behavior of a continuous medium will be validated by treating the joint as a glued joint. Comparisons of model behavior will be compared with FLAC simulations using the FLAC ver 4.0 code from Itasca Consulting Group, Inc.

Conventions

The conventions for SI units used in the analyses are shown in Table 2.2 (excerpted from the UDEC manual) below.

Table 2.2 System of SI units for thermal problems

Information potentially subject to copyright protection was redacted from this and page 47 of this scientific notebook. The redacted material is from the UDEC Manual.

Excerpted from UDEC manual

Geometry of the Problem

The geometry of the problem is illustrated in the diagram on page 47 (Fig 7.1). Initial conditions and boundary conditions are also shown on this diagram. Material properties are listed in the UDEC input files in the following sections.

[redacted]

Figure 7.1 Model geometry for Case 7

The dimensions of the problem will be checked to ensure temperature changes do not reach the outer boundaries. Options for heat source include a specified flux or a source. Solution of the problem will require alternating thermal and mechanical timesteps to come to equilibrium.

Development of UDEC Input File

The UDEC input file development process involved building a prototype model with a horizontal joint and a square heated zone 5 m on a side centered on x=50 y=45. to test the logic and command sequence.

Plot commands that are useful for this exercise include the following: blo (block assemblage); bo (boundary); bo xcon (boundary conditions applied in x-direction); bo ycon (boundary conditions applied in y-direction); ccdif (color coded principal stress tensors)*; ccm (color coded principal stress tensors based on magnitude of mean stress)*; ccs1 (color coded principal stress tensors based on most compressive principal stress)*; ccs2 (as prior but based on least compressive principal stress)*; closure (joint closure); disp (gridpoint displacement vectors); dsh (directions of shear displacement); evol (contours of volumetric strain in deformable block zones); exx (x-strain)*; exy (shear strain)*; ey (y-strain)*; fdil (principal finite strains based on magnitude of dilation)*; fstrain (principal finite strain tensor)*; gp-extra (extra gridpoint FISH variable); hist (time history of variable); ~~p~~ idi (principal infinitesimal strains scaled to magnitude of dilation in the zone); istr (infinitesimal strain tensors); jcons (joints and constitutive model); jline ~~x1, x2,~~ x1 y1 x2 y2 [nd or sd]; joint x_1, y_1, x_2, y_2 [nd (normal displacement); nstr (normal stress); sdisp (shear displacement); sstr (shear stress); R Aug 14/04 ~~vel~~ (] (joint parameters; ma (mechanical aperture of joints); mod (material model); mohr (contours of strength/stress ratios for zones in deformable blocks); open (joints with zero normal force or stress); plas (plastic state of zones in deformable blocks);

---

* in deformable block zones

pline [disp, nstr, sig1, sig2, sst, sxx, syy, sxy, szz, vel, xd, xv, yd, yv] (line plot of selected zone or gridpoint variables); prop (property plot); sd (principal stress difference)*; separ (magnitude of joint separation); shear (shear displacement); sig1 (sigma 1)*; R Aug 14/04 ~~sigma2~~ sig2 (sigma2)*; slip (joints that are at limiting slip); smax (R Aug 14/04 ~~mag~~ maximum principal stress in x,y plane)*; smin (minimum principal stress in xy plane)*; str (principal stress tensors)*; sxx (xx-stress)*; syy (yy-stress)*; sxy (xy stress)*; szz (out of plane stress)*; table n (table of values); tcont (single contour that separates tension and compression regions); temp (temperature contours); thist (temperature history); xd (x-displacement); xv (x-velocity); yd (y-displacement); yvel (y-vel); z_extra (zone variable from FISH); zones (zones in deformable blocks).

Modifiers - alias (rename variables in legend); back (background pen color); fill (filled contour plots); grid (contouring points); interval val (contouring interval); label (labels plots); nc (no corner rounding plotted);

Print Commands

at x,y (model information); blocks (general block data); bou [disp, interior, state, thermal, vel] (conditions at boundaries); contact [aperature, disp, state, stress]; energy; ffield; file; gridpoint; history; info; joint; pline; prop; str; table; thermal; thist; version; zone

Selected Plots

Joint Condition
PLOT JOINT 0 50 100 50 NDISP (Joint normal displacement)
PLOT JOINT 0 ~~500~~ 50 100 50 SDISP (Joint shear displacement)
Aug 14/04
PLOT JOINT 0 50 100 50 SSTR (Joint shear stress)
PLOT JOINT 0 50 100 50 NSTR (Joint normal stress)
PLOT ~~SLIP~~ BLO SLIP (Joint slip)

Contour Plots
PLO TEMP FILL BLO IW (Temperature contour plot)
PLO DISP BLO IW (Displacement vector plot)
PLO XD FILL BLO IW (X-displacement contours)
PLO YD FILL BLO IW (Y-displacement contours)
PLO SIG1 FILL BLO IW (Sigma 1 contour plot - compression negative)
PLO SIG2 FILL BLO IW (Sigma 2 contour plot - compression negative)
PLO SDIFF FILL BLO IW (S1-S2 contour plot - compression negative.)

Histories
PLO THIST 1 2 3 4 5 6 (Temperature histories)
PLO HIST 1 2 3 4 5 6 (Y-displacement histories)
PLO HIST 7 (Unbalanced force)
PLO HIST 8 9 (Normal and shear displacement on joint of interest)

Case 7.1 Horizontal joint with no slip allowed

File FLAT.TXT (opposite page) is a test run with a flat joint above a heat source. Joint strength parameters and joint stiffnesses are set artificially high to create a glued stiff joint. This file is used to establish a logical process for assessing thermally-induced displacement on joints.

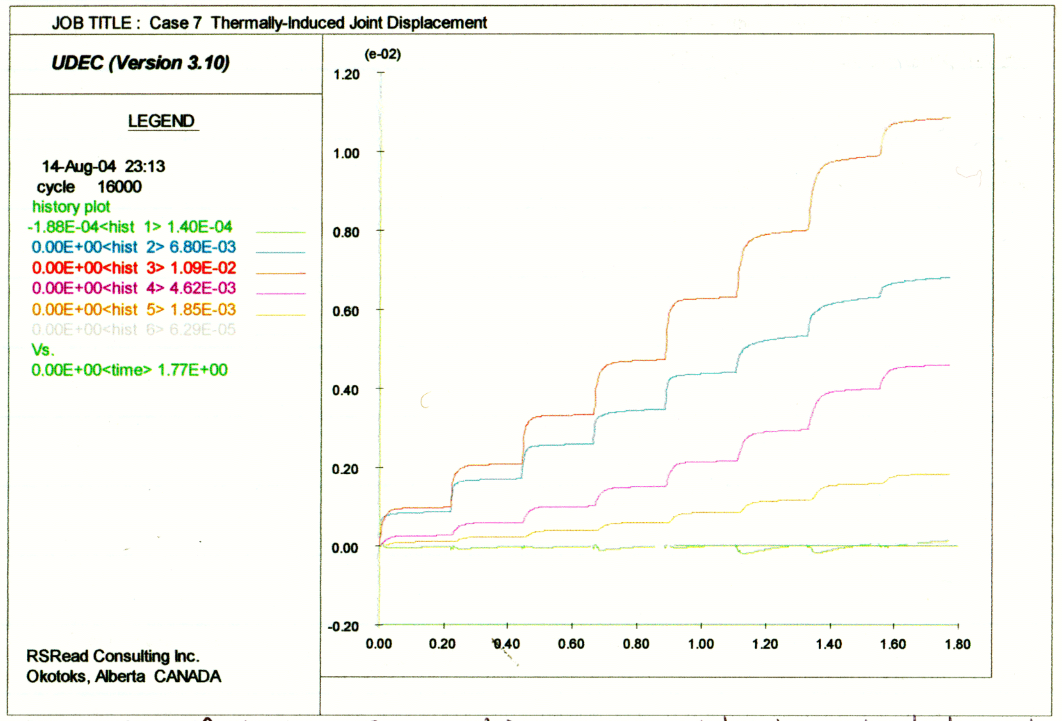
```
; Flat transgressing joint in a heated infinite rock mass
;
config thermal
set mech on
;
; Geometry
;
rou 0.001
bl 0,0 0,100 100,100 100,0
crack 0 50 100 50
crack 0 47.5 100 47.5
crack 47.5 42.5 47.5 47.5
crack 52.5 42.5 52.5 47.5
crack 0 42.5 100 42.5
gen quad 2.0
;
; Material properties
;
prop m=1 de=2210.0 k=19.0e9 g=13.0e9
prop jm=1 jkn=19.0e11 jks=13.0e11
prop jm=1 jcoh=1.0e20 jfric=0.0 jten=1.0e20 jd=0
prop m=1 thexp=15.0e-6 cond=20.0 spec=1000.0
;
; Initial conditions
;
initem 34.0 0 100 0 100
;
; Boundary conditions
;
bound yvel 0.0 range (0,100) (-0.1, 0.1)
bound yvel 0.0 range (0,100) (99.1, 100.1)
bound xvel 0.0 range (-0.1, 0.1) (0,100)
bound xvel 0.0 range (99.1, 100.1) (0,100)
;
; Apply heat source
;
thapp source 50000 0 range 47.5 52.5 42.5 47.5
;
; Thermal histories
;
thist temp 50,45 ;1
thist temp 50,47 ;2
thist temp 50,50 ;3
thist temp 50,60 ;4
thist temp 50,75 ;5
thist temp 50,100 ;6
;
; Mechanical histories
;
hist ydisp 50,45 ;1
hist ydisp 50,47 ;2
hist ydisp 50,50 ;3
hist ydisp 50,60 ;4
hist ydisp 50,75 ;5
hist ydisp 50,100 ;6
hist unbalanced ;7
hist ndis 50 50 ;8
hist sdis 50 50 ;9
;
; Thermal mechanical analysis
;
;
set nther 2500
set nmech 2000
run age 1000000 temp 50
;
save 7ffinal.sav
;
set plot emf color
title
Case 7  Thermally-Induced Joint Displacement
```

Aug 14/04

```
;
; Joint condition plots
;
set out 7fjnd.emf
plot joint 0 50 100 50 ndisp
copy
;
set out 7fjsd.emf
plot joint 0 50 100 50 sdisp
copy
;
set out 7fjss.emf
plot joint 0 50 100 50 sstr
copy
;
set out 7fjns.emf
plot joint 0 50 100 50 nstr
copy
;
; Contour plots
;
set out 7ftemp.emf
plot temp fill blo iw
copy
;
set out 7fdisp.emf
plot disp blo iw
copy
;
set out 7fxd.emf
plot xd fill blo iw
copy
;
set out 7fyd.emf
plot yd fill blo iw
copy
;
set out 7fsig1.emf
plot sig1 fill blo iw
copy
;
set out 7fsig2.emf
plot sig2 fill blo iw
copy
;
set out 7fsdif.emf
plot sdiff fill blo iw
copy
;
set out 7fthist.emf
plo thist 1 2 3 4 5 6
copy
;
set out 7fydhist.emf
plo hist 1 2 3 4 5 6
copy
;
set out 7funbal.emf
plo hist 7
copy
;
set out 7jns.emf
plo hist 8 9
copy
;
ret
```

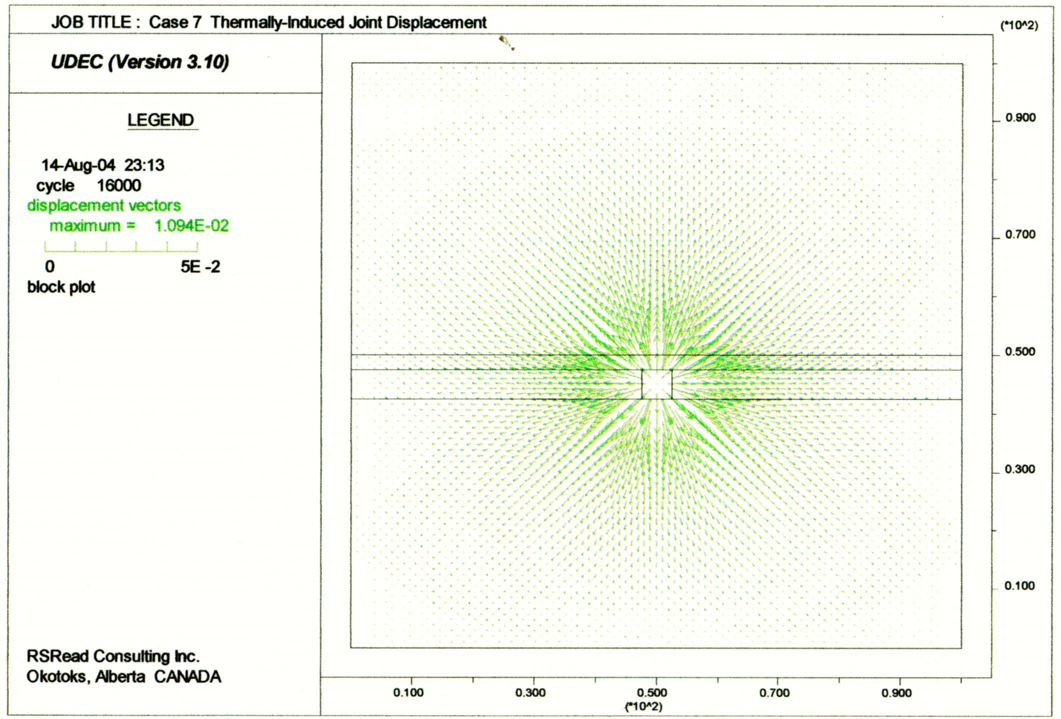
Aug 14/04

File FLAT.TXT
(Input for UDEC)

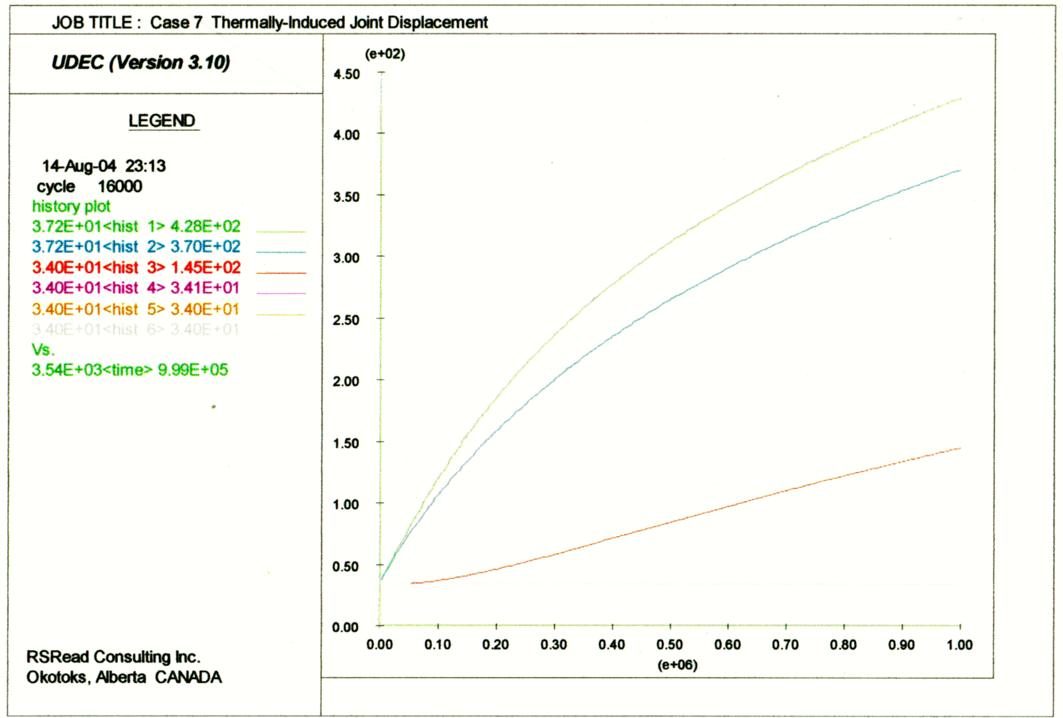


From file 7fydhist.emf   Y-Displacement history at select points

Aug 14/04

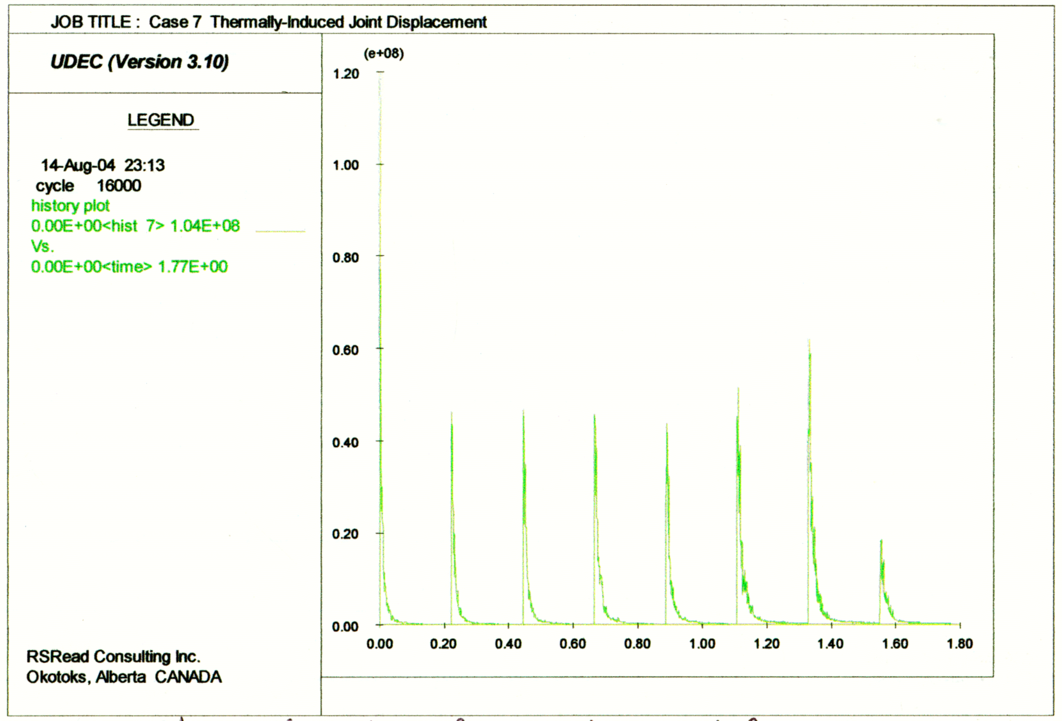


From file 7fdisp.emf   Displacement vectors

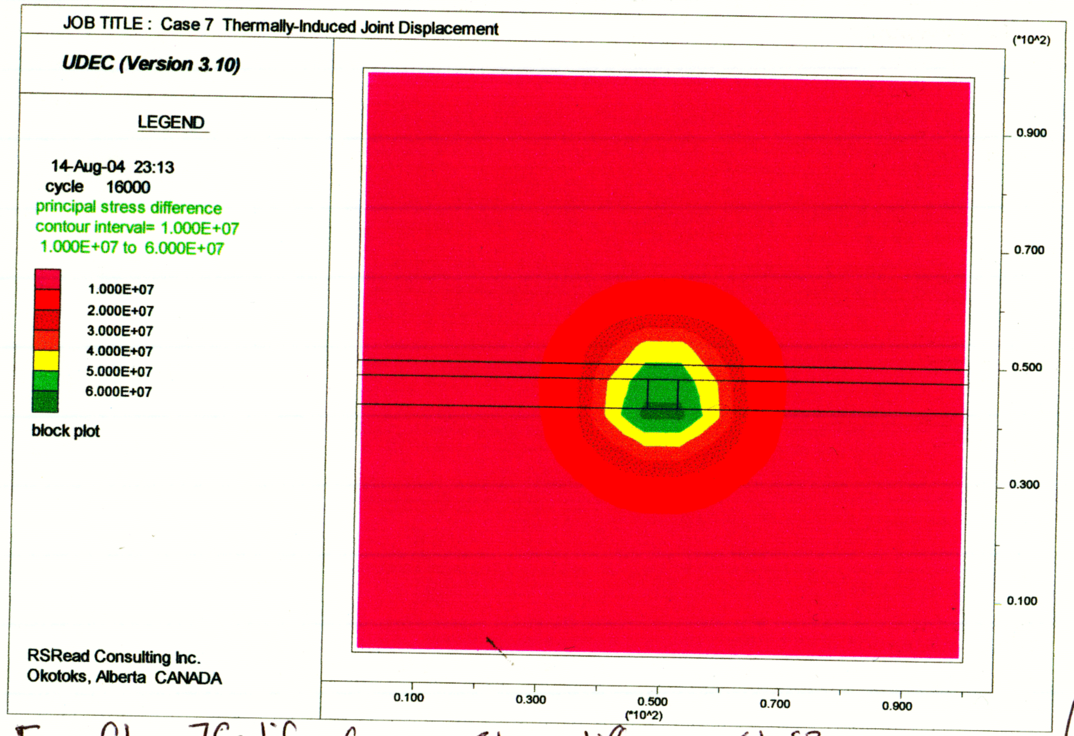


From file 7fthist.emf   Temperature history at select points

Aug 14/04



From file 7funbal.emf   Unbalanced force during calculations


JOB TITLE : Case 7 Thermally-Induced Joint Displacement

UDEC (Version 3.10)

LEGEND

14-Aug-04 23:13
cycle 16000
principal stress difference
contour interval= 1.000E+07
1.000E+07 to 6.000E+07

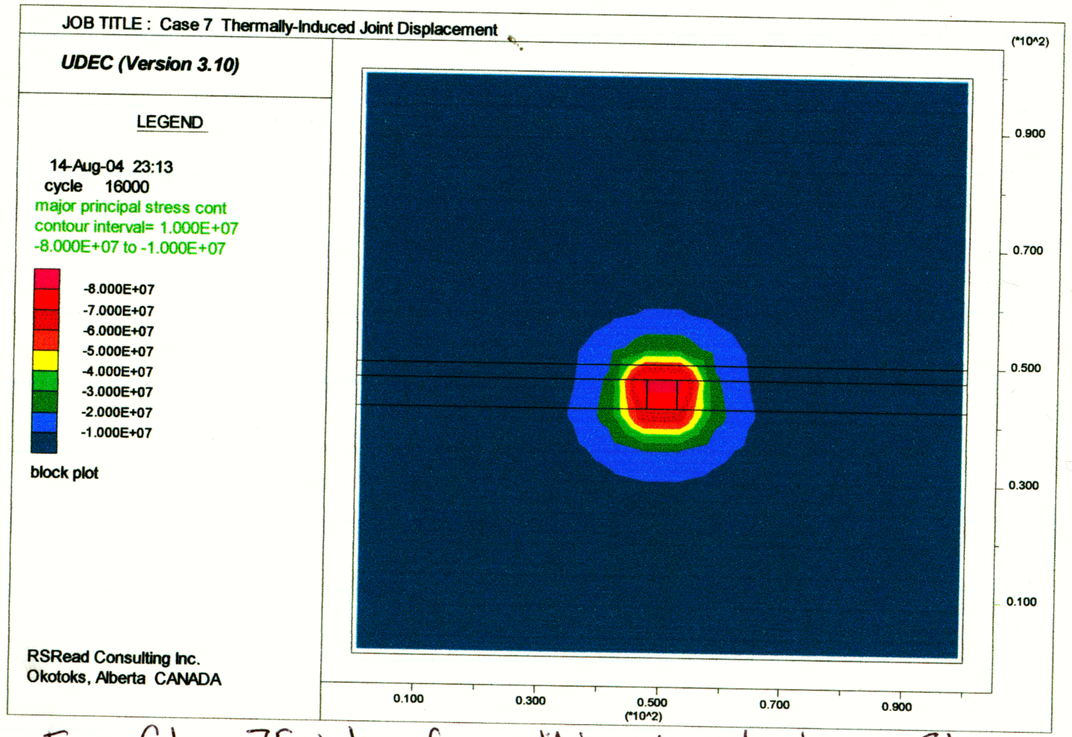
1.000E+07
2.000E+07
3.000E+07
4.000E+07
5.000E+07
6.000E+07

block plot

RSRead Consulting Inc.
Okotoks, Alberta CANADA

From file 7fsdif.emf Stress difference S1-S2

Aug 14/04


JOB TITLE : Case 7 Thermally-Induced Joint Displacement

UDEC (Version 3.10)

LEGEND

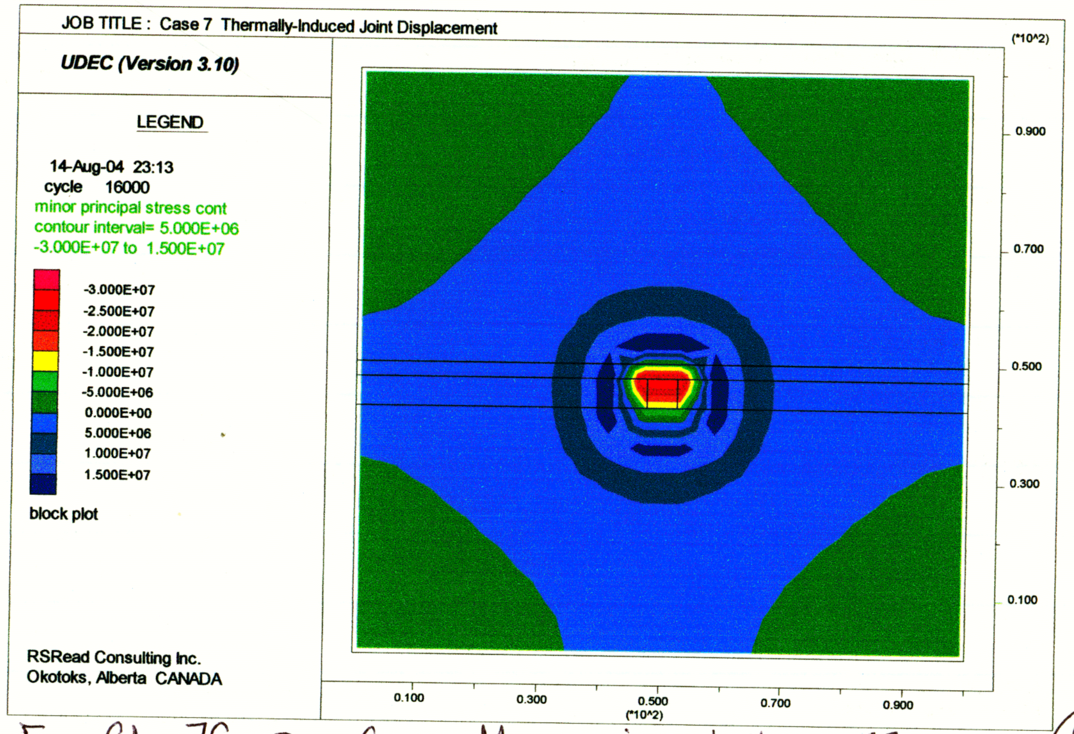
14-Aug-04 23:13
cycle 16000
major principal stress cont
contour interval= 1.000E+07
-8.000E+07 to -1.000E+07

-8.000E+07
-7.000E+07
-6.000E+07
-5.000E+07
-4.000E+07
-3.000E+07
-2.000E+07
-1.000E+07

block plot

RSRead Consulting Inc.
Okotoks, Alberta CANADA

From file 7fsig1.emf Major principal stress S1


JOB TITLE : Case 7 Thermally-Induced Joint Displacement

UDEC (Version 3.10)

LEGEND

14-Aug-04 23:13
cycle 16000
minor principal stress cont
contour interval= 5.000E+06
-3.000E+07 to 1.500E+07

-3.000E+07
-2.500E+07
-2.000E+07
-1.500E+07
-1.000E+07
-5.000E+06
0.000E+00
5.000E+06
1.000E+07
1.500E+07

block plot

RSRead Consulting Inc.
Okotoks, Alberta CANADA

From file 7fsig2.emf Minor principal stress S2

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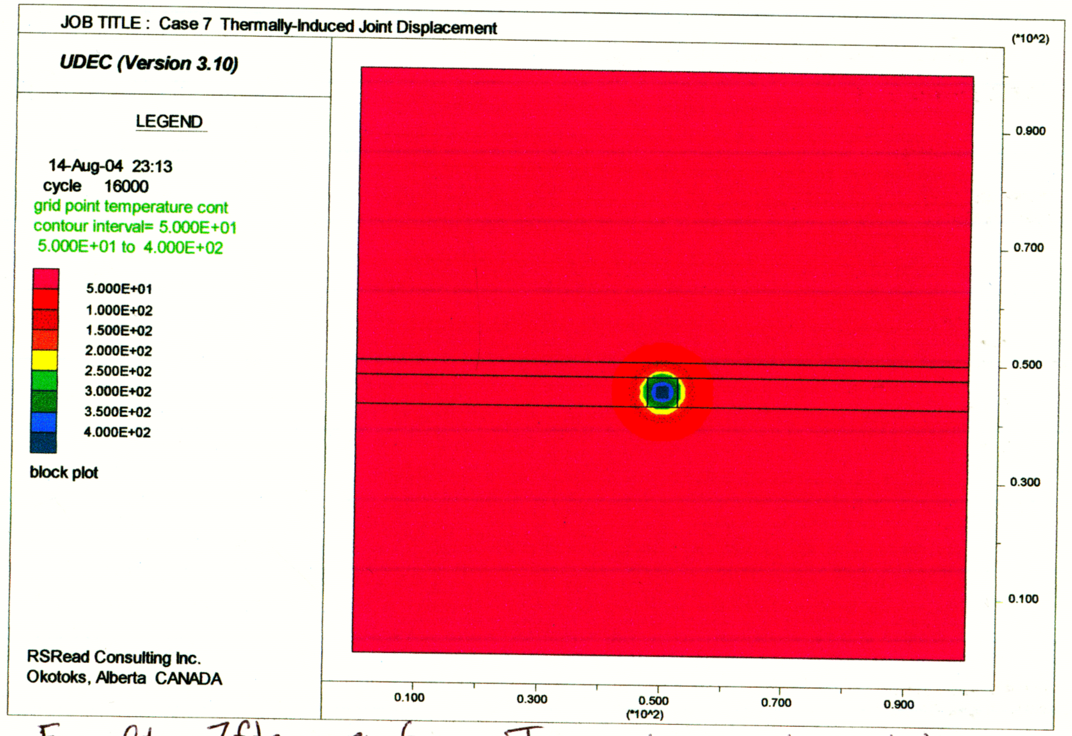

JOB TITLE : Case 7 Thermally-Induced Joint Displacement

UDEC (Version 3.10)

LEGEND

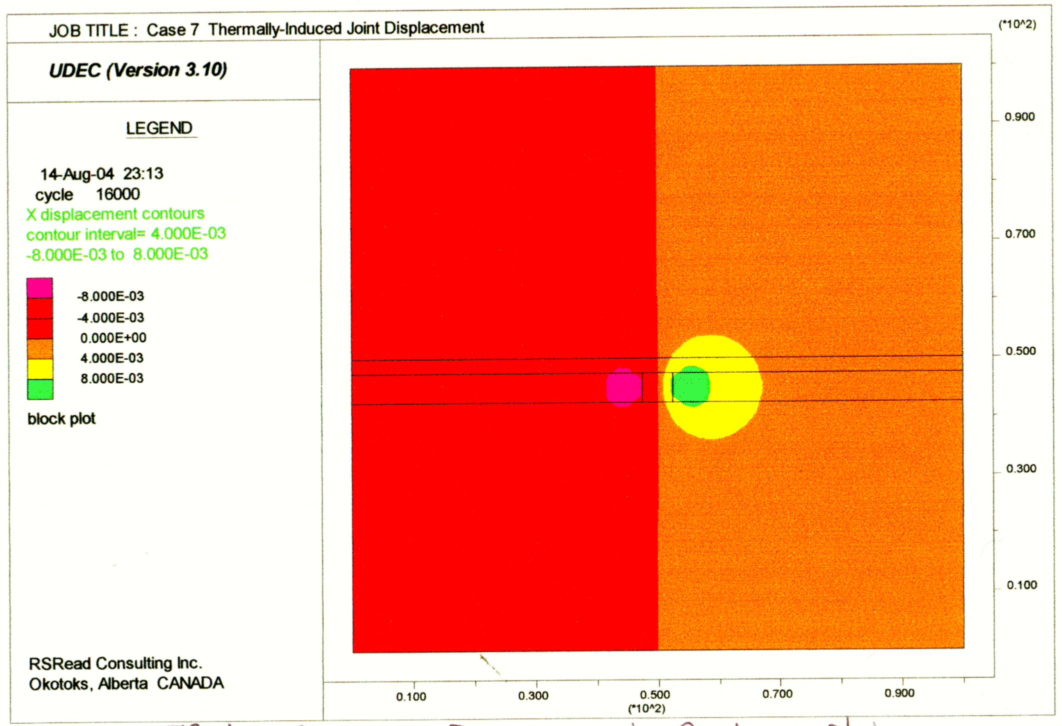
14-Aug-04 23:13
cycle 16000
grid point temperature cont
contour interval= 5.000E+01
5.000E+01 to 4.000E+02

5.000E+01
1.000E+02
1.500E+02
2.000E+02
2.500E+02
3.000E+02
3.500E+02
4.000E+02

block plot

RSRead Consulting Inc.
Okotoks, Alberta CANADA

From file 7ftemp.emf Temperature contour plot.



JOB TITLE : Case 7 Thermally-Induced Joint Displacement

UDEC (Version 3.10)

LEGEND

14-Aug-04 23:13
cycle 16000
X displacement contours
contour interval= 4.000E-03
-8.000E-03 to 8.000E-03

-8.000E-03
-4.000E-03
0.000E+00
4.000E-03
8.000E-03

block plot

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Okotoks, Alberta CANADA

From file 7fxd.emf X Displacement Contour Plot

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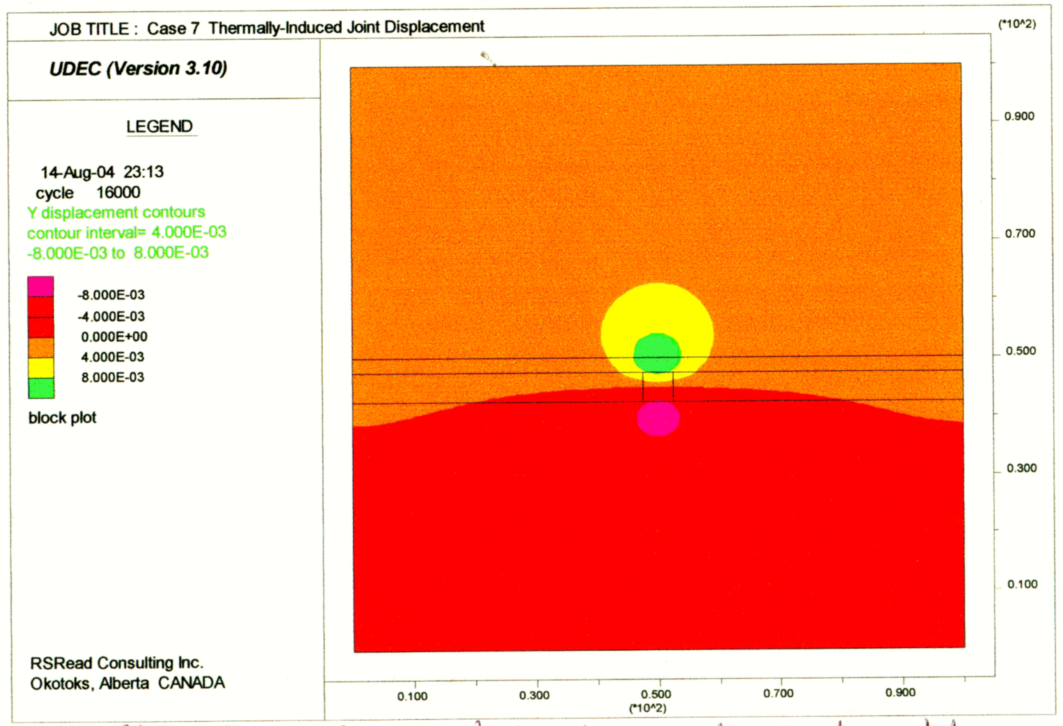


JOB TITLE : Case 7 Thermally-Induced Joint Displacement

UDEC (Version 3.10)

LEGEND

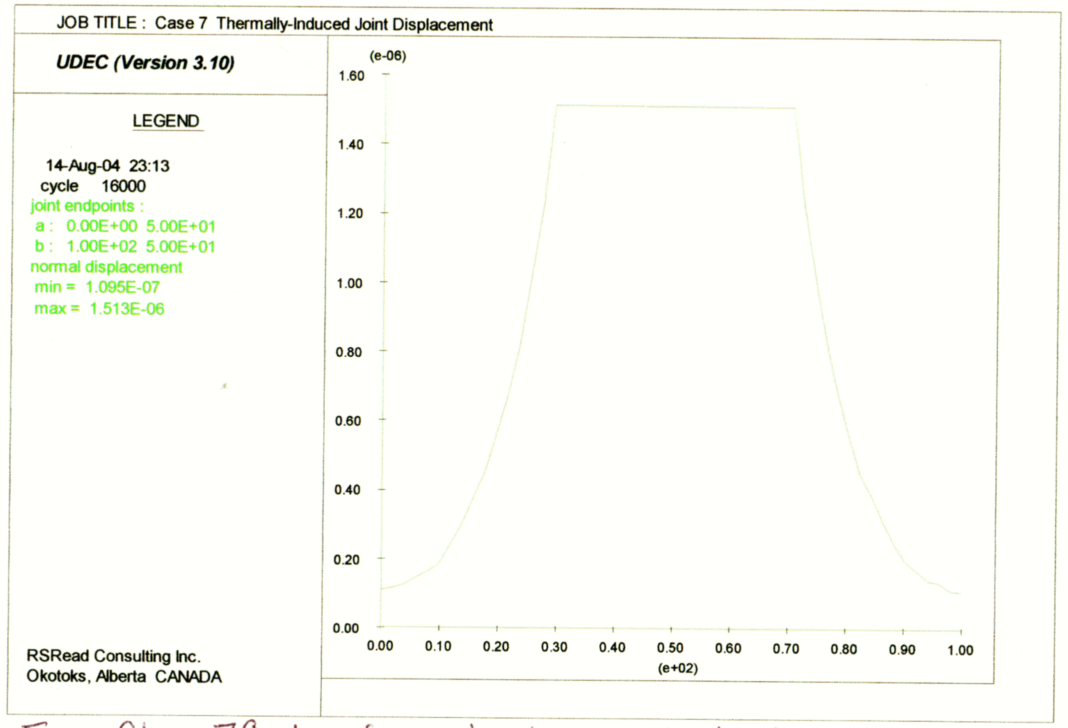
14-Aug-04 23:13
cycle 16000
Y displacement contours
contour interval= 4.000E-03
-8.000E-03 to 8.000E-03

-8.000E-03
-4.000E-03
0.000E+00
4.000E-03
8.000E-03

block plot

RSRead Consulting Inc.
Okotoks, Alberta CANADA

From file 7fyd.emf Y- Displacement Contour plot



JOB TITLE : Case 7 Thermally-Induced Joint Displacement

UDEC (Version 3.10)

LEGEND

14-Aug-04 23:13
cycle 16000
joint endpoints :
a : 0.00E+00 5.00E+01
b : 1.00E+02 5.00E+01
normal displacement
min = 1.095E-07
max = 1.513E-06

RSRead Consulting Inc.
Okotoks, Alberta CANADA

From file 7fjnd.emf Joint normal displacement

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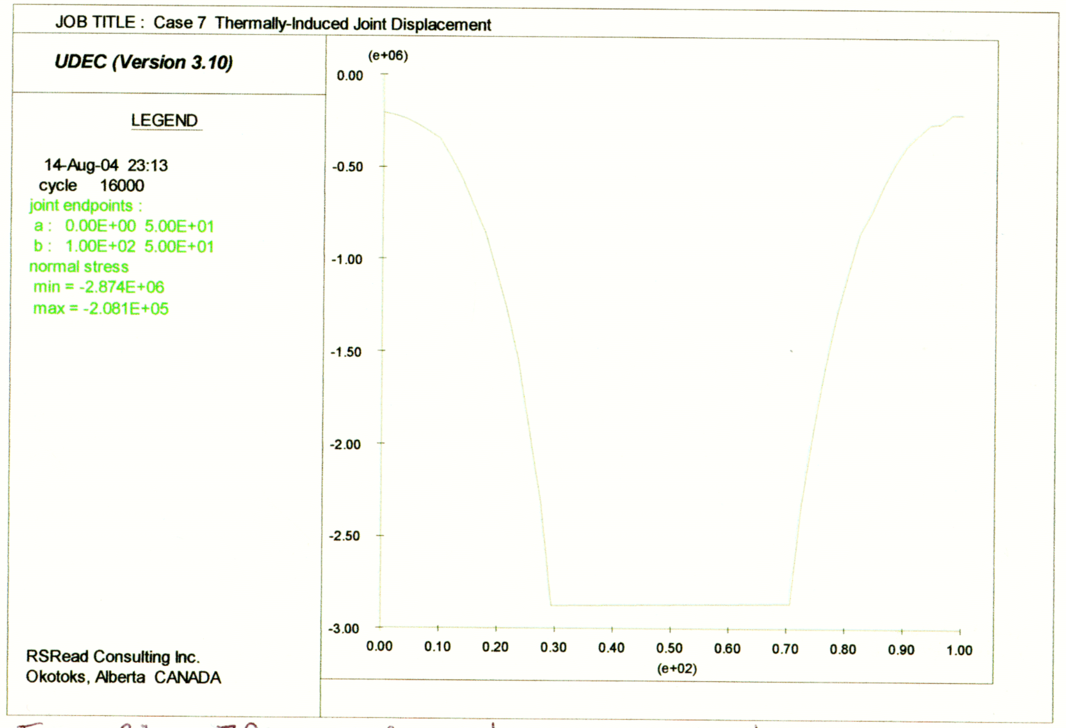

JOB TITLE : Case 7 Thermally-Induced Joint Displacement

UDEC (Version 3.10)

LEGEND

14-Aug-04 23:13
cycle 16000
joint endpoints :
a : 0.00E+00 5.00E+01
b : 1.00E+02 5.00E+01
normal stress
min = -2.874E+06
max = -2.081E+05

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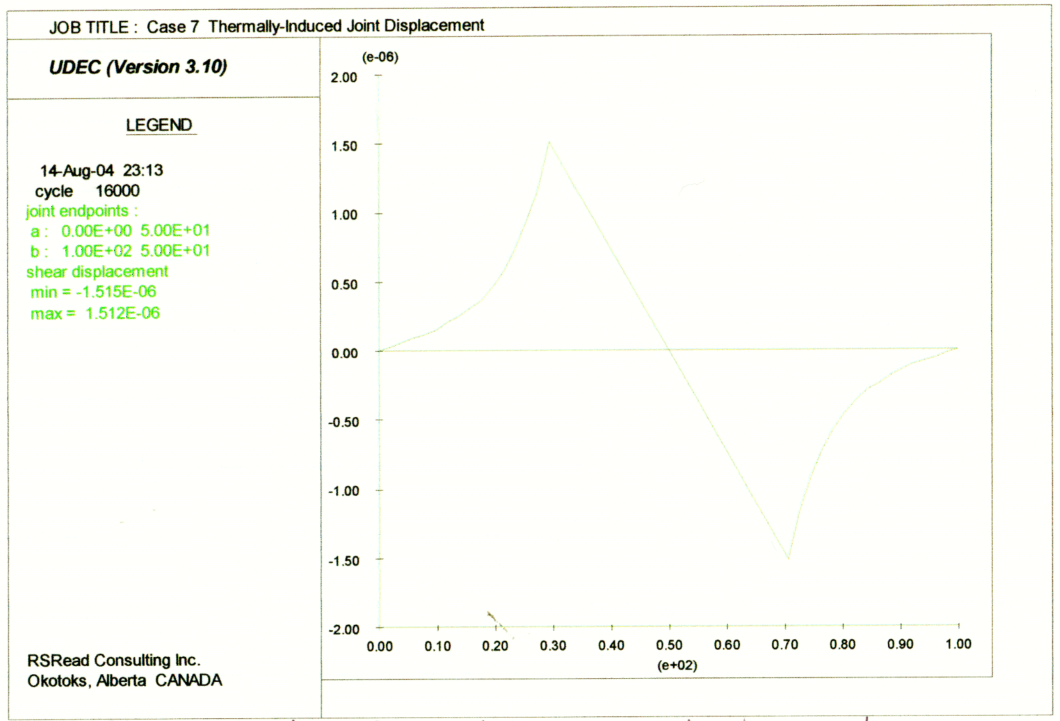
Okotoks, Alberta CANADA

From file 7fjns.emf Joint normal stress



JOB TITLE : Case 7 Thermally-Induced Joint Displacement

UDEC (Version 3.10)

LEGEND

14-Aug-04 23:13
cycle 16000
joint endpoints :
a : 0.00E+00 5.00E+01
b : 1.00E+02 5.00E+01
shear displacement
min = -1.515E-06
max = 1.512E-06

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Okotoks, Alberta CANADA

From file 7fjsd.emf Joint shear displacement

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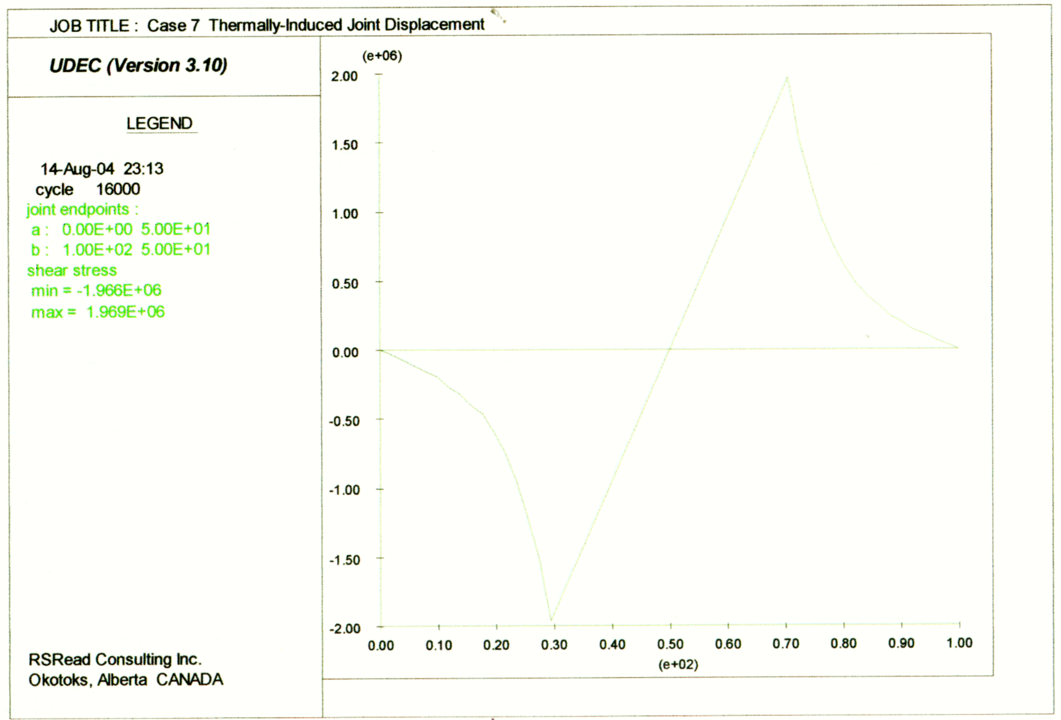

JOB TITLE : Case 7 Thermally-Induced Joint Displacement

UDEC (Version 3.10)

LEGEND

14-Aug-04 23:13
cycle 16000
joint endpoints :
a : 0.00E+00 5.00E+01
b : 1.00E+02 5.00E+01
shear stress
min = -1.966E+06
max = 1.969E+06

RSRead Consulting Inc.
Okotoks, Alberta CANADA

From file 7fjss.emf Joint shear stress

Case 7.1 - Flat Transgressing Joint above a Heated Zone. (No slip)

This case is the basis for FLAT.TXT input file for UDEC. The plots from running this input file are shown on pages 50-58. The increase in temperature within the heated zone causes outward displacement from the center of the heated zone, and increased stresses in the modelled volume. The shear and normal displacements on the horizontal joint are very ~~smooth~~ R Aug 14/04 small but follow a consistent pattern. The general pattern of stresses and displacements agrees with expected responses for stress and displacement.

* Note that stresses in FLAC and UDEC use a convention of compression = negative stress.

Properties assigned to the blocks and joints in this run are as follows:

Mass density 2210 kg/m³
Bulk modulus 19 GPa
Shear modulus 13 GPa
Joint normal stiffness 1900 GPa
Joint shear stiffness 1300 GPa.
Joint cohesion $1e^{20}$ Pa
Joint friction ~~J friction~~ R Aug 14/04 0 degrees
joint tensile strength $1e^{20}$ Pa
Joint dilation angle 0°
Coefficient of thermal expansion $15.0e^{-6}$
Thermal conductivity 20 (W/mK)
Specific heat 1000 J/(kg K)

Heat Source.
$50 kW/m^3 \times 25 m^2$
$= 1250$ kW/m

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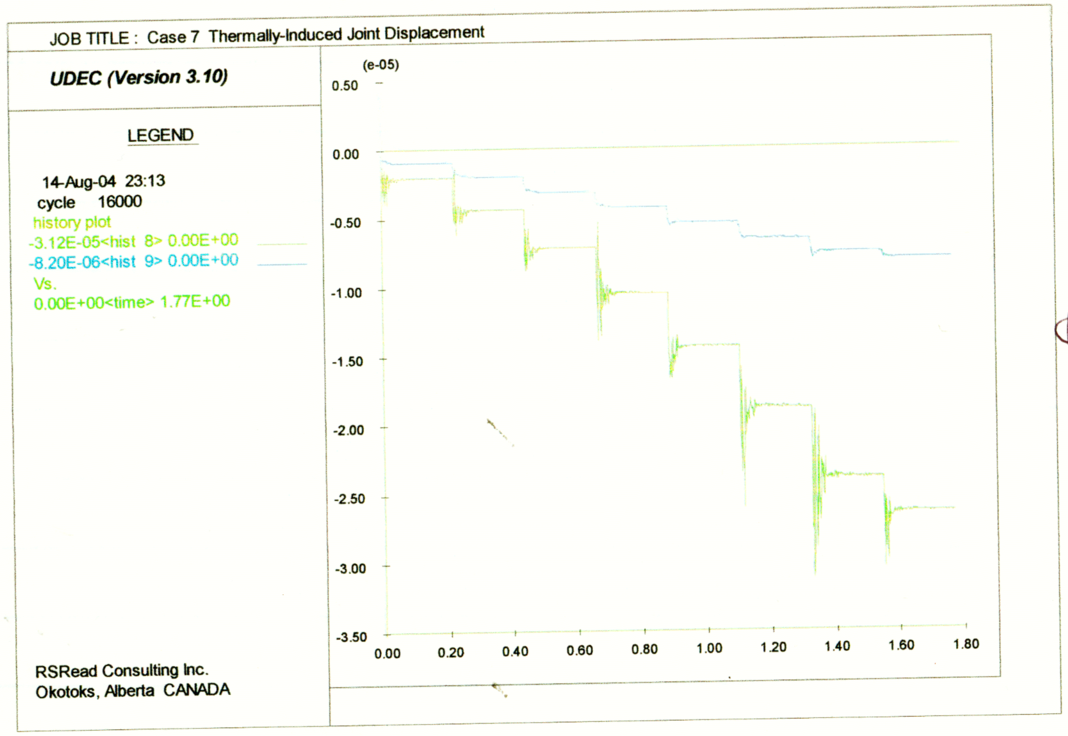
Note: Plot for normal and shear displacement for Case 7.1 (FLAT.TXT) inadvertently missed - contained below.



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From file 7jns.emf   Normal and shear displacement at center of joint

Results (Case 7.1)

The results from Case 7.1 for a horizontal transgressing joint above a heat source, with slip prevented by artificially increasing the values of joint strength, demonstrate that the model responds appropriately in a qualitative sense. Displacements and stresses are generated in the model as a results of heating. No slip occurs along the joints, and displacements on joints are very small due to the high stiffness values used for joints. This case will be compared with a similar geometry run using FLAC 4.0.

Case 7.2 Horizontal joint with slip allowed.

The UDEC input file FLAT.TXT was modified to change the joint properties to allow slip to occur. The new input file was saved as FLAT2.TXT (see page 62). The plots generated for this case follow the input file on pages 63 to 71.

The joint properties applied to the horizontal transgressing joint were as follows:

joint cohesion	100 kPa
joint friction	20°
joint dilation	0°
joint tensile strength	1 MPa
joint normal stiffness	190 GPa
joint shear stiffness	130 GPa

Results (Case 7.2)

The plots from Case 7.2 using UDEC confirm that joint slip occurs along a limited portion of the transgressing joint. This results in localized large shear displacements. The influence of the slipping joint on the displacement pattern and stress distribution within the modeled volume is evident in the plots.

These results confirm that heating of a rock volume near a transgressing joint with realistic strength properties can result

(cont. pg 71)

```
; Case 7.2 Flat transgressing joint in a heated
; infinite rock mass (slip allowed on joint)
;
config thermal
set mech on
;
; Geometry
;
rou 0.001
bl 0,0 0,100 100,100 100,0
crack 0 50 100 50
crack 0 47.5 100 47.5
crack 47.5 42.5 47.5 47.5
crack 52.5 42.5 52.5 47.5
crack 0 42.5 100 42.5
gen quad 2.0
;
; Material properties
;
prop m=1 de=2210.0 k=19.0e9 g=13.0e9
prop jm=1 jkn=19.0e11 jks=13.0e11
prop jm=1 jcoh=1.0e20 jfric=0.0 jten=1.0e20 jd=0
prop m=1 thexp=15.0e-6 cond=20.0 spec=1000.0
prop jm=2 jkn=19.0e10 jks=13.0e10
prop jm=2 jcoh=100.0e3 jfric=20.0 jten=1.0e6 jd=0
change jmat 2 range 0 100 49.9 50.1
;
; Initial conditions
;
initem 34.0 0 100 0 100
;
; Boundary conditions
;
bound yvel 0.0 range (0,100) (-0.1, 0.1)
bound yvel 0.0 range (0,100) (99.1, 100.1)
bound xvel 0.0 range (-0.1, 0.1) (0,100)
bound xvel 0.0 range (99.1, 100.1) (0,100)
;
; Apply heat source
;
thapp source 50000 0 range 47.5 52.5 42.5 47.5
;
; Thermal histories
;
thist temp 50,45 ;1
thist temp 50,47 ;2
thist temp 50,50 ;3
thist temp 50,60 ;4
thist temp 50,75 ;5
thist temp 50,100 ;6
;
; Mechanical histories
;
hist ydisp 50,45 ;1
hist ydisp 50,47 ;2
hist ydisp 50,50 ;3
hist ydisp 50,60 ;4
hist ydisp 50,75 ;5
hist ydisp 50,100 ;6
hist unbalanced ;7
hist ndis 50 50 ;8
hist sdis 50 50 ;9
;
; Thermal mechanical analysis
;
;
set nther 2500
set nmech 2000
run age 1000000 temp 50
;
save 7f2final.sav
;
set plot emf color
set color iw
title
Case 7.2  Thermally-Induced Joint Displacement (Slip Allowed)
;
; Joint condition plots
;
set out 7f2jndl.emf
plot joint 0 50 100 50 ndisp 0.05
copy
;
set out 7f2jsdl.emf
plot joint 0 50 100 50 sdisp 0.05
copy
;
set out 7f2jssl.emf
plot joint 0 50 100 50 sstr 0.05
copy
;
set out 7f2jnsl.emf
plot joint 0 50 100 50 nstr 0.05
copy
;
```

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```
; Contour plots
;
set out 7f2tempc.emf
plot temp fill temp iw blo iw
copy
;
set out 7f2dispc.emf
plot disp blo iw
copy
;
set out 7f2xdc.emf
plot xd fill xd iw blo iw
copy
;
set out 7f2ydc.emf
plot yd fill yd iw blo iw
copy
;
set out 7f2sig1c.emf
plot sig1 fill sig1 iw blo iw
copy
;
set out 7f2sig2c.emf
plot sig2 fill sig2 iw blo iw
copy
;
set out 7f2sdifc.emf
plot sdiff fill sdiff iw blo iw
copy
;
; History plots
;
set out 7f2thisth.emf
plo thist 1 2 3 4 5 6
copy
;
set out 7f2ydhisth.emf
plo hist 1 2 3 4 5 6
copy
;
set out 7f2unbalh.emf
plo hist 7
copy
;
set out 7f2jnsh.emf
plo hist 8 9
copy
;
; Joint condition plots
;
set out 7f2shear.emf
plo blo iw shear red
copy
;
set out 7f2slip.emf
plo blo iw slip red
copy
;
ret
```

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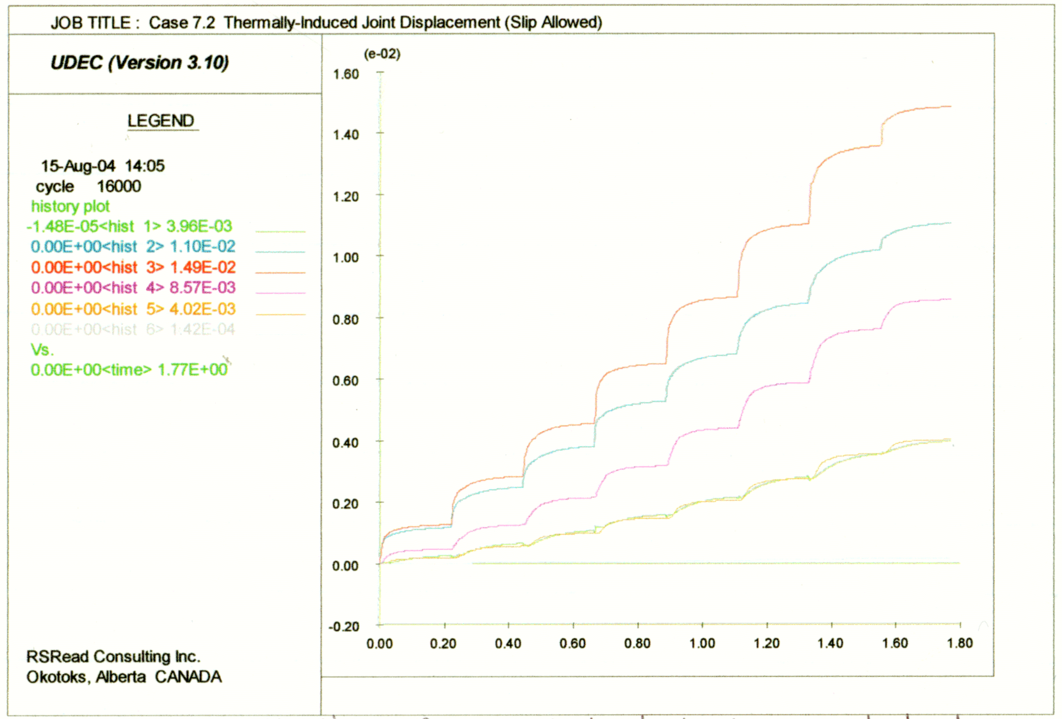
UDEC input file

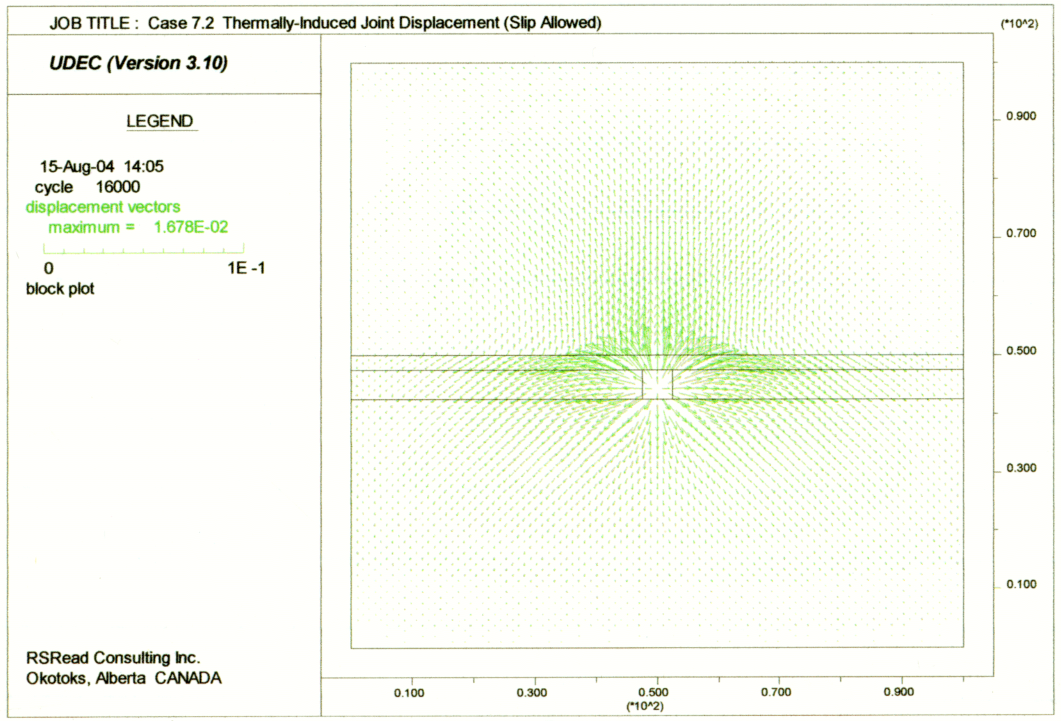
FLATZ.TXT used

for Case 7.2

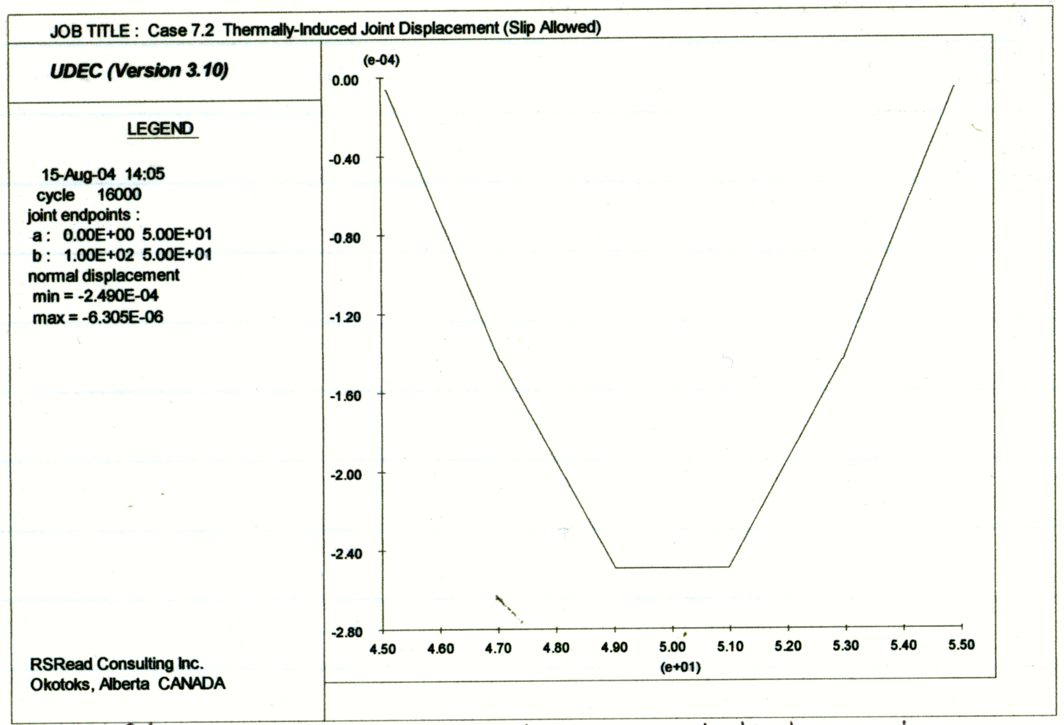


From file 7f2ydhisth.emf   Vertical displacement histories

Aug 15/2004



From file 7f2dispc.emf   Displacement vectors



JOB TITLE : Case 7.2 Thermally-Induced Joint Displacement (Slip Allowed)

UDEC (Version 3.10)

LEGEND

15-Aug-04 14:05
cycle 16000
joint endpoints :
a : 0.00E+00 5.00E+01
b : 1.00E+02 5.00E+01
normal displacement
min = -2.490E-04
max = -6.305E-06

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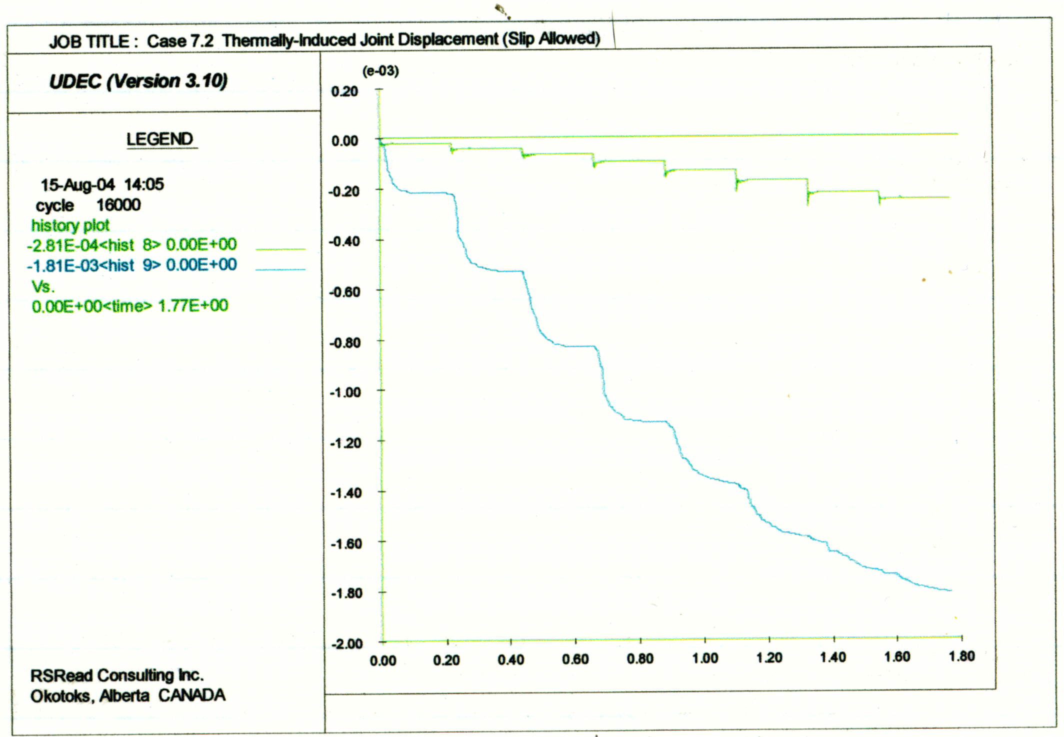
From file 7f2jndl.emf Joint normal displacement vs position

Aug 15/2004



JOB TITLE : Case 7.2 Thermally-Induced Joint Displacement (Slip Allowed)

UDEC (Version 3.10)

LEGEND

15-Aug-04 14:05
cycle 16000
history plot
-2.81E-04<hist 8> 0.00E+00
-1.81E-03<hist 9> 0.00E+00
Vs.
0.00E+00<time> 1.77E+00

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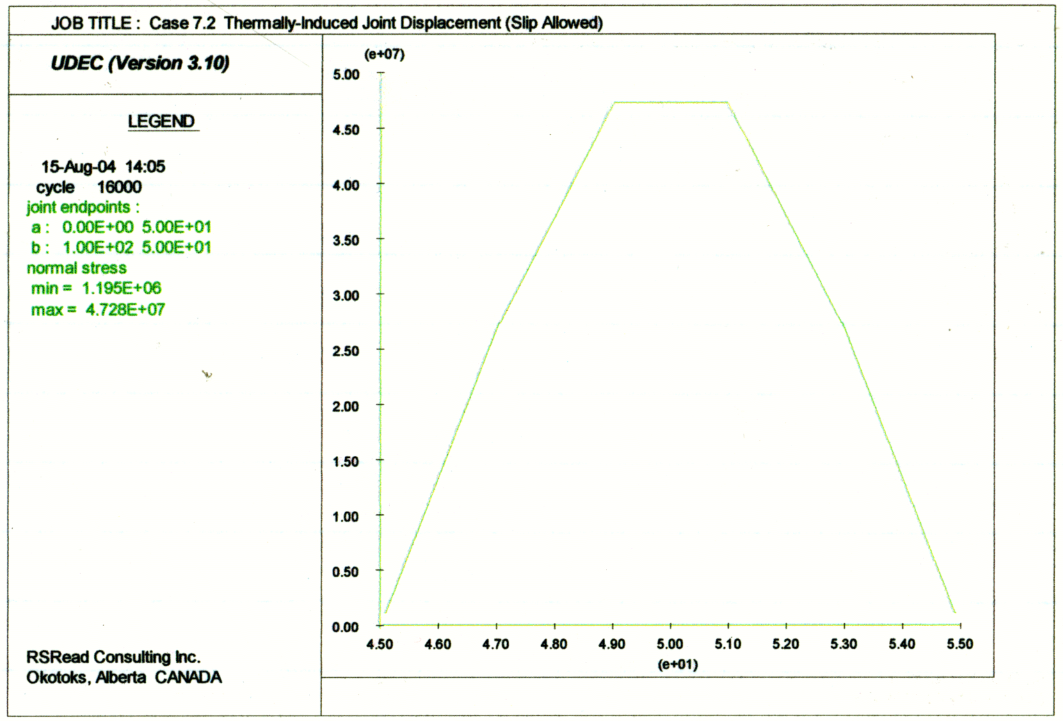
From file 7f2jnsh.emf ~~Joint~~ Normal displacement history at x=50 y=50

Aug 15/04



JOB TITLE : Case 7.2 Thermally-Induced Joint Displacement (Slip Allowed)

UDEC (Version 3.10)

LEGEND

15-Aug-04 14:05
cycle 16000
joint endpoints :
a : 0.00E+00 5.00E+01
b : 1.00E+02 5.00E+01
normal stress
min = 1.195E+06
max = 4.728E+07

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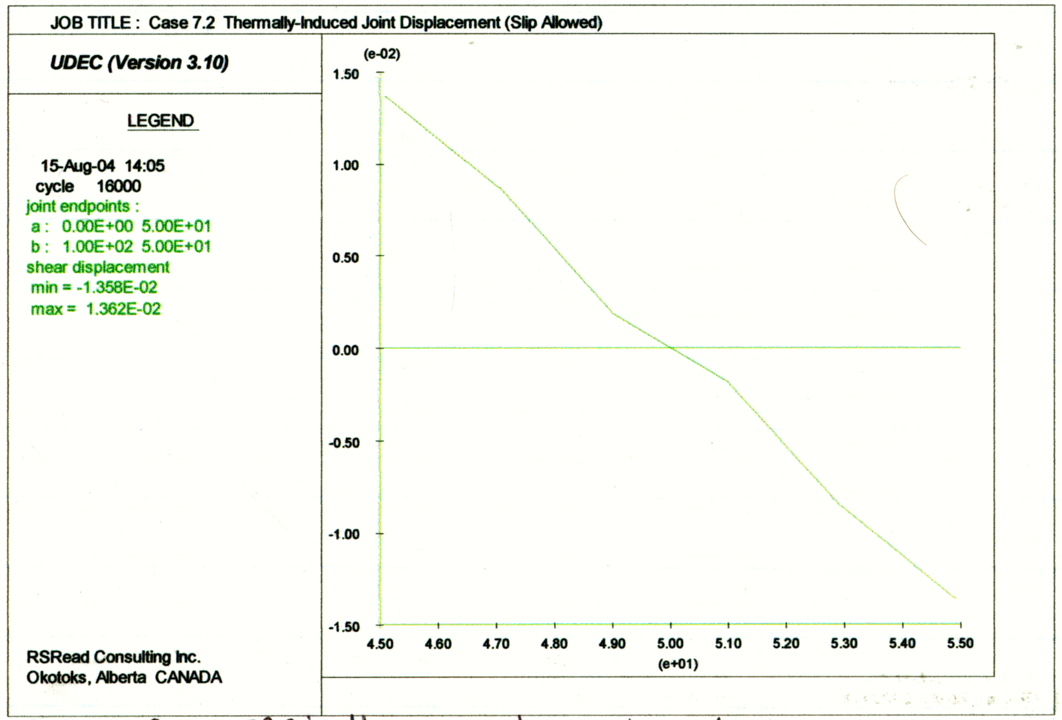
From file 7f2jnsl.emf Joint normal stress vs position

Aug 15/2004



JOB TITLE : Case 7.2 Thermally-Induced Joint Displacement (Slip Allowed)

UDEC (Version 3.10)

LEGEND

15-Aug-04 14:05
cycle 16000
joint endpoints :
a : 0.00E+00 5.00E+01
b : 1.00E+02 5.00E+01
shear displacement
min = -1.358E-02
max = 1.362E-02

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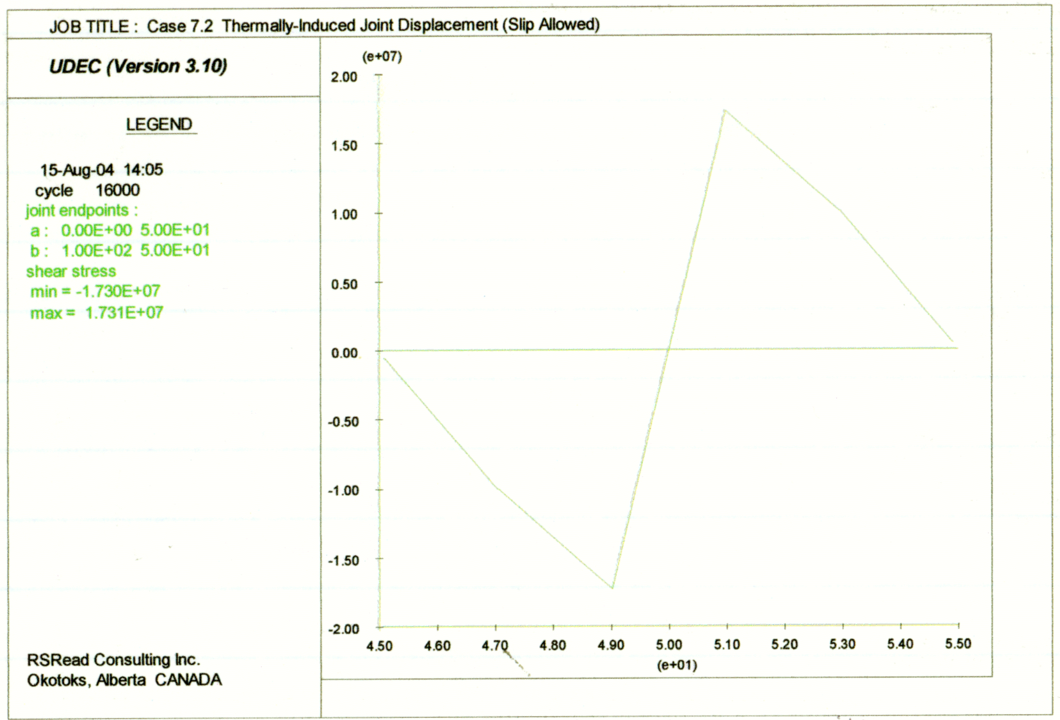
From file 7f2jsdl.emf Joint shear displacement vs position


JOB TITLE : Case 7.2 Thermally-Induced Joint Displacement (Slip Allowed)

UDEC (Version 3.10)

LEGEND

15-Aug-04 14:05
cycle 16000
joint endpoints :
a : 0.00E+00 5.00E+01
b : 1.00E+02 5.00E+01
shear stress
min = -1.730E+07
max = 1.731E+07

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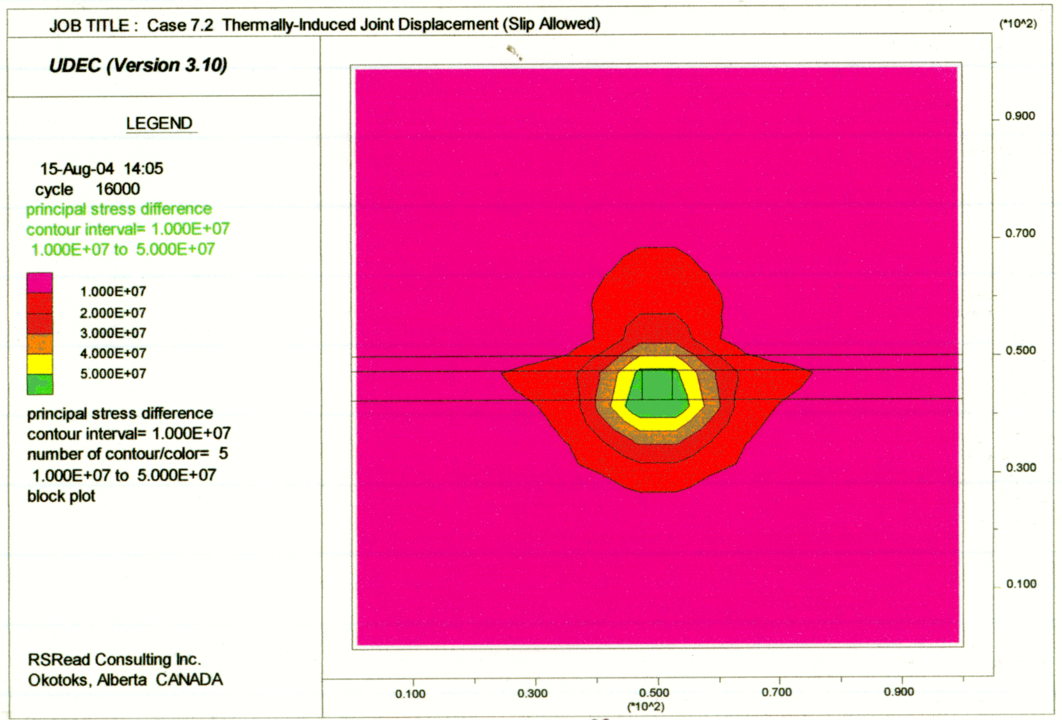
From file 7f2jss1.emf Joint shear stress vs position

Aug 15/04.


JOB TITLE : Case 7.2 Thermally-Induced Joint Displacement (Slip Allowed)

UDEC (Version 3.10)

LEGEND

15-Aug-04 14:05
cycle 16000
principal stress difference
contour interval= 1.000E+07
1.000E+07 to 5.000E+07

1.000E+07
2.000E+07
3.000E+07
4.000E+07
5.000E+07

principal stress difference
contour interval= 1.000E+07
number of contour/color= 5
1.000E+07 to 5.000E+07
block plot

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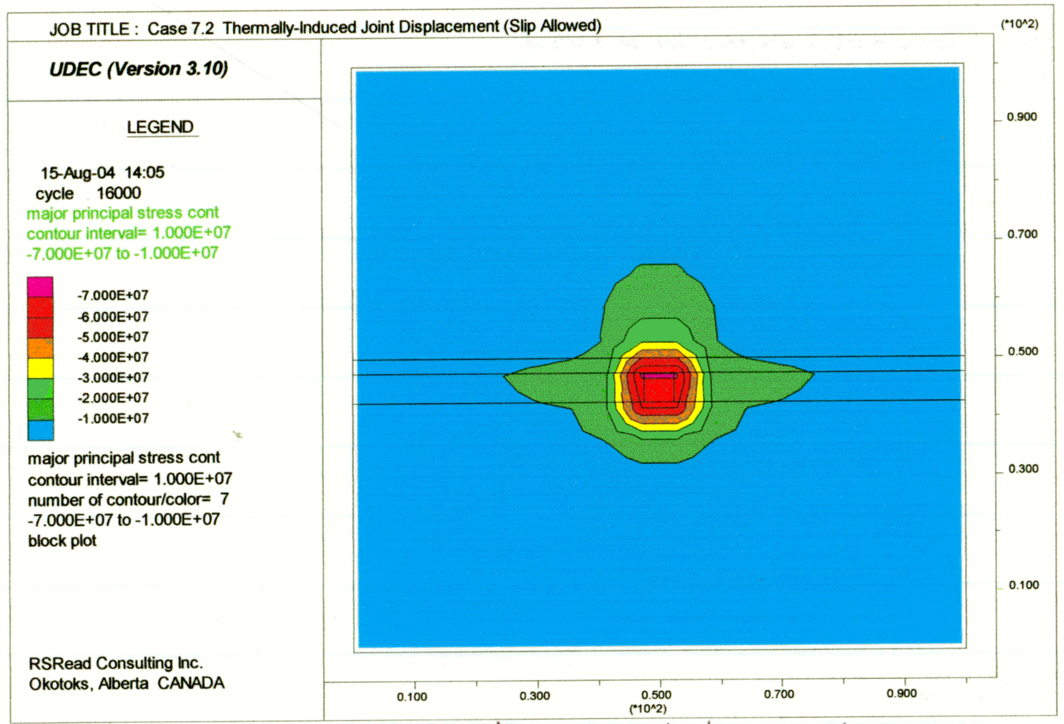
From file 7f2sdifc.emf Stress difference contour plot


JOB TITLE : Case 7.2 Thermally-Induced Joint Displacement (Slip Allowed)

UDEC (Version 3.10)

LEGEND

15-Aug-04 14:05
cycle 16000
major principal stress cont
contour interval= 1.000E+07
-7.000E+07 to -1.000E+07

-7.000E+07
-6.000E+07
-5.000E+07
-4.000E+07
-3.000E+07
-2.000E+07
-1.000E+07

major principal stress cont
contour interval= 1.000E+07
number of contour/color= 7
-7.000E+07 to -1.000E+07
block plot

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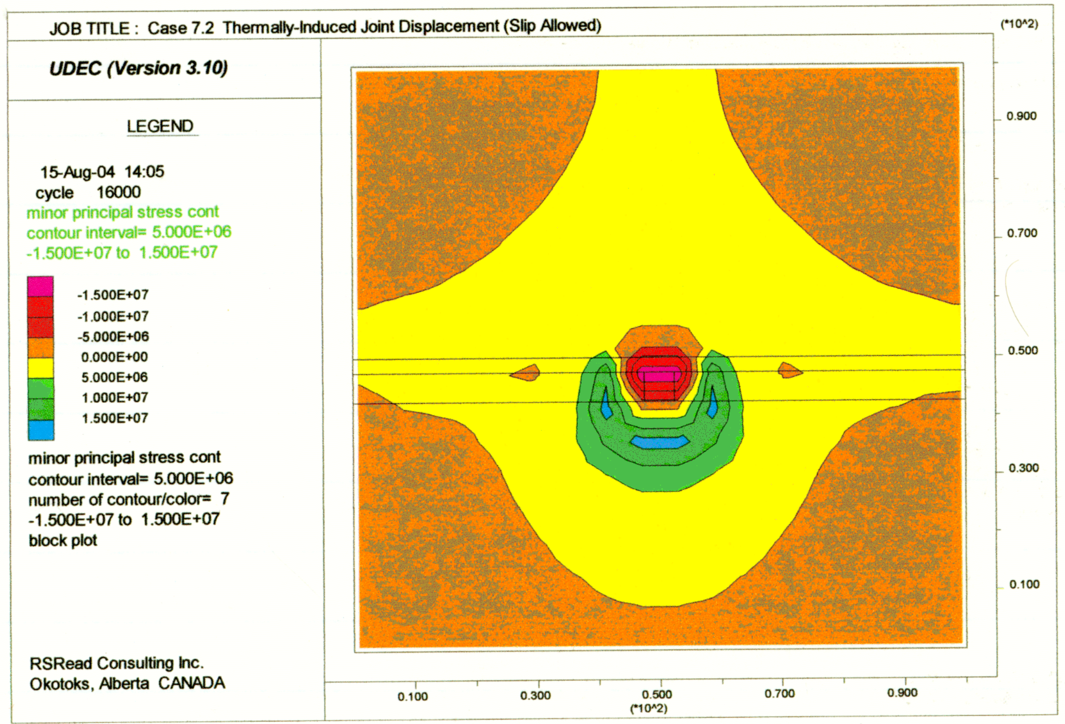
From file 7f2sig1c.emf Max principal stress contours

Aug 15/04


JOB TITLE : Case 7.2 Thermally-Induced Joint Displacement (Slip Allowed)

UDEC (Version 3.10)

LEGEND

15-Aug-04 14:05
cycle 16000
minor principal stress cont
contour interval= 5.000E+06
-1.500E+07 to 1.500E+07

-1.500E+07
-1.000E+07
-5.000E+06
0.000E+00
5.000E+06
1.000E+07
1.500E+07

minor principal stress cont
contour interval= 5.000E+06
number of contour/color= 7
-1.500E+07 to 1.500E+07
block plot

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From file 7f2sig2c.emf Min principal stress contours.