CAELinux and finite element analysis.
Tutorial 2, measurements on a deformed shape

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Contents

Abstract

The goal of this tutorial is to teach how to measure a part's displacements under loads. Two methods are illustrated:

- The direct measurement in the SALOME post-pro module
- The data's extraction as a table directly from Code-Aster.

1 Introduction

While this may be regarded as slightly unrelated to our main goal (being able to quickly master the SALOME + CODE-ASTER package), this was important to me since i just had to do so at my workplace. To be more specific, i had to investigate the shape a soft piece should initially have in order to have the desired shape under a given load. Needless to say, shapes and materials used in this tutorial have nothing to do with the products i'm working on. To get quicker to the point, the current tutorial is based on the work already done in the first tutorial:

`CAELinux et l'analyse par éléments finis. Exercice 1, cube percé`

I will use the perforated cube, but this time, there will be slight differences during the construction process. Regarding the tutorial, we will measure the perforation's displacement and go in details into the nodes' displacements at the intersection between the cylindrical bore and the squared face.

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2 Creation of the perforated cube

2.1 Creation of the cube

This time, we will follow a quicker pace than the first time. Launch SALOME, Geometry module, menu File / New. Construct the cube with the New Entity menu, Primitives, Box. Choose the 3D dimensions input option (click on the right in the dialog box) then enter the dimensions 2, 2, 2 and validate with OK. Zoom on the cube, display it as you feel like, by now you should know what to do. We just constructed a cube and one of its corner is just at the system's origin.

2.2 Creation of the cylinder

As for the cube, we will use the option Primitives in the New Entity menu. But this time, we will use the Cylinder. We aim to center the cylinder on the face.We could create the cube at the origin simply by giving the dimensions like we did before and translate it afterwards. However, i prefer to define the cylinder at the accurate location straight, the cylinder being centered on the Z=0 face. To do so, create the point (1,1,0) corresponding to the center of the face and the vector (0,0,1) perpendicular to the face. Once done, go back to the cylinder's creation, you shouldn't have any difficulties ending the job.

2.3 Create the perforated cube, create the circle of nodes

The "perforation" part is a classic by now (menu Operation / Boolean / Cut), see the previous tutorial if needed. At this point, the perforated cube has been created. We need to successively:

- Explode the volume into faces, create the fixed boundary face and the loaded face.
- Create a circle to follow its displacement.

Exploding the faces shouldn't be a major source of headaches (menu New Entity / Explode / Face [select the part to explode] then OK. Check out the face in the Z=0 plane. In this tutorial, it is Face_5 but, if you followed another method to create the perforated cube, the faces' numbers may be different. Explode then the face into edges and locate the wire corresponding to the circle. Edge_1 in my case. Now, you should have a display close to the figure 1 Personnaly, i took the habit of naming the faces and edges after meaningful designations. So, Face_2 is base, Face_4 pression and Edge_1 cercle. That's it. The Geometry is completed, we will now mesh.

3 Mesh

3.1 Mesh and creation of mesh groups and nodes

Regarding the mesh generation, you can eventually go back to the Tutorial 1. The current mesh will be generated with these values:

- Average Length 0.2 so 1/10th of the edge. The mesh is rather coarse but it doesn't overload your computer and is fine enough for this tutorial.
- Max. Element Volume 1.

It is easy to create the groups of mesh corresponding to the faces base and pression. I then name those groups Base and Pression, with an upper case to distinguish them from the solid's faces. Creating the group Cercle on which are located the nodes we are interested into is similar. However, one has to click on the case Node instead of Face in the dialog box named Elements type. For more details, go to 2. So, you created the mesh, you can now export it.

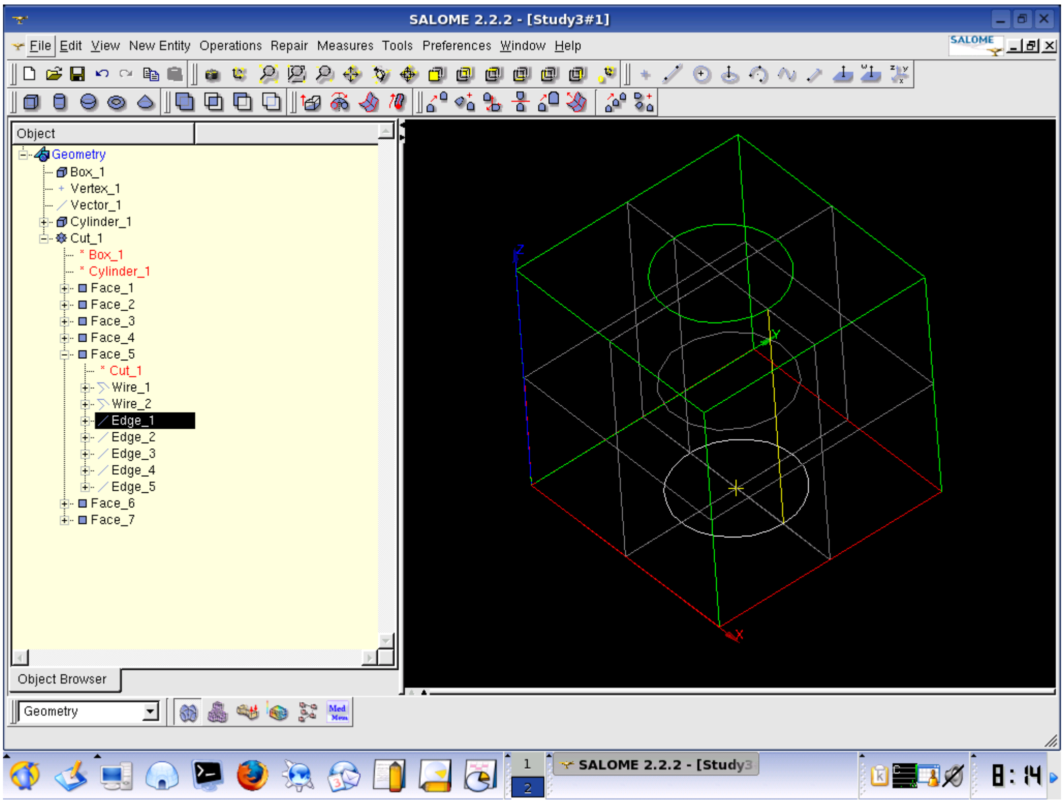


Figure 1: The circle in the background of the perforated cube

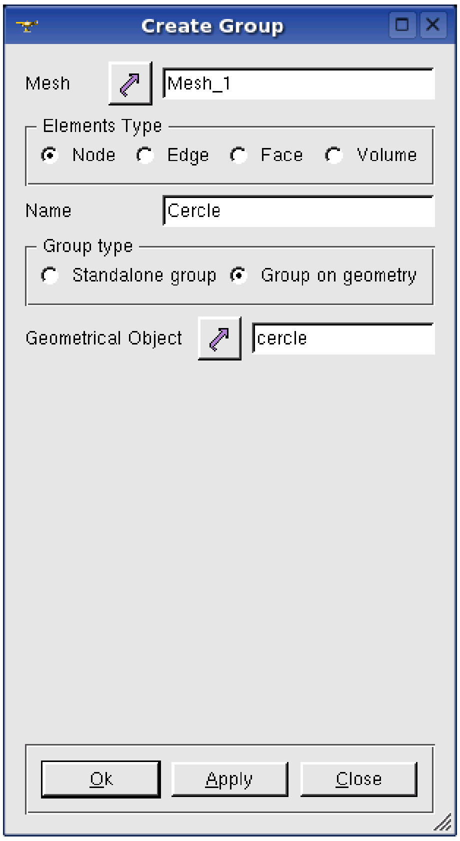


Figure 2: Dialog box Creation of the circle of nodes

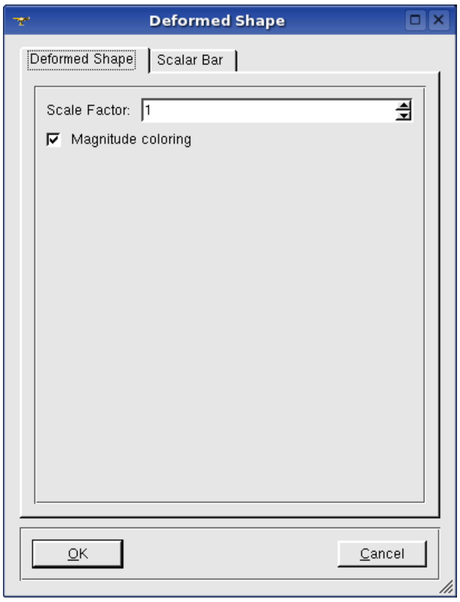


Figure 3: Setting up the scale factor of the deformed shape

3.2 Code-Aster analysis and going back to the Salome's post-pro module

To create a new analysis, nothing's new out there: launch ASTK then EFICAS and edit the file *.comm for Code-Aster. I fixed the face Base (DDL_IMPO DX=0, DY=0, DZ=0) then applied an uniformed 1e6 Pascal pressure load (PRES_REP) on the face Pression. A quick RUN and then we can go back to SALOME, this time in the Post-pro module.
Import the Code-Aster result then display the deformed part (SolutionDEPL / 0,INCONNUE / Deformed Shape). Take care! We are about to measure directly the position of the nodes. It is now mandatory to set the scale factor to 1. See figure **??**. If you choose another scale factor, you can increase/decrease the size of the displacement and change the measurements. Select Def.Shape:1 in the left menu and right-click on the view of the perforated cube. Choose the option Selection Info to display the corresponding dialog box. You should have a display similar to 4. One just needs to click on a node to display the dialog box "Data on elements", so the numerical values associated with the given node:

- Scalar Value gives the value of the displacement (norm of the displacement vector).
- Vector Values is the projection of the displacement vector in the coordinates' system.
- Coordinates gives the node's coordinates.

Note that the coordinates are those of the node in its current displaced position and not its original position. This will be meaningful later when we will get the table corresponding to all the nodes of the circle: the X, Y, Z coordinates will be the original ones!

4 Modify the *.comm file in order to create the displacements table

Up to now, we didn't used the concept of nodes group and we didn't use the group "Cercle". As a matter of fact, we just reproduce the steps of the previous tutorial, only adding the direct measurement on choosed nodes in the post-pro module of SALOME. Now, it's time to get our hand dirty and digg the *.comm file so Code-Aster generates the corresponding table. So:

- Go back to EFICAS
- Thanks to the "Nouvelle commande" tab (on the right), add a new line IMPR_RESU, leaving the previous IMPR_RESU line untouched.

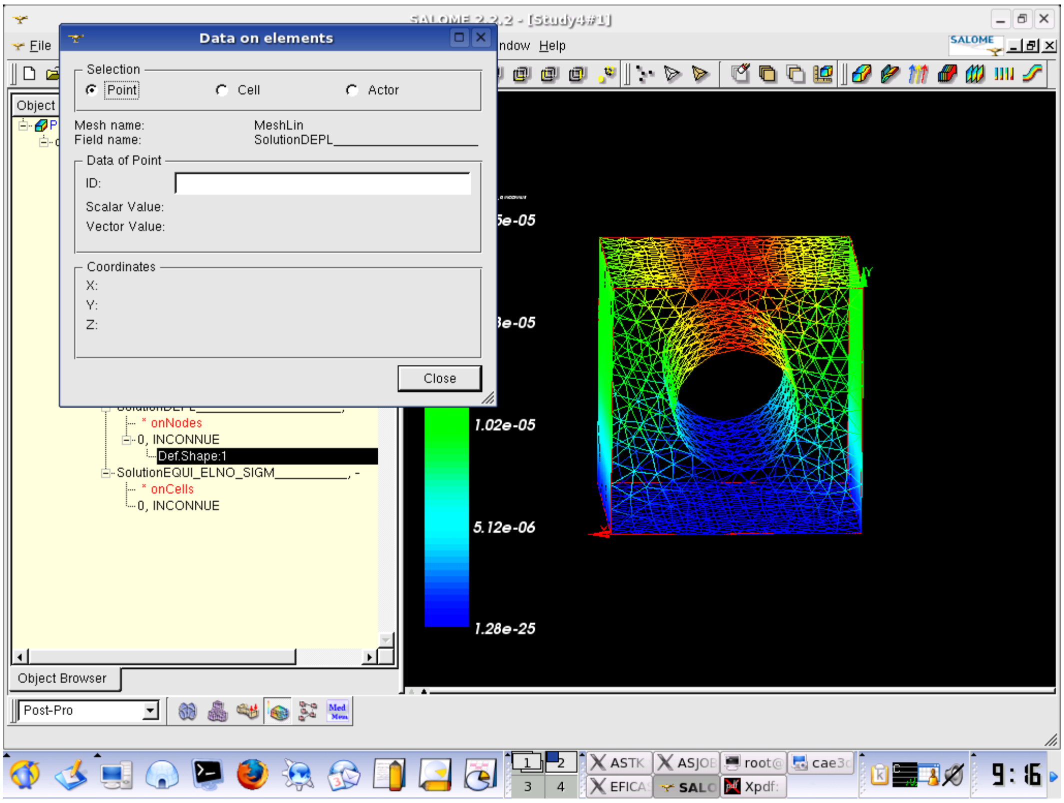


Figure 4: Measurement screen and node displacement

Do as shown in figure 5. The script corresponding to this set-up is the following:

- Adjust the values MODELE and FORMAT, the value for format, which should be MED, (in the standard IMPR_RESU) has to be set to RESULTAT.
- In RESU, enter MAILLAGE.
- Create a new entry "RESULTAT". This is will add more options. Set-up RESULTAT to the default value.
- In the field b-extrac, add NOM_CHAM and select DEPL from the list.
- In b_comp, add NOM_CMP and enter successively "DX" then "DY" and finally "DZ" in the list of values.
- In b_topologie, add GROUP_NO and enter "Cercle" so CODE-ASTER will only calculate the displacements of the selected nodes.
- We will end by adding IMPR_COOR to b_valeurs by setting it to oui.

One just needs to launch a new analysis with Code-Aster so the solver generates a results table. To have access to those results, you only need to open the file with the extension *.resu in the sub-folder corresponding to the study. The table, as seen in figure 6 is located at the very end of the file, just before the table giving the cpu usage. There are many ways to read this file, either use a text editor like Vi or (Vim), or use commands like tail and head with the flux redirection commands to display the content of the file and copy the selected part in a new file. The screen 6 was obtained with the following command:

```
tail -n 45 cube_perce.resu | head -n 27
```

Just » jml.txt at the end like this:

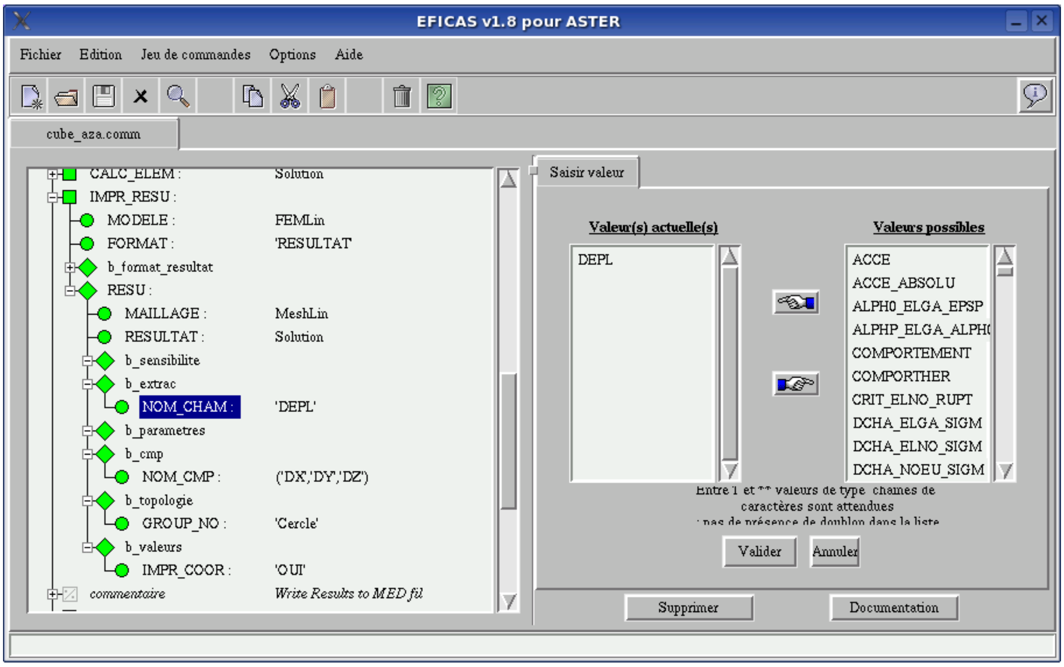


Figure 5: IMPR_RESU crafted to generate a table

```
tail -n 45 cube_perce.resu | head -n 27   >> jml.txt
```

and we got a nifty text file with all our numerical files!
TAKE CARE when interpreting the results ! I alredy pointed out previously: here the table refers to both coordinates and displacements projections. The displacements are then the original coordinates, before any deformation occurs, as opposed to SALOME in which we measured the coordinates after deformation.

5 Analysis, results's validity

5.1 Units

Before, i only mentionned that the pressure was 1e6 Pascal (N/m2). This means all our dimensions' units are meters. So we've got in this tutorial a 2m by 2m steel cube with a bore at 500mm. In the industrial world, dimensions are usually millimeters, so the solids you will eventually import within SALOME would have been generated using the mm as the default unit. Following this, you can

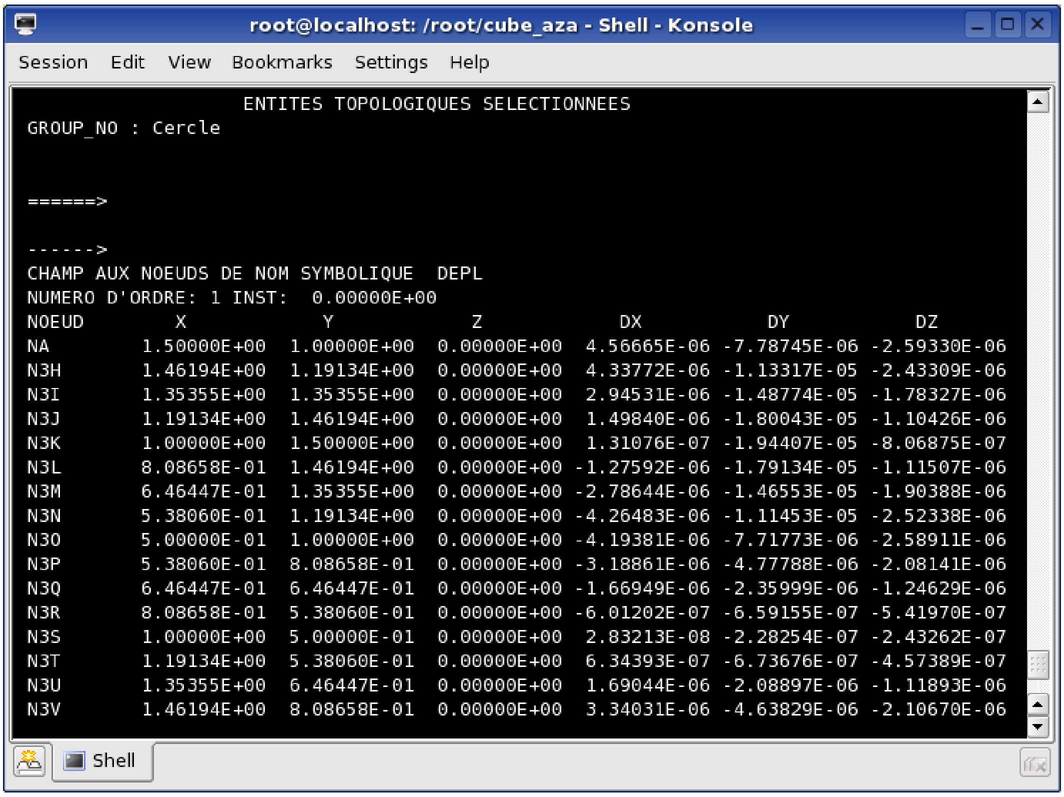
- either transform the volumes by applying a scale factor. But be aware that mm is usually a good unit.
- or express all the others parameters in a unit system linked to the mm, for instance the pressure in N/mm2.

5.2 Check the results

I would like to enforce the rigourous check of caracteristic points, easy to identify, like X=1, Y=0.5 for instance, to see if the two methods give you the same results. In addition, the calculation takes into account an elastic behavior for the steel. As a result, twice the load should generates...twice the deformation. Try this with the two methods to check if you got everything right.

5.3 Results accuracy

As always, when you just got a result, you should ask yourself if this one is accurate. Get a close look at the deformed shape under the pressure load, on the face Y=2 named PRESSION, we've got




```
                    ENTITES TOPOLOGIQUES SELECTIONNEES
GROUP_NO : Cercle


======>

------>
CHAMP AUX NOEUDS DE NOM SYMBOLIQUE  DEPL
NUMERO D'ORDRE: 1 INST:  0.00000E+00
NOEUD        X            Y            Z            DX           DY           DZ
NA         1.50000E+00  1.00000E+00  0.00000E+00  4.56665E-06 -7.78745E-06 -2.59330E-06
N3H        1.46194E+00  1.19134E+00  0.00000E+00  4.33772E-06 -1.13317E-05 -2.43309E-06
N3I        1.35355E+00  1.35355E+00  0.00000E+00  2.94531E-06 -1.48774E-05 -1.78327E-06
N3J        1.19134E+00  1.46194E+00  0.00000E+00  1.49840E-06 -1.80043E-05 -1.10426E-06
N3K        1.00000E+00  1.50000E+00  0.00000E+00  1.31076E-07 -1.94407E-05 -8.06875E-07
N3L        8.08658E-01  1.46194E+00  0.00000E+00 -1.27592E-06 -1.79134E-05 -1.11507E-06
N3M        6.46447E-01  1.35355E+00  0.00000E+00 -2.78644E-06 -1.46553E-05 -1.90388E-06
N3N        5.38060E-01  1.19134E+00  0.00000E+00 -4.26483E-06 -1.11453E-05 -2.52338E-06
N3O        5.00000E-01  1.00000E+00  0.00000E+00 -4.19381E-06 -7.71773E-06 -2.58911E-06
N3P        5.38060E-01  8.08658E-01  0.00000E+00 -3.18861E-06 -4.77788E-06 -2.08141E-06
N3Q        6.46447E-01  6.46447E-01  0.00000E+00 -1.66949E-06 -2.35999E-06 -1.24629E-06
N3R        8.08658E-01  5.38060E-01  0.00000E+00 -6.01202E-07 -6.59155E-07 -5.41970E-07
N3S        1.00000E+00  5.00000E-01  0.00000E+00  2.83213E-08 -2.28254E-07 -2.43262E-07
N3T        1.19134E+00  5.38060E-01  0.00000E+00  6.34393E-07 -6.73676E-07 -4.57389E-07
N3U        1.35355E+00  6.46447E-01  0.00000E+00  1.69044E-06 -2.08897E-06 -1.11893E-06
N3V        1.46194E+00  8.08658E-01  0.00000E+00  3.34031E-06 -4.63829E-06 -2.10670E-06
```

Figure 6: Table at the end of xxxx.resu

displacement on the circle in the X and Y direction (something we would have expected) but also in the Z direction. This displacement in the Z direction is due to the POISSON coefficient of the material. As a consequence, if you want to quantify the displacement on the face, you get an accurate value whereas if you want to have this displacement in the current section (which is common for this kind of long product) then you should really ask yourself if your result is good or not. If you only want to analyze a section of a "long" product, you should probably fix the two perforated faces so you don't have displacements in the Z direction.

6 Conclusion, author, translation

This tutorial is the second one of a serie of others in which i write down my various experiences with CAELinux.
Author's right: the present document is GPLed. If extracts are used in some articles or documents, please acknowledge the author of the initial document.
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