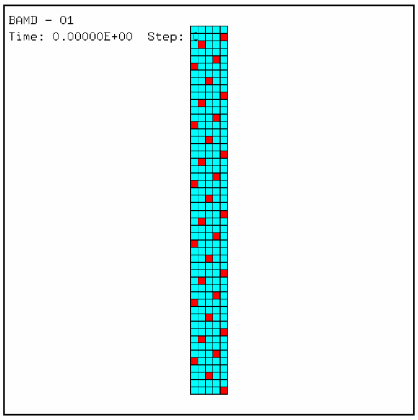
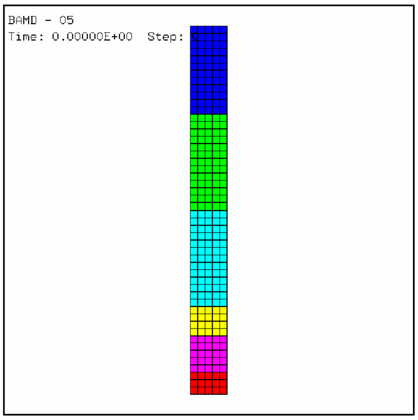
Example 15 – Bar Impact Revisited

- Taylor bar impact test:





Reference Case (no decomposition)

Case with time step partitioning (OPTI PART)

Case with domain decomposition (colors indicate sub-domains)

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<u>Problem description:</u>

This example represents the bending of a thick beam in 3D conditions. The beam is clamped at the left end and loaded by concentrated forces at the right end. The material is linear elastic.

Two solutions are obtained. The first one without domain decomposition is used as a reference, while the second uses decomposition in three sub-domains, one of which is non-conforming with the other two.

<u>Numerical Solutions</u>

BAMD01

This calculation uses no domain decomposition and is used to obtain a reference solution. It uses a regular mesh of 306 elements of type Q41L and 219 elements of type Q42L.

The mesh generation file is:

```
*%siz 40
*
opti echo 1;
*
opti titr 'BAMD - 01';
opti dime 2 elem qua4;
*
p0=0 0;
p1=3.2E-3 0;
p2=0 32.4E-3;
tol=0.01E-3;
*
base=p0 d 5 p1;
stru=base TRAN 50 p2;
elim tol (stru et p2);
*
symax=stru poin droi p0 p2 tol;
top=stru poin droi p2 (p1 PLUS p2) tol;
*
str1=chan 'POI1' stru;
bas1=chan 'POI1' base;
viti=diff str1 bas1;
*
nstr=nbel stru;
nten=(nstr + 1) / 8;
nten=enti nten;
j=0;
*
i=0 - 3;repe loop nten;i=i+8;
  si (<eg i nstr);
    eli=stru elem i;
    si (ega j 0);
      sq42=eli;
    sinon;
      sq42=sq42 et eli;
    finsi;
    j=j+1;
  finsi;
fin loop;
*
```

```
sq41=diff stru sq42;
*
mesh=stru et symax et viti;
tass mesh;
*
opti sauv form 'bamd01.msh';
sauv form mesh;
```

```
*
opti trac psc ftra 'bamd01_mesh.ps';
sq41=sq41 coul 'TURQ';
sq42=sq42 coul 'ROUG';
trac face (sq41 et sq42);
trac qual mesh;
fin;
```

The input file is:

```
BAMD - 01
$
ECHO
$VERI
$CONV win
CAST MESH
AXIS NONL
$
DIME
  PT2L 306 Q41L 219 Q42L 31 ZONE 2
  TABL 1 5
  mtpo 7
  depl 200
  tabl 1 2
TERM
$
GEOM Q41L SQ41 Q42L SQ42 TERM
$
COMP EPAI 1 TOUS
$
MATE VM23 RO 8930. YOUN 1.17D11 NU 0.35D0 ELAS 4.D8
          TRAC 2 4.D8 3.418803D-03 1.004D11 1000.003418803
          TOUS
$
CHAR 1 FACT 2
     DEPL 2 0.0 LECT BASE  TERM
     DEPL 1 0.0 LECT SYMAX TERM
     TABL 2 0.0 1.0 1.0 1.0
$
INIT VITE 2 -227. LECT VITI TERM
$
ECRI DEPL VITE TFRE 10.E-6
```

```
          POIN LECT P1 TOP TERM
     fich alic tfre 80.e-8
$
OPTI NOTE
  csta 0.5
  log 1
$
CALC TINI 0. TEND 80.D-6
*=====================================================================
SUIT
Post-treatment of bar impact problem
ECHO
*
RESU alic GARD PSCR
*
SORT GRAP
*
AXTE 1000.0 'Time [ms]'
*
COUR 1 'dr_p1'  DEPL COMP 1 NOEU LECT p1  TERM
COUR 2 'dz_p2'  DEPL COMP 2 NOEU LECT p2  TERM
COUR 3 'vr_p1'  VITE COMP 1 NOEU LECT p1  TERM
COUR 4 'vz_p2'  VITE COMP 2 NOEU LECT p2  TERM
*
TRAC 1 2 AXES 1.0 'DISPL. [M]' yzer
TRAC 3 4 AXES 1.0 'VELOC. [M/S]' yzer
*
QUAL DEPL COMP 1 LECT p1  TERM REFE  3.88425E-3 TOLE 1.E-3
     DEPL COMP 2 LECT p2  TERM REFE -1.09666E-2 TOLE 1.E-3
*=====================================================================
FIN
```

BAMD03

This calculation uses the seame mesh as the previous one (no domain decomposition). The time step partitioning technique is activated by specifying OPTI PART.

The mesh generation file is:

```
*%siz 40
*
opti echo 1;
*
opti titr 'BAMD - 03';
opti dime 2 elem qua4;
*
p0=0 0;
p1=3.2E-3 0;
p2=0 32.4E-3;
tol=0.01E-3;
*
base=p0 d 5 p1;
stru=base TRAN 50 p2;
elim tol (stru et p2);
*
symax=stru poin droi p0 p2 tol;
top=stru poin droi p2 (p1 PLUS p2) tol;
*
str1=chan 'POI1' stru;
bas1=chan 'POI1' base;
viti=diff str1 bas1;
*
nstr=nbel stru;
nten=(nstr + 1) / 8;
nten=enti nten;
j=0;
```

```
*
i=0 - 3;repe loop nten;i=i+8;
  si (<eg i nstr);
    eli=stru elem i;
    si (ega j 0);
      sq42=eli;
    sinon;
      sq42=sq42 et eli;
    finsi;
    j=j+1;
  finsi;
fin loop;
*
sq41=diff stru sq42;
*
mesh=stru et symax et viti;
tass mesh;
*
opti sauv form 'bamd03.msh';
sauv form mesh;
*
opti trac psc ftra 'bamd03_mesh.ps';
sq41=sq41 coul 'TURQ';
sq42=sq42 coul 'ROUG';
trac face (sq41 et sq42);
trac qual mesh;
fin;
```

The input file is:

```
BAMD - 03
$
ECHO
$VERI
$CONV win
CAST MESH
AXIS NONL
$
DIME
  PT2L 306 Q41L 219 Q42L 31 ZONE 2
  TABL 1 5
  mtpo 7
  depl 200
  tabl 1 2
TERM
$
GEOM Q41L SQ41 Q42L SQ42 TERM
$
COMP EPAI 1 TOUS
$
MATE VM23 RO 8930. YOUN 1.17D11 NU 0.35D0 ELAS 4.D8
          TRAC 2 4.D8 3.418803D-03 1.004D11 1000.003418803
          TOUS
$
CHAR 1 FACT 2
     DEPL 2 0.0 LECT BASE  TERM
     DEPL 1 0.0 LECT SYMAX TERM
     TABL 2 0.0 1.0 1.0 1.0
$
INIT VITE 2 -227. LECT VITI TERM
$
ECRI DEPL VITE TFRE 10.E-6
```

```
          POIN LECT P1 TOP TERM
     fich alic tfre 80.e-8
$
OPTI PART NOTE step io
  csta 0.5
  log 1
$
CALC TINI 0. TEND 80.D-6
*=====================================================================
SUIT
Post-treatment of bar impact problem
ECHO
*
RESU alic GARD PSCR
*
SORT GRAP
*
AXTE 1000.0 'Time [ms]'
*
COUR 1 'dr_p1'  DEPL COMP 1 NOEU LECT p1  TERM
COUR 2 'dz_p2'  DEPL COMP 2 NOEU LECT p2  TERM
COUR 3 'vr_p1'  VITE COMP 1 NOEU LECT p1  TERM
COUR 4 'vz_p2'  VITE COMP 2 NOEU LECT p2  TERM
*
TRAC 1 2 AXES 1.0 'DISPL. [M]' yzer
TRAC 3 4 AXES 1.0 'VELOC. [M/S]' yzer
*
QUAL DEPL COMP 1 LECT p1  TERM REFE  3.88425E-3 TOLE 1.E-3
     DEPL COMP 2 LECT p2  TERM REFE -1.09666E-2 TOLE 1.E-3
*=====================================================================
FIN
```

BAMD05

This calculation uses the same mesh as the previous ones, but with decomposition into six sub-domains of various sizes. These are all conforming with respect to one another.

The scope is to activate a sort of sub-cycling in the sub-domains that undergo larger deformations than the others (i.e. the two sub-domains close to the projectile tip).

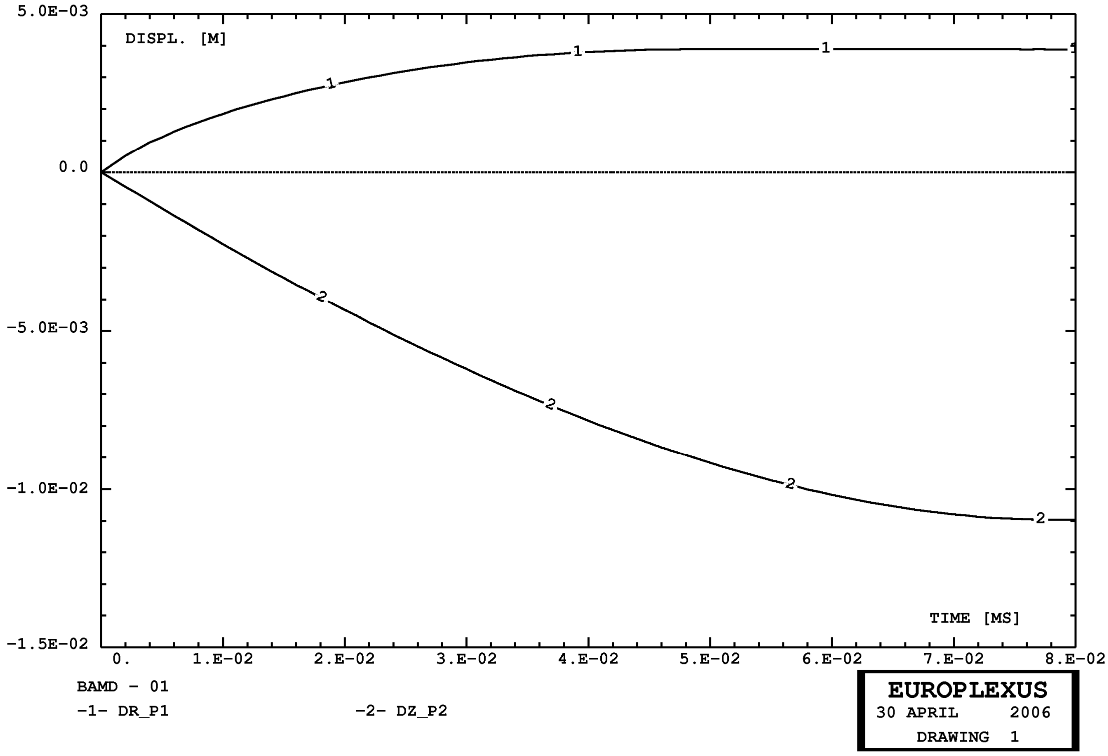
The mesh generation file is:

```
*%siz 40
*
opti echo 1;
*
opti titr 'BAMD - 05';
opti dime 2 elem qua4;
*
p0=0 0;
p1=3.2E-3 0;
p2=0 32.4E-3;
tol=0.01E-3;
*
base=p0 d 5 p1;
stru=base TRAN 50 p2;
elim tol (stru et p2);
*
symax=stru poin droi p0 p2 tol;
top=stru poin droi p2 (p1 PLUS p2) tol;
*
str1=chan 'POI1' stru;
bas1=chan 'POI1' base;
viti=diff str1 bas1;
*
nstr=nbel stru;
nten=(nstr + 1) / 8;
nten=enti nten;
j=0;
*
i=0 - 3;repe loop nten;i=i+8;
  si (<eg i nstr);
    eli=stru elem i;
    si (ega j 0);
      sq42=eli;
    sinon;
      sq42=sq42 et eli;
    finsi;
    j=j+1;
  finsi;
fin loop;
*
sq41=diff stru sq42;
*
h1=2.1e-3;
h2=5.1e-3;
h3=8.1e-3;
h4=16.2e-3;
h5=24.3e-3;
*
n1=0;n2=0;n3=0;n4=0;n5=0;n6=0;
i=0;repe loop2 (nbel stru);i=i+1;
  ei = stru elem i;
  bi = bary ei;
  xb yb = coor bi;
  si (<eg yb h1);
    si (ega n1 0);
      s1=ei;
    sinon;
      s1=s1 et ei;
    finsi;
    n1=n1+1;
  sinon;
    si (<eg yb h2);
      si (ega n2 0);
        s2=ei;
      sinon;
        s2=s2 et ei;
      finsi;
      n2=n2+1;
    sinon;
      si (<eg yb h3);
        si (ega n3 0);
          s3=ei;
        sinon;
          s3=s3 et ei;
        finsi;
        n3=n3+1;
      sinon;
        si (<eg yb h4);
          si (ega n4 0);
            s4=ei;
          sinon;
            s4=s4 et ei;
          finsi;
          n4=n4+1;
        sinon;
          si (<eg yb h5);
            si (ega n5 0);
              s5=ei;
            sinon;
              s5=s5 et ei;
            finsi;
            n5=n5+1;
          sinon;
            si (ega n6 0);
              s6=ei;
            sinon;
              s6=s6 et ei;
            finsi;
            n6=n6+1;
          finsi;
        finsi;
      finsi;
    finsi;
  finsi;
fin loop2;
*
list (nbel s1);
list (nbel s2);
list (nbel s3);
list (nbel s4);
list (nbel s5);
list (nbel s6);
list (nbel stru);
*
mesh=stru et symax et viti;
tass mesh;
*
opti sauv form 'bamd05.msh';
sauv form mesh;
*
opti trac psc ftra 'bamd05_mesh.ps';
sq41=sq41 coul 'TURQ';
sq42=sq42 coul 'ROUG';
trac face (sq41 et sq42);
trac qual mesh;
fin;
```

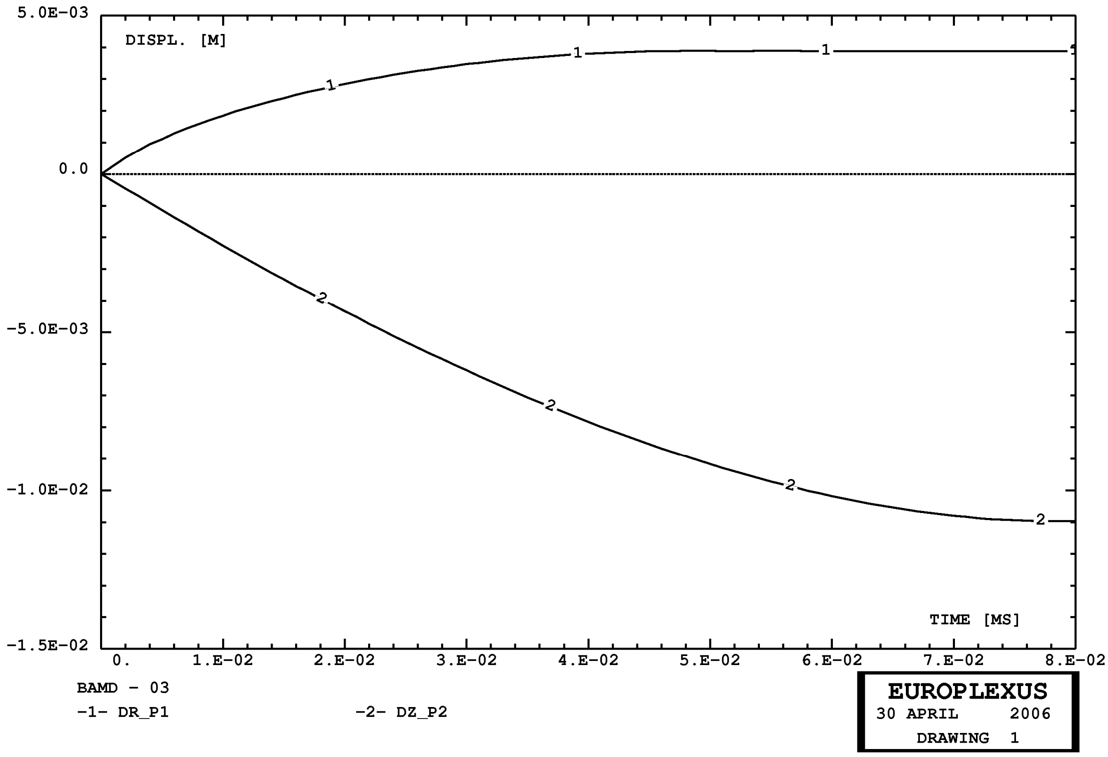
The input file is:

```
BAMD - 05
$
ECHO
$VERI
*CONV win
CAST MESH
AXIS NONL
$
DIME
  PT2L 306 Q41L 219 Q42L 31 ZONE 2
  mtpo 7
TERM
$
GEOM Q41L SQ41 Q42L SQ42 TERM
$
COMP EPAI 1 TOUS
$
MATE VM23 RO 8930. YOUN 1.17D11 NU 0.35D0 ELAS 4.D8
          TRAC 2 4.D8 3.418803D-03 1.004D11 1000.003418803
          TOUS
$
LINK COUP
     BLOQ 2 LECT BASE TERM
     BLOQ 1 LECT SYMAX TERM
$
INIT VITE 2 -227. LECT VITI TERM
$
ECRI DEPL VITE TFRE 10.E-6
          POIN LECT P1 TOP TERM
     fich alic tfre 80.e-8
$
OPTI NOTE
  csta 0.5
  log 1
*
STRU 6
     DOMA LECT s1 TERM
     DOMA LECT s2 TERM
     DOMA LECT s3 TERM
     DOMA LECT s4 TERM
     DOMA LECT s5 TERM
     DOMA LECT s6 TERM
$
CALC TINI 0. TEND 80.D-6
*======================================================================
SUIT
Post-treatment of bar impact problem
ECHO
*
RESU alic GARD PSCR
*
SORT GRAP
*
AXTE 1000.0 'Time [ms]'
*
COUR 1 'dr_p1'  DEPL COMP 1 NOEU LECT p1  TERM
COUR 2 'dz_p2'  DEPL COMP 2 NOEU LECT p2  TERM
COUR 3 'vr_p1'  VITE COMP 1 NOEU LECT p1  TERM
COUR 4 'vz_p2'  VITE COMP 2 NOEU LECT p2  TERM
*
TRAC 1 2 AXES 1.0 'DISPL. [M]' yzer
TRAC 3 4 AXES 1.0 'VELOC. [M/S]' yzer
*
QUAL DEPL COMP 1 LECT p1  TERM REFE  3.88425E-3 TOLE 1.E-2
     DEPL COMP 2 LECT p2  TERM REFE -1.09666E-2 TOLE 1.E-2
*======================================================================
FIN
```

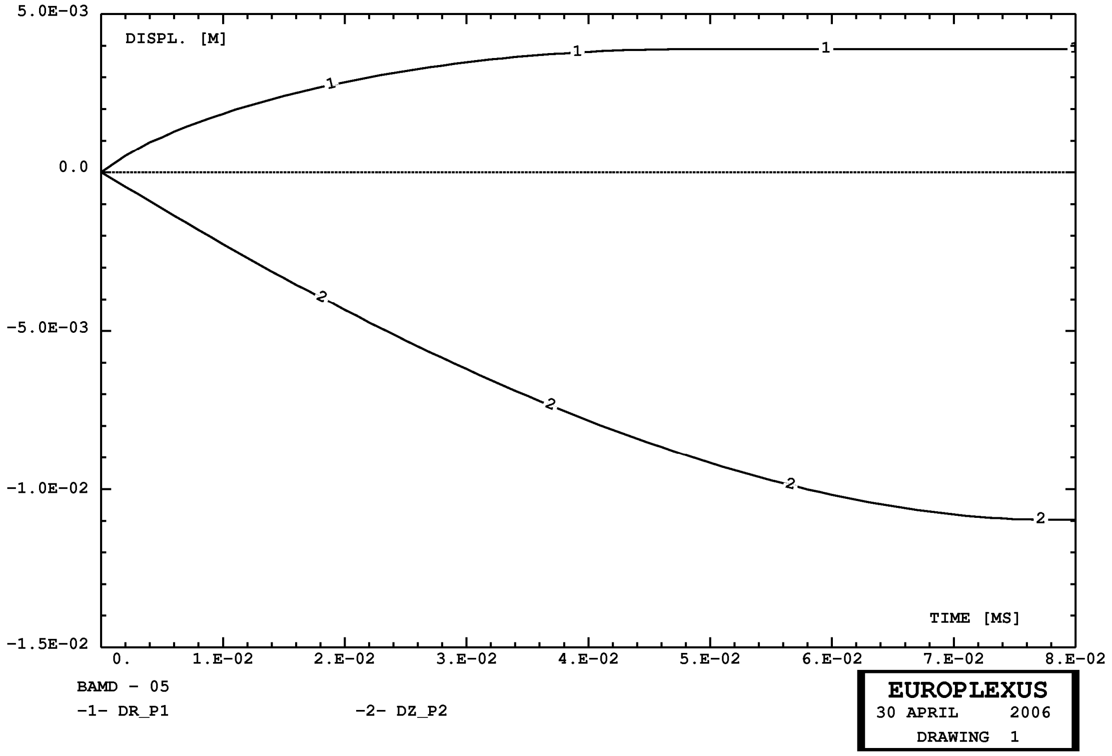
The characteristic displacements in the reference case are:



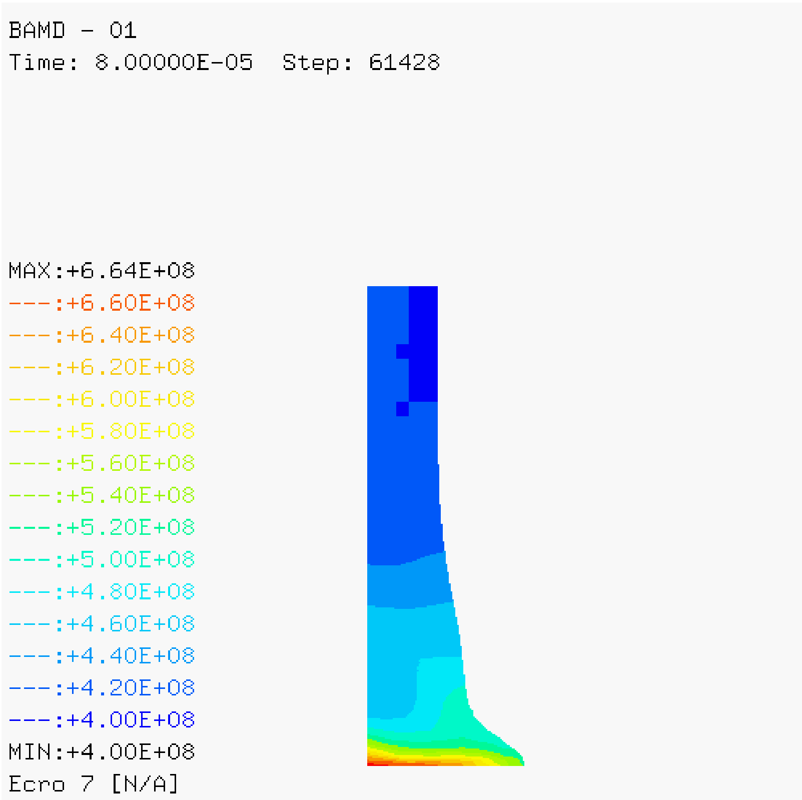
The displacements in the case with OPTI PART are:



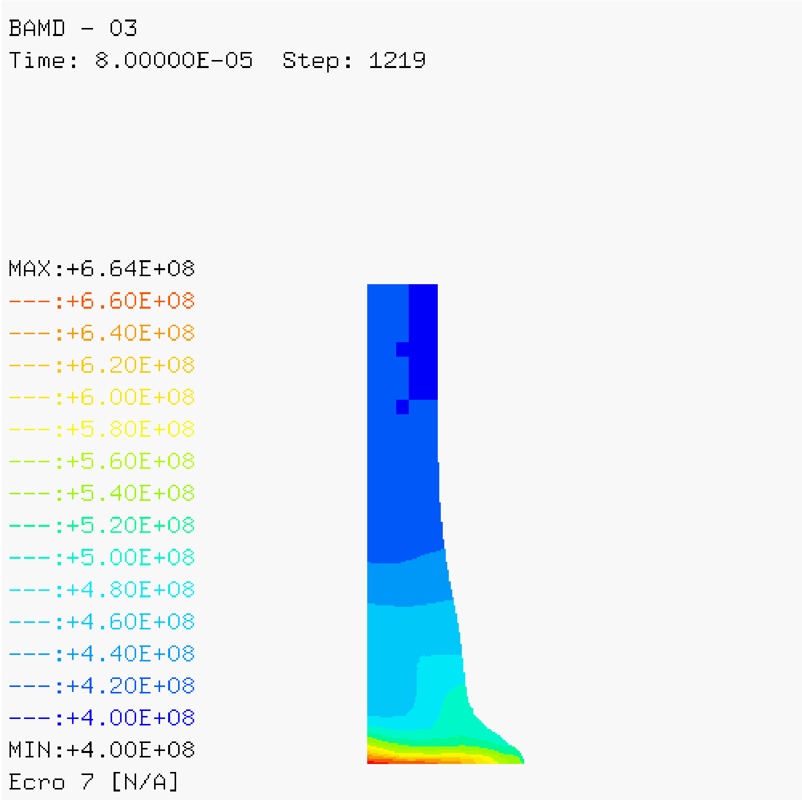
The displacements in the case with domain decomposition are:



The final yield stress field in the reference case is:



The final yield stress field in the case with OPTI PART is:



The final yield stress field in the case with domain decomposition is: