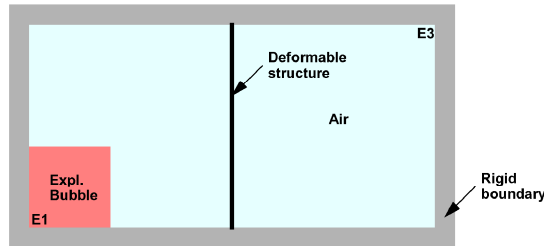


Exercise/Example 12c – Failure with CCFV

- Solve a FSI problem with failure and fragmentation by the CCFV fluid model (conforming meshes)



- Compare solutions without and with structural failure of the internal deformable wall

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PROBLEM:

An explosion takes place in a box. The external box walls are rigid. An internal deformable wall divides the box in two zones. The fluid domain is modelled by Cell-Centered Finite Volumes (CCFV) and a conforming F-S mesh is used.

The purpose is to show that in case of failure of the deformable wall the fluid flow across the failing wall can be modelled by the CCFV, thanks to the fact that fluid velocities are discretized at the cell centres, and not at nodes

Numerical Solutions

VFAL02

This is the solution without structural failure. The mesh generation file is:

```

opti echo 1;
opti titr 'VFAL02';
opti sauv form 'vfal02.msh';
opti trac pec ftra 'vfal02_msh.ps';
*
opti dime 2 elem qua4;
*
p1 = 0 0;
p2 = 2 0;
p3 = 2 1;
p4 = 0 1;
p5 = 0.4 0;
p6 = 0.4 0.4;
p7 = 0 0.4;
p8 = 0.4 1;
*
tol = 0.001;
*
c1 = p1 d 4 p5;
c2 = p5 d 4 p6;
c3 = p6 d 4 p7;
c4 = p7 d 4 p1;
expl = dall c1 c2 c3 c4 plan;
*
c1 = p5 d 16 p2;
c2 = p2 d 10 p3;
c3 = p3 d 16 p8;
c4 = p8 d 6 p6 d 4 p5;
air1 = dall c1 c2 c3 c4 plan;
*
c1 = p7 d 4 p6;
c2 = p6 d 6 p8;
c3 = p8 d 4 p4;

c4 = p4 d 6 p7;
air2 = dall c1 c2 c3 c4 plan;
*
air = air1 et air2;
flui = expl et air;
elim tol flui;
*
e1 = expl elem cont p1;
e3 = air1 elem cont p3;
*
p9 = 1 0;
p10 = 1 1;
p11 = 1 0.5;
p12 = 1 0.3;
p13 = 1 0.7;
stru1 = p9 d 3 p12;
stru2 = p13 d 3 p10;
stru3 = p12 d 2 p11 d 2 p13;
stru = stru1 et stru2 et stru3;
elim tol (flui et stru);
*
contfl = cont flui;
*
mesh = flui et stru et e1 et e3;
*
sauv form mesh;
trac qual mesh;
*
list (nb1 mesh);
list (nbno mesh);
*
fin;

```

The EUROPLEXUS input file reads:

```
VFAL02
ECHO
!conv win
CAST mesh
DELA ALE
DIME
NALE 1 NBLE 162
TERM
GEBM Q4VF flui ED01 stru TERM
COMP EPAI 0.02 LECT stru1 stru2 TERM
0.002 LECT stru3 TERM
COUL roug LECT expl TERM
tunq LECT air TERM
GRIL LAGR LECT stru TERM
EULE LECT contf1 DIFF p9 p10 TERM
AUTO AUTR
MATE GAZP RO 13. GAMMA 1.4 CV 720. PINI 1.E6 PREF 1.E5
LECT expl TERM
GAZP RO 1.3 GAMMA 1.4 CV 720. PINI 1.E5 PREF 1.E5
LECT air TERM
VM23 RO 7800. XONG 1.6E11 NU 0.333 ELAS 1.05E8
TRAC 2 1.05E8 .656256E-3 1.6105E10 1.00066
LECT stru TERM
LINK COUP
BLOQ 12 LECT p9 p10 TERM
ECRI DEPL VITE ACCE FINT FEXT CONT ECRO VFCC FREQ 100
POIN LECT p1 p5 p6 p7 p3 p11 TERM
ELEM LECT e1 e3 TERM
FICH ALIC FREQ 2
FICH ALIC TEMP FREQ 1
POIN LECT p1 p5 p6 p7 p3 p11 SUIT 133 TERM
ELEM LECT e1 e3 TERM
OPTI NOTE LOG 1
CSTA 0.5
VFCC FC0N 1 : rusanov
CALC TINI 0.0 PAS1 1.E-5 NMAX 400 TFIN 1.0
*=====
PLAY
CAME 1 EYE 1.00000E+00 5.00000E-01 5.03115E+00
!
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
sler cam1 1 nfra 1
scen geom navi free
face hfro
vect scco fiel vcvi scal user prog 10 pas 10 140 term
SUPP LECT air TERM
text vscs
colo pape
freq 200
go
trac offs fich bmp rend
go
trac offs fich bmp rend
ENDPLAY
*=====
SUIT
Post treatment
ECHO
conv win
RESU ALIC GARD PSRCR
OPTI PRIN
SORT VISU NSTO 1
*=====
PLAY
CAME 1 EYE 1.00000E+00 5.00000E-01 5.03115E+00
!
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
sler cam1 1 nfra 1
scen geom navi free
iso filli fiel vcvi scal user prog 0.61E5 pas 0.2E5 3.21E5 term
SUPP LECT air TERM
text isca
vect scco fiel vcvi scal user prog 10 pas 10 140 term
SUPP LECT air TERM
colo pape
trac offs fich avi nocl nfto 201 fps 10 kfrc 10 comp -1 rend
freq 1
gotr loop 199 offs fich avi cont nocl rend
go
trac offs fich avi cont rend
ENDPLAY
*=====
SUIT
Post treatment
ECHO
conv win
RESU ALIC GARD PSRCR
OPTI PRIN
SORT VISU NSTO 1
*=====
PLAY
CAME 1 EYE 1.00000E+00 5.00000E-01 5.03115E+00
!
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
sler cam1 1 nfra 1
scen geom navi free
iso filli fiel vcvi scal user prog 10 pas 10 140 term
SUPP LECT air TERM
text isca
vect scco fiel vcvi scal user prog 10 pas 10 140 term
SUPP LECT air TERM
colo pape
trac offs fich avi nocl nfto 201 fps 10 kfrc 10 comp -1 rend
freq 1
gotr loop 199 offs fich avi cont nocl rend
go
trac offs fich avi cont rend
ENDPLAY
*=====
SUIT
Post-treatment (time curves from alice temps file)
ECHO
*
RESU ALIC TEMP GARD PSRCR
*
SORT GRAP
*
AXTE 1.0 'Time [s]'
*
COUR 1 'vcvi_e1' VCVI NORM ELEM LECT e1 TERM
COUR 2 'vcvi_e3' VCVI NORM ELEM LECT e3 TERM
COUR 3 'p_e1' ECRO COMP 1 ELEM LECT e1 TERM
COUR 4 'p_e3' ECRO COMP 1 ELEM LECT e3 TERM
COUR 5 'd_11' DEPL COMP 1 NOEU LECT p11 TERM
COUR 6 'd_133' DEPL COMP 1 NOEU LECT 133 TERM
*
trac 1 2 axes 1.0 'VELOC. [M/S]'
trac 3 4 axes 1.0 'PRESS [PA]'
trac 5 axes 1.0 'DISPL [M]'
trac 6 axes 1.0 'DISPL [M]'
LIST 1 2 axes 1.0 'VELOC. [M/S]'
LIST 3 4 axes 1.0 'PRESS [PA]'
LIST 5 axes 1.0 'DISPL [M]'
LIST 6 axes 1.0 'DISPL [M]'
*
!
J'ai l'impression que la qualification de VCVI ne marche pas ...
!QUAL VCVI COMP 1 LECT e1 TERM REFE 0.00000E+0 TOLE 5.E-3
! VCVI COMP 2 LECT e3 TERM REFE 0.00000E+0 TOLE 5.E-3
!qual ECRO COMP 1 LECT e1 TERM REFE 2.20448E+5 TOLE 5.E-3
! ECRO COMP 1 LECT e3 TERM REFE 1.55348E+5 TOLE 5.E-3
*=====
FIN
```

VFAL03

This is identical to the previous test but the deformable wall may undergo failure. Failing elements are eroded. The Cast3m mesh generation file is identical to the previous case. The EUROPLEXUS input file reads:

```
VFAL03
ECHO
!conv win
CAST mesh
DELA ALE EROS 0.0
DIME
NALE 1 NBLE 162
TERM
GEBM Q4VF flui ED01 stru TERM
opti dump
COMP EPAI 0.02 LECT stru1 stru2 TERM
0.002 LECT stru3 TERM
COUL roug LECT expl TERM
tunq LECT air TERM
GRIL LAGR LECT stru TERM
EULE LECT contf1 DIFF p9 p10 TERM
AUTO AUTR
MATE GAZP RO 13. GAMMA 1.4 CV 720. PINI 1.E6 PREF 1.E5
LECT expl TERM
GAZP RO 1.3 GAMMA 1.4 CV 720. PINI 1.E5 PREF 1.E5
LECT air TERM
VM23 RO 7800. XONG 1.6E11 NU 0.333 ELAS 1.05E8
FAIL PEPS LIM1 0.002
TRAC 2 1.05E8 .656256E-3 1.6105E10 1.00066
LECT stru TERM
LINK COUP
BLOQ 12 LECT p9 p10 TERM
ECRI DEPL VITE ACCE FINT FEXT CONT ECRO VFCC FAIL FREQ 100
POIN LECT p1 p5 p6 p7 p3 p11 TERM
ELEM LECT e1 e3 TERM
FICH ALIC FREQ 2
FICH ALIC TEMP FREQ 1
POIN LECT p1 p5 p6 p7 p3 p11 SUIT 133 TERM
ELEM LECT e1 e3 TERM
OPTI NOTE LOG 1
CSTA 0.5
VFCC dump FC0N 1 : rusanov
CALC TINI 0.0 PAS1 1.E-5 NMAX 400 TFIN 1.0
!fin
*=====
PLAY
CAME 1 EYE 1.00000E+00 5.00000E-01 5.03115E+00
!
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
sler cam1 1 nfra 1
scen geom navi free
face hfro
vect scco fiel vcvi scal user prog 10 pas 10 140 term
SUPP LECT air TERM
text vscs
colo pape
freq 200
go
trac offs fich bmp obje nfai lect tous term rend
go
trac offs fich bmp obje nfai lect tous term rend
ENDPLAY
*=====
SUIT
Post treatment
ECHO
conv win
RESU ALIC GARD PSRCR
OPTI PRIN
SORT VISU NSTO 1
*=====
PLAY
CAME 1 EYE 1.00000E+00 5.00000E-01 5.03115E+00
!
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
sler cam1 1 nfra 1
scen geom navi free
iso filli fiel ecro 1 scal user prog 0.61E5 pas 0.2E5 3.21E5 term
SUPP LECT air TERM
text isca
vect scco fiel vcvi scal user prog 10 pas 10 140 term
SUPP LECT air TERM
colo pape
trac offs fich avi nocl nfto 201 fps 10 kfrc 10 comp -1
obje nfai lect tous term rend
freq 1
gotr loop 199 offs fich avi cont nocl obje nfai lect tous term rend
go
trac offs fich avi cont obje nfai lect tous term rend
ENDPLAY
*=====
SUIT
Post treatment
ECHO
conv win
RESU ALIC GARD PSRCR
OPTI PRIN
SORT VISU NSTO 1
```

```

*****
PLAY
CAME 1 EYE 1.00000E+00 5.00000E-01 5.03115E+00
!
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
sler cam1 1 nfra 1
scen geom navi free
iso fill fiel vcvi scal user prog 10 pas 10 140 term
SUPP LECT air TERM
text isca
vect scoo fiel vcvi scal user prog 10 pas 10 140 term
SUPP LECT air TERM
text vsca
colo pape
trac offs fich avi noel nfto 201 fps 10 kfre 10 comp -1
obje nfai lect tous term rend
freq 1
gotr loop 199 offs fich avi cont noel
obje nfai lect tous term rend
go
trac offs fich avi cont
obje nfai lect tous term rend
ENDPLAY
*****
SUIT
Post-treatment (time curves from alice temps file)
ECHO
*
RESU ALIC TEMP PSCR
*

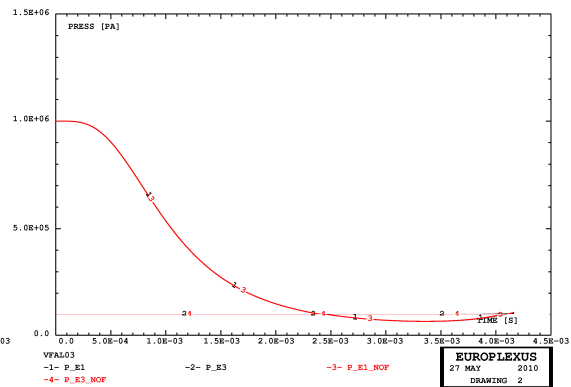
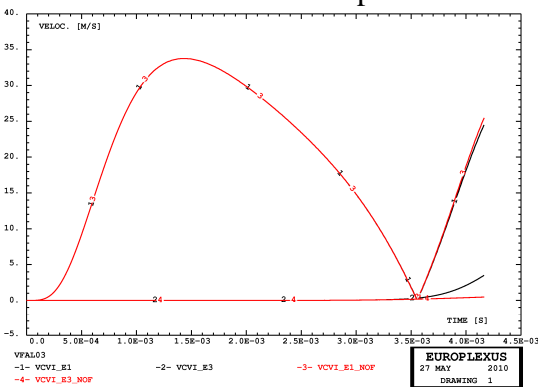
```

```

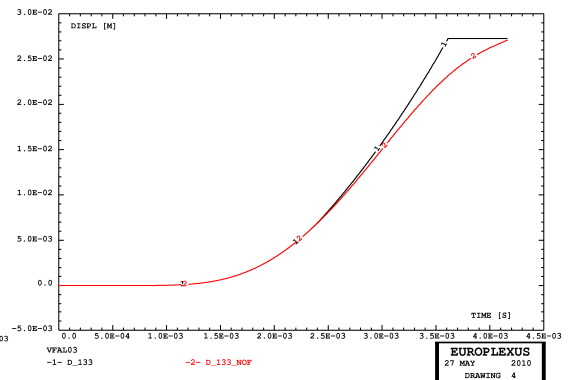
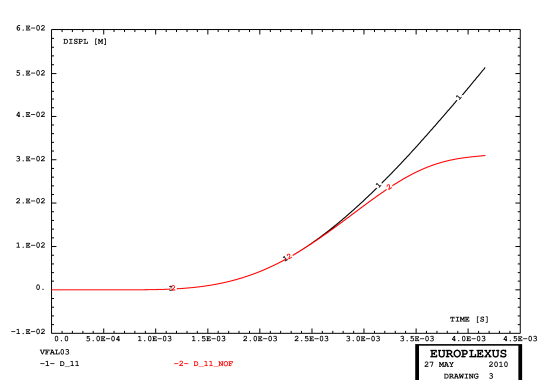
SORT GRAP
*
AXTE 1.0 'Time [s]'
*
COUR 1 'vcvi_e1' VCVI NORM ELEM LECT e1 TERM
COUR 2 'vcvi_e3' VCVI NORM ELEM LECT e3 TERM
COUR 3 'p_e1' ECRU COMP 1 ELEM LECT e1 TERM
COUR 4 'p_e3' ECRU COMP 1 ELEM LECT e3 TERM
COUR 5 'd_11' DEPL COMP 1 NOEU LECT p11 TERM
COUR 6 'd_133' DEPL COMP 1 NOEU LECT 133 TERM
RCOU 11 'vcvi_e1' FICH 'vfa102.pun' RENA 'vcvi_e1_nof'
RCOU 12 'vcvi_e3' FICH 'vfa102.pun' RENA 'vcvi_e3_nof'
RCOU 13 'p_e1' FICH 'vfa102.pun' RENA 'p_e1_nof'
RCOU 14 'p_e3' FICH 'vfa102.pun' RENA 'p_e3_nof'
RCOU 15 'd_11' FICH 'vfa102.pun' RENA 'd_11_nof'
RCOU 16 'd_133' FICH 'vfa102.pun' RENA 'd_133_nof'
*
trac 1 2 11 12 axes 1.0 'VELOC. [M/S]'
COLO noir noir roug roug
trac 3 4 13 14 axes 1.0 'PRESS [PA]'
COLO noir noir roug roug
trac 5 15 axes 1.0 'DISPL [M]'
COLO noir roug
trac 6 16 axes 1.0 'DISPL [M]'
COLO noir roug
*
! J'ai l'impression que la qualification de VCVI ne marche pas ...
!QUAL VCVI COMP 1 LECT e1 TERM REFE 0.00000E+0 TOL 5.E-3
! VCVI COMP 2 LECT e3 TERM REFE 0.00000E+0 TOL 5.E-3
!QUAL ECRU COMP 1 LECT e1 TERM REFE 2.20444E+5 TOL 5.E-3
! ECRU COMP 1 LECT e3 TERM REFE 1.55348E+5 TOL 5.E-3
*****
FIN

```

Here are some results: in red the solution without failure, in black the solution with failure. Fluid velocities and pressures:



Displacement of central point of the structure and displacement of the initially attached fluid node:

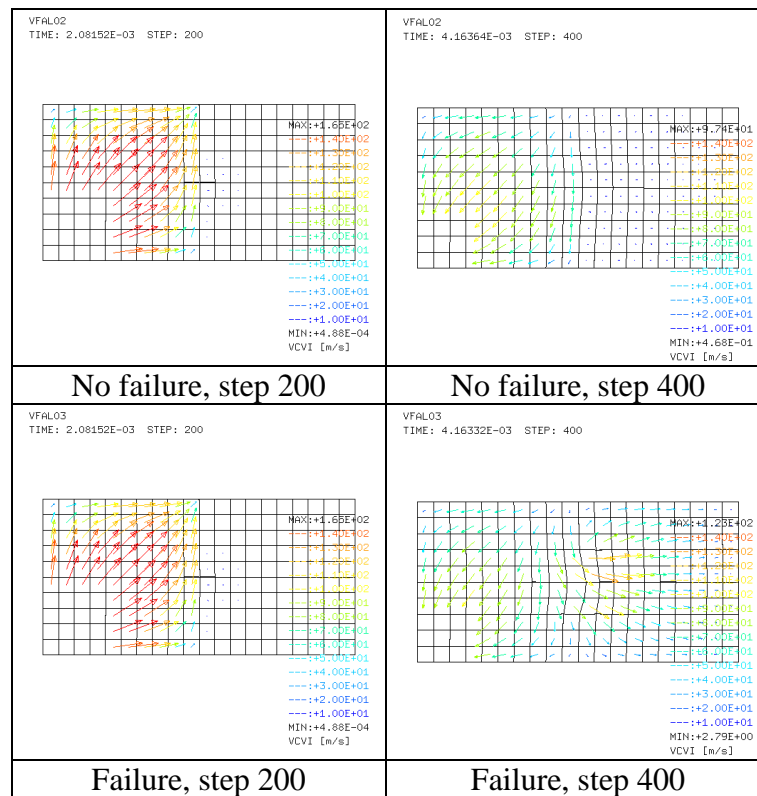


Detail of structural failure:

VFAL03
TIME: 4.16332E-03 STEP: 400



Fluid velocity maps



Fluid pressure maps:

