noeuds_bas TERM
OPTI PAS AUTO
     PASM 1.0E-12
     LOG 1
     PINS GRID DGRI EQVF
CALC TINI 0.0 DTMI 1.E-12 DTMA 1.E-04 TFIN 10.0 NMAX 900000000
FIN
```

q95_03a.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'q95_03.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 69 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 67 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

q95_03b.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'q95_03.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
```

```
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
         LINE HEOU SFRE
     ISO FILL FIEL ECRO 3 SCAL USER PROG 0.05 PAS 0.05 0.7 TERM
         SUPP LECT sur9 TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 69 FPS 25 KFRE 10 COMP -1
     OBJE LECT sur9 TERM REND
FREQ 1
GOTR LOOP 67 OFFS FICH AVI CONT NOCL
     OBJE LECT sur9 TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT sur9 TERM REND
ENDPLAY
*=====================================================================
FIN
```

q95_03c.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'q95_03.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
         !LINE HEOU SFRE
          FACE HFRO
          PINB CDES
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 69 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 67 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

q95_03d.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'q95_03.ali' GARD PSCR
OPTI PRIN
SORT GRAP
AXTE 1.0 'Time [ms]'
COUR 1 'dy_1226' DEPL COMP 2 NOEU LECT 1226 TERM
COUR 2 'dy' MULC 1 -1.0
COUR 3 'fyh' FLIA COMP 2 ZONE LECT noeuds_haut TERM
COUR 4 'fyb' FLIA COMP 2 ZONE LECT noeuds_bas TERM
TRAC 2 AXES 1.0 'DISPL. [MM]' YZER XGRD YGRD
TRAC 3 4 AXES 1.0 'FORCE [N]'
LIST 3 4 AXES 1.0 'FORCE [N]'
TRAC 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
RCOU 14 'fyb' FICH 'car401d.pun' RENA 'fyb_q4'
RCOU 24 'fyb' FICH 'q93_02d.pun' RENA 'fyb_q9q4'
RCOU 34 'fyb' FICH 'q93_03d.pun' RENA 'fyb_q93'
RCOU 44 'fyb' FICH 'q92_03d.pun' RENA 'fyb_q92'
TRAC 4 14 24 34 44 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR ROUG VERT TURQ ROSE
TRAC 4 14 24 34 44 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
     XMIN 0 XMAX 4 DX 0.4 YMIN 0 YMAX 900 DY 100
COLO NOIR ROUG VERT TURQ ROSE
FIN
```

q95_03e.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'q95_03.ali' GARD PSCR
OPTI PRIN
SORT GRAP
AXTE 1.0 'Time [ms]'
COUR  1 'ecr1_gp1' ECRO COMP 1 GAUS 1 ELEM LECT 4071 TERM
COUR  2 'ecr1_gp2' ECRO COMP 1 GAUS 2 ELEM LECT 4071 TERM
COUR  3 'ecr1_gp3' ECRO COMP 1 GAUS 3 ELEM LECT 4071 TERM
COUR  4 'ecr1_gp4' ECRO COMP 1 GAUS 4 ELEM LECT 4071 TERM
COUR  5 'ecr1_gp5' ECRO COMP 1 GAUS 5 ELEM LECT 4071 TERM
COUR  6 'ecr1_gp6' ECRO COMP 1 GAUS 6 ELEM LECT 4071 TERM
COUR  7 'ecr1_gp7' ECRO COMP 1 GAUS 7 ELEM LECT 4071 TERM
COUR  8 'ecr1_gp8' ECRO COMP 1 GAUS 8 ELEM LECT 4071 TERM
COUR  9 'ecr1_gp9' ECRO COMP 1 GAUS 9 ELEM LECT 4071 TERM
TRAC  1  2  3  4  5  6  7  8  9 AXES 1.0 'HYDR [PA]' YZER

COUR 21 'ecr2_gp1' ECRO COMP 2 GAUS 1 ELEM LECT 4071 TERM
COUR 22 'ecr2_gp2' ECRO COMP 2 GAUS 2 ELEM LECT 4071 TERM
COUR 23 'ecr2_gp3' ECRO COMP 2 GAUS 3 ELEM LECT 4071 TERM
COUR 24 'ecr2_gp4' ECRO COMP 2 GAUS 4 ELEM LECT 4071 TERM
COUR 25 'ecr2_gp5' ECRO COMP 2 GAUS 5 ELEM LECT 4071 TERM
COUR 26 'ecr2_gp6' ECRO COMP 2 GAUS 6 ELEM LECT 4071 TERM
COUR 27 'ecr2_gp7' ECRO COMP 2 GAUS 7 ELEM LECT 4071 TERM
COUR 28 'ecr2_gp8' ECRO COMP 2 GAUS 8 ELEM LECT 4071 TERM
COUR 29 'ecr2_gp9' ECRO COMP 2 GAUS 9 ELEM LECT 4071 TERM
TRAC 21 22 23 24 25 26 27 28 29 AXES 1.0 'VMIS [PA]' YZER

COUR 31 'ecr3_gp1' ECRO COMP 3 GAUS 1 ELEM LECT 4071 TERM
COUR 32 'ecr3_gp2' ECRO COMP 3 GAUS 2 ELEM LECT 4071 TERM
COUR 33 'ecr3_gp3' ECRO COMP 3 GAUS 3 ELEM LECT 4071 TERM
COUR 34 'ecr3_gp4' ECRO COMP 3 GAUS 4 ELEM LECT 4071 TERM
COUR 35 'ecr3_gp5' ECRO COMP 3 GAUS 5 ELEM LECT 4071 TERM
COUR 36 'ecr3_gp6' ECRO COMP 3 GAUS 6 ELEM LECT 4071 TERM
COUR 37 'ecr3_gp7' ECRO COMP 3 GAUS 7 ELEM LECT 4071 TERM
COUR 38 'ecr3_gp8' ECRO COMP 3 GAUS 8 ELEM LECT 4071 TERM
COUR 39 'ecr3_gp9' ECRO COMP 3 GAUS 9 ELEM LECT 4071 TERM
TRAC 31 32 33 34 35 36 37 38 39 AXES 1.0 'PL.STR. [-]' YZER

COUR 41 'ecr4_gp1' ECRO COMP 4 GAUS 1 ELEM LECT 4071 TERM
COUR 42 'ecr4_gp2' ECRO COMP 4 GAUS 2 ELEM LECT 4071 TERM
COUR 43 'ecr4_gp3' ECRO COMP 4 GAUS 3 ELEM LECT 4071 TERM
COUR 44 'ecr4_gp4' ECRO COMP 4 GAUS 4 ELEM LECT 4071 TERM
COUR 45 'ecr4_gp5' ECRO COMP 4 GAUS 5 ELEM LECT 4071 TERM
COUR 46 'ecr4_gp6' ECRO COMP 4 GAUS 6 ELEM LECT 4071 TERM
COUR 47 'ecr4_gp7' ECRO COMP 4 GAUS 7 ELEM LECT 4071 TERM
COUR 48 'ecr4_gp8' ECRO COMP 4 GAUS 8 ELEM LECT 4071 TERM
COUR 49 'ecr4_gp9' ECRO COMP 4 GAUS 9 ELEM LECT 4071 TERM
TRAC 41 42 43 44 45 46 47 48 49 AXES 1.0 'EPSX [-]' YZER

COUR 51 'ecr5_gp1' ECRO COMP 5 GAUS 1 ELEM LECT 4071 TERM
COUR 52 'ecr5_gp2' ECRO COMP 5 GAUS 2 ELEM LECT 4071 TERM
COUR 53 'ecr5_gp3' ECRO COMP 5 GAUS 3 ELEM LECT 4071 TERM
COUR 54 'ecr5_gp4' ECRO COMP 5 GAUS 4 ELEM LECT 4071 TERM
COUR 55 'ecr5_gp5' ECRO COMP 5 GAUS 5 ELEM LECT 4071 TERM
COUR 56 'ecr5_gp6' ECRO COMP 5 GAUS 6 ELEM LECT 4071 TERM
COUR 57 'ecr5_gp7' ECRO COMP 5 GAUS 7 ELEM LECT 4071 TERM
COUR 58 'ecr5_gp8' ECRO COMP 5 GAUS 8 ELEM LECT 4071 TERM
COUR 59 'ecr5_gp9' ECRO COMP 5 GAUS 9 ELEM LECT 4071 TERM
TRAC 51 52 53 54 55 56 57 58 59 AXES 1.0 'EPSY [-]' YZER

COUR 61 'ecr6_gp1' ECRO COMP 6 GAUS 1 ELEM LECT 4071 TERM
COUR 62 'ecr6_gp2' ECRO COMP 6 GAUS 2 ELEM LECT 4071 TERM
COUR 63 'ecr6_gp3' ECRO COMP 6 GAUS 3 ELEM LECT 4071 TERM
COUR 64 'ecr6_gp4' ECRO COMP 6 GAUS 4 ELEM LECT 4071 TERM
COUR 65 'ecr6_gp5' ECRO COMP 6 GAUS 5 ELEM LECT 4071 TERM
COUR 66 'ecr6_gp6' ECRO COMP 6 GAUS 6 ELEM LECT 4071 TERM
COUR 67 'ecr6_gp7' ECRO COMP 6 GAUS 7 ELEM LECT 4071 TERM
COUR 68 'ecr6_gp8' ECRO COMP 6 GAUS 8 ELEM LECT 4071 TERM
COUR 69 'ecr6_gp9' ECRO COMP 6 GAUS 9 ELEM LECT 4071 TERM
TRAC 61 62 63 64 65 66 67 68 69 AXES 1.0 'EPSXY [-]' YZER

COUR 71 'ecr7_gp1' ECRO COMP 7 GAUS 1 ELEM LECT 4071 TERM
COUR 72 'ecr7_gp2' ECRO COMP 7 GAUS 2 ELEM LECT 4071 TERM
COUR 73 'ecr7_gp3' ECRO COMP 7 GAUS 3 ELEM LECT 4071 TERM
COUR 74 'ecr7_gp4' ECRO COMP 7 GAUS 4 ELEM LECT 4071 TERM
COUR 75 'ecr7_gp5' ECRO COMP 7 GAUS 5 ELEM LECT 4071 TERM
COUR 76 'ecr7_gp6' ECRO COMP 7 GAUS 6 ELEM LECT 4071 TERM
COUR 77 'ecr7_gp7' ECRO COMP 7 GAUS 7 ELEM LECT 4071 TERM
COUR 78 'ecr7_gp8' ECRO COMP 7 GAUS 8 ELEM LECT 4071 TERM
COUR 79 'ecr7_gp9' ECRO COMP 7 GAUS 9 ELEM LECT 4071 TERM
TRAC 71 72 73 74 75 76 77 78 79 AXES 1.0 'YIELD [PA]' YZER

COUR 81 'ecr8_gp1' ECRO COMP 8 GAUS 1 ELEM LECT 4071 TERM
COUR 82 'ecr8_gp2' ECRO COMP 8 GAUS 2 ELEM LECT 4071 TERM
COUR 83 'ecr8_gp3' ECRO COMP 8 GAUS 3 ELEM LECT 4071 TERM
COUR 84 'ecr8_gp4' ECRO COMP 8 GAUS 4 ELEM LECT 4071 TERM
COUR 85 'ecr8_gp5' ECRO COMP 8 GAUS 5 ELEM LECT 4071 TERM
COUR 86 'ecr8_gp6' ECRO COMP 8 GAUS 6 ELEM LECT 4071 TERM
COUR 87 'ecr8_gp7' ECRO COMP 8 GAUS 7 ELEM LECT 4071 TERM
COUR 88 'ecr8_gp8' ECRO COMP 8 GAUS 8 ELEM LECT 4071 TERM
COUR 89 'ecr8_gp9' ECRO COMP 8 GAUS 9 ELEM LECT 4071 TERM
TRAC 81 82 83 84 85 86 87 88 89 AXES 1.0 'EPSZ [-]' YZER

COUR 111 'con1_gp1' CONT COMP 1 GAUS 1 ELEM LECT 4071 TERM
COUR 112 'con1_gp2' CONT COMP 1 GAUS 2 ELEM LECT 4071 TERM
COUR 113 'con1_gp3' CONT COMP 1 GAUS 3 ELEM LECT 4071 TERM
COUR 114 'con1_gp4' CONT COMP 1 GAUS 4 ELEM LECT 4071 TERM
COUR 115 'con1_gp5' CONT COMP 1 GAUS 5 ELEM LECT 4071 TERM
COUR 116 'con1_gp6' CONT COMP 1 GAUS 6 ELEM LECT 4071 TERM
COUR 117 'con1_gp7' CONT COMP 1 GAUS 7 ELEM LECT 4071 TERM
COUR 118 'con1_gp8' CONT COMP 1 GAUS 8 ELEM LECT 4071 TERM
COUR 119 'con1_gp9' CONT COMP 1 GAUS 9 ELEM LECT 4071 TERM
TRAC 111 112 113 114 115 116 117 118 119 AXES 1.0 'SX [PA]' YZER

COUR 121 'con2_gp1' CONT COMP 2 GAUS 1 ELEM LECT 4071 TERM
COUR 122 'con2_gp2' CONT COMP 2 GAUS 2 ELEM LECT 4071 TERM
COUR 123 'con2_gp3' CONT COMP 2 GAUS 3 ELEM LECT 4071 TERM
COUR 124 'con2_gp4' CONT COMP 2 GAUS 4 ELEM LECT 4071 TERM
COUR 125 'con2_gp5' CONT COMP 2 GAUS 5 ELEM LECT 4071 TERM
COUR 126 'con2_gp6' CONT COMP 2 GAUS 6 ELEM LECT 4071 TERM
COUR 127 'con2_gp7' CONT COMP 2 GAUS 7 ELEM LECT 4071 TERM
COUR 128 'con2_gp8' CONT COMP 2 GAUS 8 ELEM LECT 4071 TERM
COUR 129 'con2_gp9' CONT COMP 2 GAUS 9 ELEM LECT 4071 TERM
TRAC 121 122 123 124 125 126 127 128 129 AXES 1.0 'SY [PA]' YZER

COUR 131 'con3_gp1' CONT COMP 3 GAUS 1 ELEM LECT 4071 TERM
COUR 132 'con3_gp2' CONT COMP 3 GAUS 2 ELEM LECT 4071 TERM
COUR 133 'con3_gp3' CONT COMP 3 GAUS 3 ELEM LECT 4071 TERM
COUR 134 'con3_gp4' CONT COMP 3 GAUS 4 ELEM LECT 4071 TERM
COUR 135 'con3_gp5' CONT COMP 3 GAUS 5 ELEM LECT 4071 TERM
COUR 136 'con3_gp6' CONT COMP 3 GAUS 6 ELEM LECT 4071 TERM
COUR 137 'con3_gp7' CONT COMP 3 GAUS 7 ELEM LECT 4071 TERM
COUR 138 'con3_gp8' CONT COMP 3 GAUS 8 ELEM LECT 4071 TERM
COUR 139 'con3_gp9' CONT COMP 3 GAUS 9 ELEM LECT 4071 TERM
TRAC 131 132 133 134 135 136 137 138 139 AXES 1.0 'SXY [PA]' YZER

COUR 141 'con4_gp1' CONT COMP 4 GAUS 1 ELEM LECT 4071 TERM
COUR 142 'con4_gp2' CONT COMP 4 GAUS 2 ELEM LECT 4071 TERM
COUR 143 'con4_gp3' CONT COMP 4 GAUS 3 ELEM LECT 4071 TERM
COUR 144 'con4_gp4' CONT COMP 4 GAUS 4 ELEM LECT 4071 TERM
COUR 145 'con4_gp5' CONT COMP 4 GAUS 5 ELEM LECT 4071 TERM
COUR 146 'con4_gp6' CONT COMP 4 GAUS 6 ELEM LECT 4071 TERM
COUR 147 'con4_gp7' CONT COMP 4 GAUS 7 ELEM LECT 4071 TERM
COUR 148 'con4_gp8' CONT COMP 4 GAUS 8 ELEM LECT 4071 TERM
COUR 149 'con4_gp9' CONT COMP 4 GAUS 9 ELEM LECT 4071 TERM
TRAC 141 142 143 144 145 146 147 148 149 AXES 1.0 'SZ [PA]' YZER

FIN
```

q9m_03.epx

```
Q9M_03
ECHO
!CONV WIN
CAST mesh
DPLA
GEOM Q92 sur92 Q93 sur93 TERM
COMP EPAI 1. LECT sur9 TERM
     NGRO 3
       'noeuds_sym'  LECT elpeau9 TERM COND X GT 14.95
       'noeuds_haut' LECT elpeau9 TERM COND Y GT 16.95
       'noeuds_bas'  LECT elpeau9 TERM COND Y LT  0.05
     COUL VERT LECT sur92 TERM
          ROUG LECT sur93 TERM
MATE VM23 RO 0.00825 YOUN 197600.0 NU 0.29 ELAS 222.35
          TRAC 39
            222.35           0.00112525303643725
            228.192645571222 0.00117982108082602
            230.758344471793 0.001217805387003
            234.450726613396 0.00128649153144431
            239.764555869277 0.00141338337990525
            243.897432663364 0.00153429874829638
            247.411863292444 0.00165208432840306
            250.528021456793 0.00176785435959915
            253.359622970924 0.00188218432677593
            258.417356319849 0.00201778014331907
            262.901922592959 0.00233047531676599
            272.525831528572 0.00287917930935512
            280.709612952488 0.00342059520724944
            306.337249091751 0.00555028972212425
            326.269365384357 0.00765116075599371
            358.247494301277 0.0118129933922129
            390.499112131117 0.0169762100816352
            417.924578503771 0.0221150029276507
            464.338948360747 0.0323498934633641
            503.807844043327 0.0425496348382759
            538.803931461142 0.0527267405438317
            570.604298738599 0.0628876735766123
            599.971697212392 0.0730362940142328
            627.405291846074 0.0831751279951724
            653.253096704044 0.0933059367242108
            677.76931865327  0.103430006673347
            734.395540393597 0.128716576621425
            785.850853879881 0.153976978005465
            833.369446403083 0.179217456712566
            877.759003278812 0.204442100219022
            959.251671749752 0.254854512508855
            1033.30271513801 0.305229264752723
            1165.57077256009 0.405898637512956
            1282.84956691385 0.506492153678714
            1389.41887249881 0.607031472026816
            1579.77020835558 0.807994788503824
            1748.55          1.00884893724696
            2418.75489508018 2.0122406624245
            5336.94734929116 10.0270088428608
          LECT sur9 TERM
LINK COUP SPLT NONE
     BLOQ 2 LECT noeuds_bas TERM
     BLOQ 1 LECT noeuds_sym TERM
     DEPLA 2 -1. FONC 1 LECT noeuds_haut TERM
     PINB SELF DMIN 0.1 LECT elpeau9 TERM
FONC 1 TABL 4 0. 0. 0.0001 0. 1.0001 1. 100.0001  100.
ECRI DEPL TFRE 0.1 POIN LECT 4460 TERM
     FICH SPLI ALIC TFRE 0.05
REGI 'HAUT' TOUT POIN LECT noeuds_haut TERM
     'BAS'  TOUT POIN LECT noeuds_bas TERM
OPTI PAS AUTO
     PASM 1.0E-12
     LOG 1
     PINS GRID DGRI EQVF
CALC TINI 0.0 DTMI 1.E-12 DTMA 1.E-04 TFIN 10.0 NMAX 900000000
FIN
```

q9m_03a.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'q9m_03.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

q9m_03b.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'q9m_03.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
     LINE HEOU SFRE
     ISO FILL FIEL ECRO 3 SCAL USER PROG 0.05 PAS 0.05 0.7 TERM
         SUPP LECT sur9 TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1
     OBJE LECT sur9 TERM REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL
     OBJE LECT sur9 TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT sur9 TERM REND
ENDPLAY
*=====================================================================
FIN
```

q9m_03c.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'q9m_03.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
         !LINE HEOU SFRE
          FACE HFRO
          PINB CDES
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

q9m_03d.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'q9m_03.ali' GARD PSCR
OPTI PRIN
SORT GRAP
AXTE 1.0 'Time [ms]'
COUR 1 'dy_1226' DEPL COMP 2 NOEU LECT 1226 TERM
COUR 2 'dy' MULC 1 -1.0
COUR 3 'fyh' FLIA COMP 2 ZONE LECT noeuds_haut TERM
COUR 4 'fyb' FLIA COMP 2 ZONE LECT noeuds_bas TERM
TRAC 2 AXES 1.0 'DISPL. [MM]' YZER XGRD YGRD
TRAC 3 4 AXES 1.0 'FORCE [N]'
LIST 3 4 AXES 1.0 'FORCE [N]'
TRAC 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
RCOU 14 'fyb' FICH 'car401d.pun' RENA 'fyb_q4'
RCOU 24 'fyb' FICH 'q93_02d.pun' RENA 'fyb_q9q4'
RCOU 34 'fyb' FICH 'q93_03d.pun' RENA 'fyb_q93'
TRAC 4 14 24 34 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR ROUG VERT TURQ
TRAC 4 14 24 34 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
     XMIN 0 XMAX 2 DX 0.2 YMIN 0 YMAX 800 DY 100
COLO NOIR ROUG VERT TURQ
COUR 5 'dt' DT1
TRAC 5 AXES 1.0 'DELTAT [S]' YZER XGRD YGRD
LIST 5 AXES 1.0 'DELTAT [S]' YZER XGRD YGRD
RCOU 35 'dt' FICH 'q93_03d.pun' RENA 'dt_q93'
TRAC 5 35 AXES 1.0 'DELTAT [S]' YZER XGRD YGRD
COLO ROUG NOIR
FIN
```

q9m_04.epx

```
Q9M_03
ECHO
!CONV WIN
```

```
CAST mesh
DPLA
GEOM Q92 sur92 Q93 sur93 TERM
COMP EPAI 1. LECT sur9 TERM
     NGRO 3
       'noeuds_sym'  LECT elpeau9 TERM COND X GT 14.95
       'noeuds_haut' LECT elpeau9 TERM COND Y GT 16.95
       'noeuds_bas'  LECT elpeau9 TERM COND Y LT  0.05
     COUL VERT LECT sur92 TERM
          ROUG LECT sur93 TERM
MATE VM23 RO 0.00825 YOUN 197600.0 NU 0.29 ELAS 222.35
          TRAC 39
            222.35           0.00112525303643725
            228.192645571222 0.00117982108082602
            230.758344471793 0.001217805387003
            234.450726613396 0.00128649153144431
            239.764555869277 0.00141338337990525
            243.897432663364 0.00153429874829638
            247.411863292444 0.00165208432840306
            250.528021456793 0.00176785435959915
            253.359622970924 0.00188218432677593
            258.417356319849 0.00201778014331907
            262.901922592959 0.00233047531676599
            272.525831528572 0.00287917930935512
            280.709612952488 0.00342059520724944
            306.337249091751 0.00555028972212425
            326.269365384357 0.00765116075599371
            358.247494301277 0.0118129933922129
            390.499112131117 0.0169762100816352
            417.924578503771 0.0221150029276507
            464.338948360747 0.0323498934633641
            503.807844043327 0.0425496348382759
            538.803931461142 0.0527267405438317
            570.604298738599 0.0628876735766123
            599.971697212392 0.0730362940142328
            627.405291846074 0.0831751279951724
            653.253096704044 0.0933059367242108
            677.76931865327  0.103430006673347
            734.395540393597 0.128716576621425
            785.850853879881 0.153976978005465
            833.369446403083 0.179217456712566
            877.759003278812 0.204442100219022
            959.251671749752 0.254854512508855
            1033.30271513801 0.305229264752723
            1165.57077256009 0.405898637152956
            1282.84956691385 0.506492153678714
            1389.41887249881 0.607031472026816
            1579.77020835558 0.807994788503824
            1748.55          1.00884893724696
            2418.75489508018 2.012240662424 5
            5336.94734929116 10.0270088428608
          LECT sur9 TERM
LINK COUP SPLT NONE
     BLOQ 2 LECT noeuds_bas TERM
     BLOQ 1 LECT noeuds_sym TERM
     DEPLA 2 -1. FONC 1 LECT noeuds_haut TERM
     PINB SELF DMIN 0.1 LECT elpeau9 TERM
FONC 1 TABL 4 0. 0. 0.0001 0. 1.0001 1. 100.0001  100.
ECRI DEPL TFRE 0.1 POIN LECT 4460 TERM
     FICH SPLI ALIC TFRE 0.05
REGI 'HAUT' TOUT POIN LECT noeuds_haut TERM
     'BAS'  TOUT POIN LECT noeuds_bas TERM
OPTI PART PLIN
     PASM 1.0E-12
     LOG 1
     PINS GRID DGRI EQVF
CALC TINI 0.0 DTMI 1.E-12 DTMA 1.E-04 TFIN 10.0 NMAX 900000000
FIN
```

q9m_04a.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'q9m_04.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 46 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 44 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

q9m_04b.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'q9m_04.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
         LINE HEOU SFRE
     ISO FILL FIEL ECRO 3 SCAL USER PROG 0.05 PAS 0.05 0.7 TERM
         SUPP LECT sur9 TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 46 FPS 25 KFRE 10 COMP -1
     OBJE LECT sur9 TERM REND
FREQ 1
GOTR LOOP 44 OFFS FICH AVI CONT NOCL
     OBJE LECT sur9 TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT sur9 TERM REND
ENDPLAY
*=====================================================================
FIN
```

q9m_04c.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'q9m_04.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
         !LINE HEOU SFRE
          FACE HFRO
          PINB CDES
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 46 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 44 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

q9m_04d.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'q9m_04.ali' GARD PSCR
OPTI PRIN
SORT GRAP
AXTE 1.0 'Time [ms]'
COUR 1 'dy_1226' DEPL COMP 2 NOEU LECT 1226 TERM
COUR 2 'dy' MULC 1 -1.0
COUR 3 'fyh' FLIA COMP 2 ZONE LECT noeuds_haut TERM
COUR 4 'fyb' FLIA COMP 2 ZONE LECT noeuds_bas TERM
TRAC 2 AXES 1.0 'DISPL. [MM]' YZER XGRD YGRD
TRAC 3 4 AXES 1.0 'FORCE [N]'
LIST 3 4 AXES 1.0 'FORCE [N]'
TRAC 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
RCOU 14 'fyb' FICH 'car401d.pun' RENA 'fyb_q4'
RCOU 24 'fyb' FICH 'q93_02d.pun' RENA 'fyb_q9q4'
RCOU 34 'fyb' FICH 'q93_03d.pun' RENA 'fyb_q93'
TRAC 4 14 24 34 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR ROUG VERT TURQ
TRAC 4 14 24 34 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
     XMIN 0 XMAX 2 DX 0.2 YMIN 0 YMAX 800 DY 100
COLO NOIR ROUG VERT TURQ
COUR 5 'dt' DT1
TRAC 5 AXES 1.0 'DELTAT [S]' YZER XGRD YGRD
LIST 5 AXES 1.0 'DELTAT [S]' YZER XGRD YGRD
RCOU 35 'dt' FICH 'q93_03d.pun' RENA 'dt_q93'
RCOU 45 'dt' FICH 'q9m_03d.pun' RENA 'dt_q9m_03'
TRAC 5 35 45 AXES 1.0 'DELTAT [S]' YZER XGRD YGRD
COLO ROUG NOIR VERT
FIN
```

q9m_05.epx

```
Q9M_05
ECHO
!CONV WIN
CAST mesh
DPLA
GEOM Q92 sur92 Q93 sur93 TERM
COMP EPAI 1. LECT sur9 TERM
     NGRO 3
```

```
       'noeuds_sym'  LECT elpeau9 TERM COND X GT 14.95
       'noeuds_haut' LECT elpeau9 TERM COND Y GT 16.95
       'noeuds_bas'  LECT elpeau9 TERM COND Y LT  0.05
     COUL VERT LECT sur92 TERM
          ROUG LECT sur93 TERM
MATE VM23 RO 0.00825 YOUN 197600.0 NU 0.29 ELAS 222.35
          TRAC 39
            222.35           0.00112525303643725
            228.192645571222 0.00117982108082602
            230.758344471793 0.001217805387003
            234.450726613396 0.00128649153144431
            239.764555869277 0.00141338337990525
            243.897432663364 0.00153429874829638
            247.411863292444 0.00165208432840306
            250.528021456793 0.00176785435959915
            253.359622970924 0.00188218432677593
            258.417356319849 0.00210778014331907
            262.901922592959 0.00233047531676599
            272.525831528572 0.00287917930935512
            280.709612952488 0.00342059520724944
            306.337249091751 0.00555028972212425
            326.269365384357 0.00765116075599371
            358.247494301277 0.0118129933922129
            390.499112131117 0.0169762100816352
            417.924578503771 0.0221150029276507
            464.338948360747 0.0323498934633641
            503.807844043327 0.0425496348382759
            538.803931461142 0.0527267405438317
            570.604298738599 0.0628876735766123
            599.971697212392 0.0730362940142328
            627.405291846074 0.0831751279951724
            653.253096704044 0.0933059367242108
            677.76931865327  0.103430006673347
            734.395540393597 0.128716576621425
            785.850853879881 0.153976978005465
            833.369446403083 0.179217456712566
            877.759003278812 0.204442100219022
            959.251671749752 0.254854512508855
            1033.30271513801 0.305229264752723
            1165.57077256009 0.405898637512956
            1282.84956691385 0.506492153678714
            1389.41887249881 0.607031472026816
            1579.77020835558 0.807994788503824
            1748.55          1.00884893724696
            2418.75489508018 2.0122406624245
            5336.94734929116 10.0270088428608
          LECT sur9 TERM
LINK COUP SPLT NONE
     BLOQ 2 LECT noeuds_bas TERM
     BLOQ 1 LECT noeuds_sym TERM
     DEPLA 2 -1. FONC 1 LECT noeuds_haut TERM
     PINB SELF DMIN 0.1 LECT elpeau9 TERM
FONC 1 TABL 4 0. 0. 0.0001 0. 1.0001 1. 100.0001  100.
ECRI DEPL TFRE 0.1 POIN LECT 4460 TERM
     FICH SPLI ALIC TFRE 0.05
REGI 'HAUT' TOUT POIN LECT noeuds_haut TERM
     'BAS'  TOUT POIN LECT noeuds_bas TERM
OPTI PART PLIN
     CSTA 0.5
     LOG 1
     PINS GRID DGRI EQVF
CALC TINI 0.0 DTMI 1.E-12 DTMA 1.E-04 TFIN 10.0 NMAX 900000000
FIN
```

q9m_05a.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'q9m_05.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 120 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 118 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

q9m_05b.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'q9m_05.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
     COLO PAPE
SLER CAM1 1 NFRA 1
     LINE HEOU SFRE
ISO FILL FIEL ECRO 3 SCAL USER PROG 0.05 PAS 0.05 0.7 TERM
    SUPP LECT sur9 TERM
TEXT ISCA
COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 120 FPS 25 KFRE 10 COMP -1
     OBJE LECT sur9 TERM REND
FREQ 1
GOTR LOOP 118 OFFS FICH AVI CONT NOCL
     OBJE LECT sur9 TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT sur9 TERM REND
ENDPLAY
*=====================================================================
FIN
```

q9m_05c.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'q9m_05.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE   5.56399E+00  8.50620E+00  4.84072E+01
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  5.56399E+00  8.50620E+00  0.00000E+00
!RSPHERE:  1.27387E+01
!RADIUS :  4.84072E+01
!ASPECT :  1.00000E+00
!NEAR   :  3.56685E+01
!FAR    :  7.38847E+01
SCEN GEOM NAVI FREE
        !LINE HEOU SFRE
         FACE HFRO
         PINB CDES
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 120 FPS 25 KFRE 10 COMP -1 REND
FREQ 1
GOTR LOOP 118 OFFS FICH AVI CONT NOCL REND
GO
TRAC OFFS FICH AVI CONT REND
ENDPLAY
*=====================================================================
FIN
```

q9m_05d.epx

```
Post treatment (visualization from alice file)
ECHO
RESU SPLI ALIC 'q9m_05.ali' GARD PSCR
OPTI PRIN
SORT GRAP
AXTE 1.0 'Time [ms]'
COUR 1 'dy_1226' DEPL COMP 2 NOEU LECT 1226 TERM
COUR 2 'dy' MULC 1 -1.0
COUR 3 'fyh' FLIA COMP 2 ZONE LECT noeuds_haut TERM
COUR 4 'fyb' FLIA COMP 2 ZONE LECT noeuds_bas TERM
TRAC 2 AXES 1.0 'DISPL. [MM]' YZER XGRD YGRD
TRAC 3 4 AXES 1.0 'FORCE [N]'
LIST 3 4 AXES 1.0 'FORCE [N]'
TRAC 4 AXES 1.0 'FORCE [N]' XAXE 2 1.0 'DISPL. [MM]' YZER XGRD YGRD
RCOU 14 'fyb' FICH 'car401d.pun' RENA 'fyb_q4'
RCOU 24 'fyb' FICH 'q93_02d.pun' RENA 'fyb_q9q4'
RCOU 34 'fyb' FICH 'q93_03d.pun' RENA 'fyb_q93'
TRAC 4 14 24 34 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
COLO NOIR ROUG VERT TURQ
TRAC 4 14 24 34 AXES 1.0 'FORCE [N]' YZER XGRD YGRD
     XMIN 0 XMAX 2 DX 0.2 YMIN 0 YMAX 800 DY 100
COLO NOIR ROUG VERT TURQ
COUR 5 'dt' DT1
TRAC 5 AXES 1.0 'DELTAT [S]' YZER XGRD YGRD
LIST 5 AXES 1.0 'DELTAT [S]' YZER XGRD YGRD
RCOU 35 'dt' FICH 'q93_03d.pun' RENA 'dt_q93'
RCOU 45 'dt' FICH 'q9m_03d.pun' RENA 'dt_q9m_03'
RCOU 55 'dt' FICH 'q9m_04d.pun' RENA 'dt_q9m_04'
TRAC 5 35 45 55 AXES 1.0 'DELTAT [S]' YZER XGRD YGRD
COLO ROUG NOIR VERT TURQ
FIN
```

readq4.dgibi

```
opti echo 1;
opti dime 2 elem qua4;
opti trac psc ftra 'readq4_mesh.ps';
opti sauv form 'mesh_q4.msh';
sur4 = read 'mesh4.write' mesh elem;
trac qual sur4;
tol = 0.0001;

nodlag = cont sur4;
elepin = sur4 elem appu larg nodlag;
elim tol (sur4 et nodlag);
trac qual nodlag;
```

```
trac qual elepin;

mesh = sur4;

tass mesh;
sauv form mesh;
fin;
```

readq4a.dgibi

```
opti echo 1;
opti donn 'pxq42q92.proc';
opti donn 'pxq92q4.proc';
opti dime 2 elem qua4;
opti trac psc ftra 'readq4_mesh.ps';
opti sauv form 'mesh_q9q4.msh';
sur4 = read 'mesh4.write' mesh elem;
trac qual sur4;

i = 0;
repe loop1 (nbel sur4);
  i = i + 1;
  q4i = sur4 elem i;
  q9i = pxq42q92 q4i;
  si (ega i 1);
    sur9 = q9i;
  sinon;
    sur9 = sur9 et q9i;
  finsi;
fin loop1;

tol = 0.001;

elim tol (sur4 et sur9);
trac qual sur9;

peau9 = cont sur9;
trac qual peau9;

elpeau9 = sur9 elem appu larg peau9;
trac qual elpeau9;

i = 0;
repe loop2 (nbel elpeau9);
  i = i + 1;
  q9i = elpeau9 elem i;
  q44i = pxq92q4 q9i;
  si (ega i 1);
    sur4p = q44i;
  sinon;
    sur4p = sur4p et q44i;
  finsi;
fin loop2;

trac qual sur4p;

mesh = sur9 et sur4p;
elim tol mesh;

trac qual mesh;

tass mesh;
sauv form mesh;
fin;
```

readq4q9mixed.dgibi

```
opti echo 1;
opti donn 'pxq42q92.proc';
opti dime 2 elem qua4;
opti trac psc ftra 'readq4_mesh.ps';
opti sauv form 'mesh_q9mixed.msh';
sur4 = read 'mesh4.write' mesh elem;
trac qual sur4;

i = 0;
repe loop1 (nbel sur4);
  i = i + 1;
  q4i = sur4 elem i;
  q9i = pxq42q92 q4i;
  si (ega i 1);
    sur9 = q9i;
  sinon;
    sur9 = sur9 et q9i;
  finsi;
fin loop1;

tol = 0.001;

elim tol (sur4 et sur9);

trac qual sur9;

peau9 = cont sur9;
trac qual peau9;

elpeau9 = sur9 elem appu larg peau9;
trac qual elpeau9;

i = 0;
n = 0;
j = 0;
repe loop3 (nbel sur9);
  i = i + 1;
  j = j + 1;
  si (ega j 5);
    q9i = sur9 elem i;
    n = n + 1;
    si (ega n 1);
      sur93 = q9i;
    sinon;
      sur93 = sur93 et q9i;
    finsi;
    j = 0;
  finsi;
fin loop3;
sur92 = diff sur9 sur93;

mesh = sur9;
elim tol mesh;

trac qual mesh;
trac qual sur93;
trac qual sur92;

tass mesh;
sauv form mesh;
fin;
```

self01.epx

```
SELF01
ECHO
 CONV WIN
CAST mesh
LAGR DPLA
GEOM Q42L mesh TERM
COMP EPAI 1. LECT mesh TERM
     NGRO 3
       'noeuds_sym'  LECT mesh TERM COND X LT 0.1
       'noeuds_haut' LECT mesh TERM COND Y GT 11.9
       'noeuds_bas'  LECT mesh TERM COND Y LT 0.1
     COUL VERT LECT mesh TERM
MATE VM23 RO 0.00825 YOUN 197600.0 NU 0.29 ELAS 222.35
          TRAC 39
            222.35           0.00112525303643725
            228.192645571222 0.00117982108082602
            230.758344471793 0.001217805387003
            234.450726613396 0.00128649153144431
            239.764555869277 0.00141338337990525
            243.897432663364 0.00153429874829638
            247.411863292444 0.00165208432840306
            250.528021456793 0.00176785435959915
            253.359622970924 0.00188218432677593
            258.417356319849 0.00210778014331907
            262.901922592959 0.00233047531676599
            272.525831528572 0.00287917930935512
            280.709612952488 0.00342059520724944
            306.337249091751 0.00555028972212425
            326.269365384357 0.00765116075599371
            358.247494301277 0.0118129933922129
            390.499112131117 0.0169762100816352
            417.924578503771 0.0221150029276507
            464.338948360747 0.0323498934633641
            503.807844043327 0.0425496348382759
            538.803931461142 0.0527267405438317
            570.604298738599 0.0628876735766123
            599.971697212392 0.0730362940142328
            627.405291846074 0.0831751279951724
            653.253096704044 0.0933059367242108
            677.76931865327  0.103430006673347
            734.395540393597 0.128716576621425
            785.850853879881 0.153976978005465
            833.369446403083 0.179217456712566
            877.759003278812 0.204442100219022
            959.251671749752 0.254854512508855
            1033.30271513801 0.305229264752723
            1165.57077256009 0.405898637512956
            1282.84956691385 0.506492153678714
            1389.41887249881 0.607031472026816
            1579.77020835558 0.807994788503824
            1748.55          1.00884893724696
            2418.75489508018 2.0122406624245
            5336.94734929116 10.0270088428608
          LECT mesh TERM
LINK COUP SPLT NONE
     BLOQ 2 LECT noeuds_bas TERM
     BLOQ 1 LECT noeuds_sym TERM
     VITE 2 -1.0 FONC 1 LECT noeuds_haut TERM
     PINB BODY MLEV 2 LECT plaq1 TERM
          SELF MLEV 2 LECT ring TERM
          BODY MLEV 2 LECT plaq2 TERM
FONC 1 TABL 2 0 100 100 100
INIT VITE 2 -100 LECT noeuds_haut TERM
ECRI DEPL TFRE 0.1 POIN LECT 1 TERM
     FICH ALIC FREQ 1
OPTI PAS AUTO
     LOG 1
     PINS GRID DGRI EQVF
CALC TINI 0.0 TFIN 80.E-3
FIN
```

test03.wxm

```
/* [wxMaxima batch file version 1] [ DO NOT EDIT BY HAND! ]*/
/* [ Created with wxMaxima version 13.04.2 ] */

/* [wxMaxima: input   start ] */
L1x : (1/2)*x*(x-1);
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
L2x : (1+x)*(1-x);
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
L3x : (1/2)*x*(x+1);
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
L1y : (1/2)*y*(y-1);
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
L2y : (1+y)*(1-y);
/* [wxMaxima: input   end   ] */
```

```
/* [wxMaxima: input   start ] */
L3y : (1/2)*y*(y+1);
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
L1z : (1/2)*z*(z-1);
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
L2z : (1+z)*(1-z);
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
L3z : (1/2)*z*(z+1);
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
N1 : L1x*L1y*L1z;
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
N2 : L3x*L1y*L1z;
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
N3 : L3x*L3y*L1z;
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
N4 : L1x*L3y*L1z;
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
N5 : L1x*L1y*L3z;
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
N6 : L3x*L1y*L3z;
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
N7 : L3x*L3y*L3z;
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
N8 : L1x*L3y*L3z;
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
N9 : L2x*L2y*L1z;
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
N10 : L2x*L1y*L2z;
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
N11 : L3x*L2y*L2z;
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
N12 : L2x*L3y*L2z;
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
N13 : L1x*L2y*L2z;
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
N14 : L2x*L2y*L3z;
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
N15 : L2x*L1y*L1z;
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
N16 : L3x*L2y*L1z;
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
N17 : L2x*L3y*L1z;
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
N18 : L1x*L2y*L1z;
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
N19 : L1x*L1y*L2z;
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
N20 : L3x*L1y*L2z;
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
N21 : L3x*L3y*L2z;
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
N22 : L1x*L3y*L2z;
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
N23 : L2x*L1y*L3z;
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
N24 : L3x*L2y*L3z;
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
N25 : L2x*L3y*L3z;
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
N26 : L1x*L2y*L3z;
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
N27 : L2x*L2y*L2z;
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
Sx : N1*a1+N2*a2+N3*a3+N4*a4+N5*a5+N6*a6+N7*a7+N8*a8+N9*a9+
N10*a10+N11*a11+N12*a12+N13*a13+N14*a14+N15*a15+N16*a16+N17*a17+N18*a18+
N19*a19+N20*a20+N21*a21+N22*a22+N23*a23+N24*a24+N25*a25+N26*a26+N27*a27;
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
Sy : N1*b1+N2*b2+N3*b3+N4*b4+N5*b5+N6*b6+N7*b7+N8*b8+N9*b9+
N10*b10+N11*b11+N12*b12+N13*b13+N14*b14+N15*b15+N16*b16+N17*b17+N18*b18+
N19*b19+N20*b20+N21*b21+N22*b22+N23*b23+N24*b24+N25*b25+N26*b26+N27*b27;
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
Sz : N1*c1+N2*c2+N3*c3+N4*c4+N5*c5+N6*c6+N7*c7+N8*c8+N9*c9+
N10*c10+N11*c11+N12*c12+N13*c13+N14*c14+N15*c15+N16*c16+N17*c17+N18*c18+
N19*c19+N20*c20+N21*c21+N22*c22+N23*c23+N24*c24+N25*c25+N26*c26+N27*c27;
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
Sx8 : 8*Sx;
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
Sy8 : 8*Sy;
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
Sz8 : 8*Sz;
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
expand(Sx8);
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
expand(Sy8);
/* [wxMaxima: input   end   ] */

/* [wxMaxima: input   start ] */
expand(Sz8);
/* [wxMaxima: input   end   ] */

/* Maxima can't load/batch files which end with a comment! */
"Created with wxMaxima"$
```

List of input files

European Commission
EUR 26629 – Joint Research Centre – Institute for the Protection and Security of the Citizen

Title: Pinball-based Contact-Impact Model with Parabolic Elements in EUROPLEXUS

Author(s): Folco Casadei, Martin Larcher, Georgios Valsamos, Bertrand Langrand

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Abstract

Contact-impact algorithms are an important component of numerical simulation software in fast transient dynamics. Traditionally, contact algorithms have been based on so-called sliding lines and sliding surfaces. However, sliding-based algorithms may present some difficulties in detecting contact in complex geometrical situations, especially in 3D. The pinball contact-impact method as an alternative formulation has been implemented in EUROPLEXUS, initially based upon a strong Lagrange-multiplier based solution strategy of the contact constraints.
Recently, at Onera Lille (F) some crash calculations involving many contacts were attempted, initially with linear-displacement continuum elements (CAR4 in 2D). However, to improve accuracy and to help mitigate spurious locking phenomena, it was desired to perform the same calculations with parabolic elements, namely by the 9-node Lagrange element Q93.
The present work considers two different approaches to modeling contact with parabolic elements. The first approach uses a phantom mesh of linear-displacement elements, used only for contact detection, and superposed to the structural mesh made of parabolic elements. Such a technique is fully general and could be useful also in other special contact situations, not only with parabolic elements. The second approach is based on a (new) 'native' pinball formulation for the parabolic elements, which has now been developed and implemented in EUROPLEXUS.

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