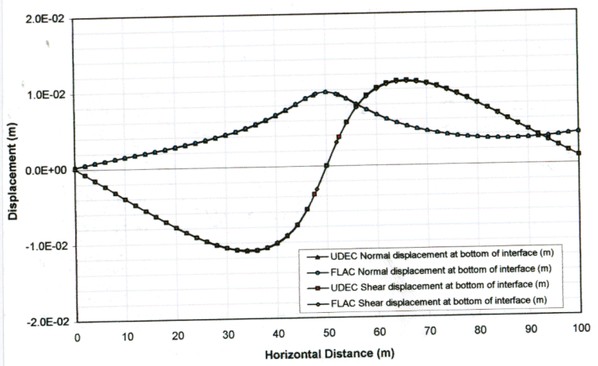
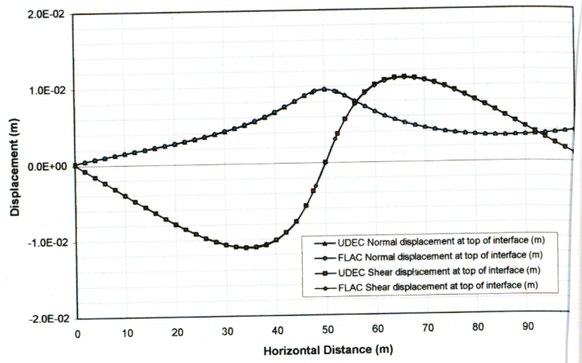
SN673 Vol 1

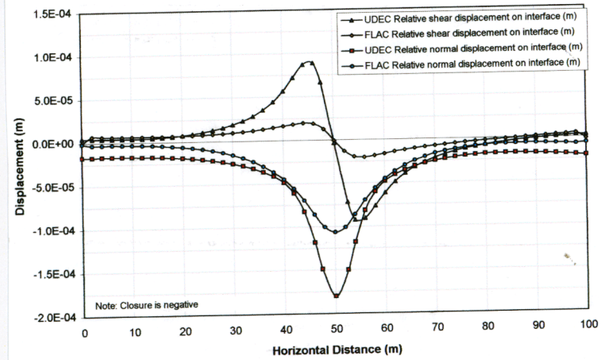
Case 7.7 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (No Slip Allowed)



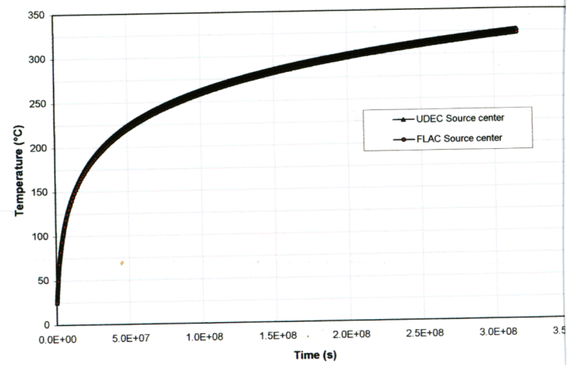
Case 7.7 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (No Slip Allowed)



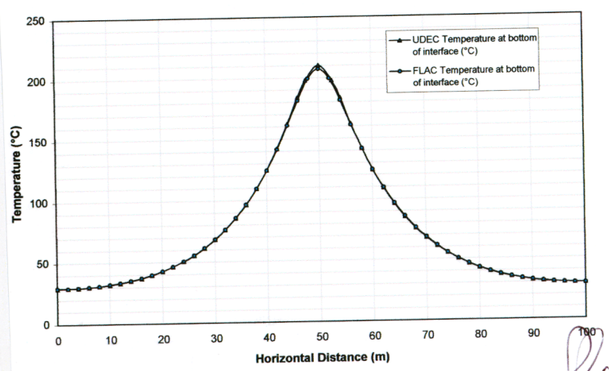
Case 7.7 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (No Slip Allowed)



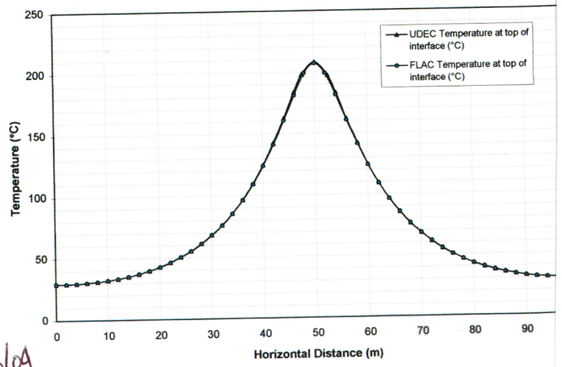
Case 7.7 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (No Slip Allowed)



Case 7.7 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (No Slip Allowed)



Case 7.7 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (No Slip Allowed)



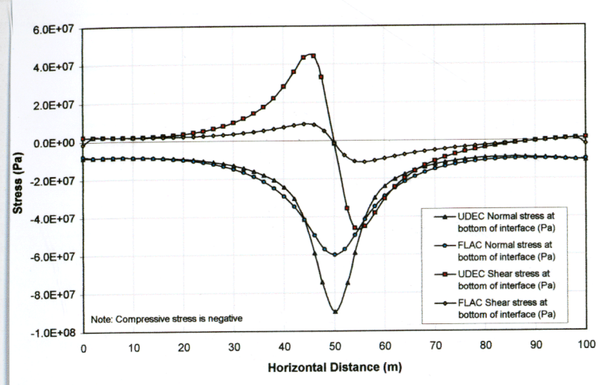
Sep 30/04.

File C77.xls Comparison of UDEC/FLAC Case 7.7.

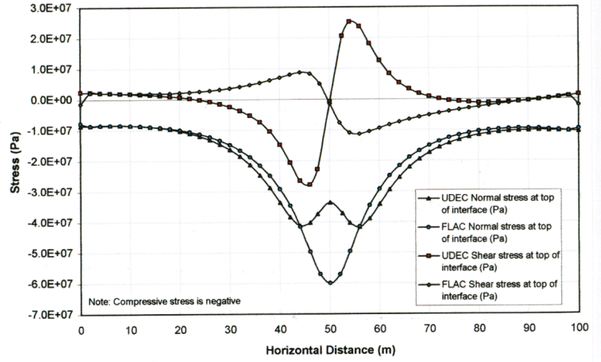
SN673 Vol 1.

Sep 30/04.

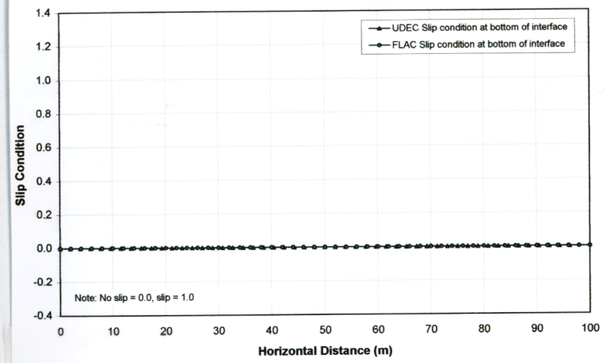
Case 7.7 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (No Slip Allowed)



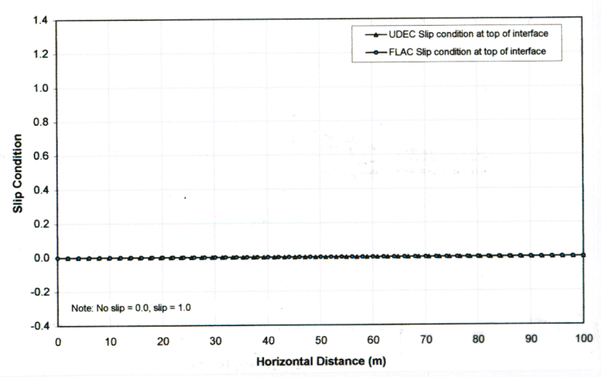
Case 7.7 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (No Slip Allowed)



Case 7.7 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (No Slip Allowed)



Case 7.7 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (No Slip Allowed)



File C77.xls Comparison of UDEC/FLAC Case 7.7.

Sep 30/04

- File u78input.txt created and test run conducted.
- Plots saved in file u78plots.doc. under directory /Case7/UDEC/

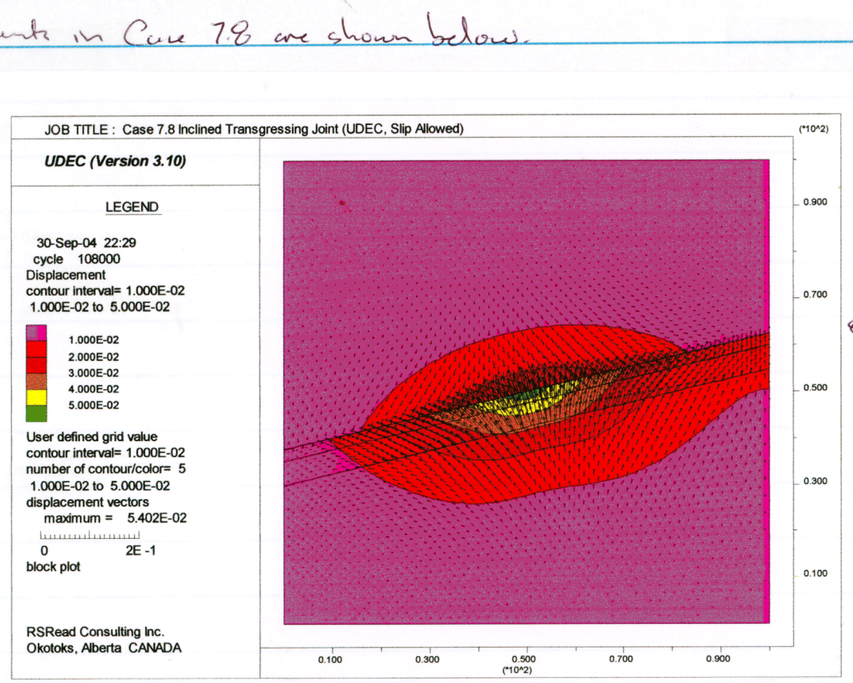
Sep 30/04

Notebook SN673 and 654 (Vol 1) packaged for delivery to CNWRA for copying.

SN 673 Vol 1.

Oct 5/2004 R

- updated files f71.xls, f72.xls, f73.xls, f74.xls, f77.xls, f78.xls u78.xls and associated comparison files c71.xls, c72.xls, c73.xls, c74.xls, c77.xls, c78.xls - mean values were summarized improperly in summary tables.
- Case 7.8 - UDEC file u78.input.txt run to create UDEC output. Plots captured in u78plots.doc under directory /Case 7/UDEC. See pages 81-83 for code for u78.input.txt
- Note that u78.input.txt was modified slightly to correct an issue with producing u78bdata.out, an output file from UDEC.
- Displacements in Case 78 are shown below.



Oct 5/2004

UDEC file u78disp.emf Displacement contours and vectors.


```
; Case 7.8 UDEC Base case with inclined transgressing joint
in a heated
; infinite rock mass (slip allowed on joint, typical Yucca
Mountain
; properties and conditions used, source 1500 W/m).
;
config thermal
set mech on
;
; Key Points
;
;A, 0.000, 37.534
;B, 100.000, 62.466
;C, 0.000, 34.957
;D, 100.000, 59.890
;E, 0.000, 29.804
;F, 100.000, 54.737
;G, 48.179, 46.969
;H, 49.389, 42.118
;I, 53.031, 48.179
;J, 54.240, 43.328
;K, 51.210, 45.149
;L, 50.605, 47.574
;M, 50.000, 50.000
;N, 48.790, 54.851
;O, 45.162, 69.406
;P, 37.534, 100.000
;Q, 0.000, 37.534
;R, 18.465, 42.138
;S, 30.594, 45.162
;T, 40.297, 47.581
;U, 47.574, 49.395
;V, 50.000, 50.000
;W, 52.426, 50.605
;X, 59.703, 52.419
;Y, 69.406, 54.838
;Z, 81.535, 57.862
;AA, 100.000, 62.466
;
; Geometry
;
rou 0.001
bl 0,0 0,100 100,100 100,0
crack 0.000 37.534 100.000 62.466 ; Main joint A-B
crack 0.000 34.957 100.000 59.890 ; Top C-D
crack 0.000 29.804 100.000 54.737 ; Bottom E-F
crack 48.179 46.969 49.389 42.118 ; Left side G-H
crack 53.031 48.179 54.240 43.328 ; Right side I-J
;
;
gen quad 2.0
;
; Material properties
;
prop m=1 de=2210.0 k=19.2e9 g=13.6e9
prop jm=1 jkn=5.0e11 jks=5.0e11
prop jm=1 jcoh=1.0e20 jfric=0.0 jten=1.0e20 jd=0
prop m=1 thexp=10.0e-6 cond=2.13 spec=990.0
;
prop jm=2 jkn=5.0e4 jks=5.0e4
prop jm=2 jcoh=100.0e3 jfric=41.0 jten=40.0e3 jd=0
;
; Initial conditions
;
initemp 25.0 0 100 0 100
;
ini syy -8.1e6 grad 0 0.022e6
ini sxx -2.1546e6 grad 0 0.005852e6
ini sxy 0.0
ini szz -2.1546e6 grad 0 0.005852e6
;
; 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 1500 0 range 49.389 53.031 43.328 46.969
;
; Equilibrate model
;
set ovtol 0.1
step 4000
;
; Alter joint properties
;
change jmat=2 range block 358 143
change jmat=2 range block 143 358
;
; Zero displacements and velocities
;
ini xd 0
ini yd 0
ini nd 0
ini sd 0
ini xv 0
ini yv 0
ini bxv 0
ini byv 0
ini brv 0
;
; Thermal histories
;
thist temp 51.210, 45.149  ; 1
thist temp 50.605, 47.574  ; 2
thist temp 50.000, 50.000  ; 3
thist temp 48.790, 54.851  ; 4
thist temp 45.162, 69.406  ; 5
thist temp 37.534, 100.000 ; 6
;
; Time and unbalanced force histories
;
hist thtime ; 1
hist unbal ; 2
;
; Mechanical histories
;
hist ydisp 51.210, 45.149  ; 3
hist ydisp 50.605, 47.574  ; 4
hist ydisp 50.000, 50.000  ; 5
hist ydisp 48.790, 54.851  ; 6
hist ydisp 45.162, 69.406  ; 7
hist ydisp 37.534, 100.000 ; 8
;
hist xdisp 51.210, 45.149  ; 9
hist xdisp 50.605, 47.574  ; 10
hist xdisp 50.000, 50.000  ; 11
hist xdisp 48.790, 54.851  ; 12
hist xdisp 45.162, 69.406  ; 13
hist xdisp 37.534, 100.000 ; 14
;
; Histories of normal displacement along joint
;
hist ndis 0.000  37.534 ;15
hist ndis 18.465 42.138 ;16
hist ndis 30.594 45.162 ;17
hist ndis 40.297 47.581 ;18
hist ndis 47.574 49.395 ;19
hist ndis 50.000 50.000 ;20
hist ndis 52.426 50.605 ;21
hist ndis 59.703 52.419 ;22
hist ndis 69.406 54.838 ;23
hist ndis 81.535 57.862 ;24
hist ndis 100.00 62.466 ;25
;
; Histories of shear displacement along joint
;
hist sdis 0.000  37.534 ;26
hist sdis 18.465 42.138 ;27
hist sdis 30.594 45.162 ;28
hist sdis 40.297 47.581 ;29
hist sdis 47.574 49.395 ;30
hist sdis 50.000 50.000 ;31
hist sdis 52.426 50.605 ;32
hist sdis 59.703 52.419 ;33
hist sdis 69.406 54.838 ;34
hist sdis 81.535 57.862 ;35
hist sdis 100.00 62.466 ;36
;
; Histories of sratio along joint
;
hist srat 0.000  37.534 ;37
hist srat 18.465 42.138 ;38
hist srat 30.594 45.162 ;39
hist srat 40.297 47.581 ;40
hist srat 47.574 49.395 ;41
hist srat 50.000 50.000 ;42
hist srat 52.426 50.605 ;43
hist srat 59.703 52.419 ;44
hist srat 69.406 54.838 ;45
hist srat 81.535 57.862 ;46
hist srat 100.00 62.466 ;47
;
; Thermal mechanical analysis
;
damp auto
run age 50000
step 2000
set nther 2500
set nmech 2000
run age 315400000 temp 50 s 1000000
step 4000
;
cal dispmag.fis
disp_mag
save u78final.sav
;
```

Oct 5/04.

3 of 3

File u78mat.txt (UDEC input for Case u78)

```
set plot emf color
title
Case 7.8 Inclined Transgressing Joint (UDEC, Slip Allowed)
;
; Geometry
;
set out u78grid.emf
set color iw
plo zone green blo iw
copy

; Joint condition plots
;
set out u78jndl.emf
set color iw
plot joint 0 37.534 100 62.466 ndisp 2
copy
;
set out u78jnsl.emf
set color iw
plot joint 0 37.534 100 62.466 nstr 2
copy
;
set out u78jsdl.emf
set color iw
plot joint 0 37.534 100 62.466 sdisp 2
copy
;
set out u78jssl.emf
set color iw
plot joint 0 37.534 100 62.466 sstr 2
copy
;
set out u78shear.emf
set color iw
plo blo iw shear red
copy
;
set out u78slip.emf
set color iw
plo blo iw slip red
copy
;
; Contour plots
;
set out u78temp.emf
set color iw
plot temp fill temp iw blo iw
copy
;
set out u78disp.emf
set color iw
plot gp_extra fill alias 'Displacement' gp_extra iw disp iw
blo iw
copy
;
set out u78xd.emf
set color iw
plot xd fill xd iw blo iw
copy
;
set out u78yd.emf
set color iw
plot yd fill yd iw blo iw
copy
;
set out u78sig1.emf
set color iw
plot sig1 fill sig1 iw blo iw
copy
;
set out u78sig2.emf
set color iw
plot sig2 fill sig2 iw blo iw
copy
;
set out u78sdif.emf
set color iw
plot sdiff fill sdiff iw blo iw
copy
;
; History plots
;
set out u78thist.emf
set color iw
plo thist 1 2 3 4 5 6
copy
;
set out u78ydhist.emf
set color iw
plo hist 3 4 5 6 7 8
copy
;
set out u78xdhist.emf
set color iw
```

```
plo hist 9 10 11 12 13 14
copy
;
set out u78unbal.emf
set color iw
plo hist 2
copy
;
set out u78jndh.emf
set color iw
plo hist 15 16 17 18 19 20 21 22 23 24 25 vs 1
copy
;
set out u78jsdh.emf
set color iw
plo hist 26 27 28 29 30 31 32 33 34 35 36 vs 1
copy
;
set out u78jsrh.emf
set color iw
plo hist 37 38 39 40 41 42 43 44 45 46 47 vs 1
copy
;
;
; Create output tables
;
def xxx
  nn=2000
end
xxx
def table_fill
  array u78c(13,nn)
  array u78b(9,nn)
  ic=contact_head
  ib=block_head
  ii=1
  thvalr=thvald*pi/180.0
  mval=tan(thvalr)
  bval=50.0-50.0*mval
;
; Contact information
;
  loop while ic # 0
    xval=c_x(ic)
    yval=c_y(ic)
    ycal=mval*xval+bval
    lval=sqrt(xval^2+(yval-bval)^2)
    blk1=c_b1(ic)
    blk2=c_b2(ic)
    clval=c_length(ic)
    dclos=c_ndis(ic)
    dride=c_sdis(ic)
    nfval=c_nforce(ic)
    sfval=c_sforce(ic)
    nsval=-nfval/clval
    ssval=-sfval/clval
    tyval=c_type(ic)
    slipc=fmem(ic+$kgam)
;
; Create table entries
;
   if abs(yval-ycal)<0.1 then
    table(1,ii)=yval
    table(2,ii)=xval
    table(3,ii)=lval
    table(4,ii)=blk1
    table(5,ii)=blk2
    table(6,ii)=nfval
    table(7,ii)=sfval
    table(8,ii)=dclos
    table(9,ii)=dride
    table(10,ii)=nsval
    table(11,ii)=ssval
    table(12,ii)=tyval
    table(13,ii)=slipc
;
; Array entries
;
     u78c(1,ii)=string(yval)
     u78c(2,ii)=string(xval)
     u78c(3,ii)=string(lval)
     u78c(4,ii)=string(blk1)
     u78c(5,ii)=string(blk2)
     u78c(6,ii)=string(nfval)
     u78c(7,ii)=string(sfval)
     u78c(8,ii)=string(dclos)
     u78c(9,ii)=string(dride)
     u78c(10,ii)=string(nsval)
     u78c(11,ii)=string(ssval)
     u78c(12,ii)=string(tyval)
     u78c(13,ii)=string(slipc)
     ii=ii+1
    end_if
    ic=c_next(ic)
  end_loop
```

Oct 5/04

Pg 2 of 3


```
  ii=1
;
; Gridpoints on joint
;
  loop while ib # 0
    cg=b_gp(ib)
    loop while cg # 0
      blkc=ib
      xval=gp_x(cg)
      yval=gp_y(cg)
      ycal=mval*xval+bval
      lval=sqrt(xval^2+(yval-bval)^2)
      dxval=gp_xdis(cg)
      dyval=gp_ydis(cg)
      thetav=atan2(dyval,dxval)
      dtvalb=sqrt((dxval*dxval)+(dyval*dyval))
      dsval=dtvalb*cos(thetav-thvalr)
      dnval=dtvalb*sin(thetav-thvalr)
      gtemp=fmem(cg+$kgtemp)
;
; Create table entries
;
      if abs(yval-ycal)<0.1 then
        table(13,ii)=yval
        table(14,ii)=xval
        table(15,ii)=lval
        table(16,ii)=blkc
        table(17,ii)=dxval
        table(18,ii)=dyval
        table(19,ii)=dsval
        table(20,ii)=dnval
;
; Array entries
;
        u78b(1,ii)=string(yval)
        u78b(2,ii)=string(xval)
        u78b(3,ii)=string(lval)
        u78b(4,ii)=string(blkc)
        u78b(5,ii)=string(dxval)
        u78b(6,ii)=string(dyval)
        u78b(7,ii)=string(dsval)
        u78b(8,ii)=string(dnval)
        u78b(9,ii)=string(gtemp)
        ii=ii+1
      end_if
      cg=gp_next(cg)
    end_loop
    ib=b_next(ib)
  end_loop
  status=open('u78cdata.out',1,1)
  status=write(u78c,2000)
  status=close
  status=open('u78bdata.out',1,1)
  status=write(u78b,2000)
end
;
set thvald=14.0
cal contact.fin
cal jmat.fin
table_fill
;
; Write thermal histories to files
;
thist write 1 u78t1.out
thist write 2 u78t2.out
thist write 3 u78t3.out
thist write 4 u78t4.out
thist write 5 u78t5.out
thist write 6 u78t6.out
;
ret
```

```
status=open('u78bdata.out',1,1)
status=write(u78b,5000)
status=close
status=open('u78cdata.out',1,1)
status=write(u78c,5000)
status=close
```

Oct 5/04

Code modified to overcome problem writing to u78bdata.out.

Pg 3 of 3

Oct 5/04

SW673 Vol 1

Case 7.8 Summary of Results (FLAC)

Parameter	Maximum X	Maximum Value	Minimum X	Minimum Value	Mean Value	Σ Absolute Values
FLAC Shear displacement at bottom of interface (m)	64.00	2.07E-02	34.00	-2.34E-02	-1.06E-03	7.11E-01
FLAC Shear displacement at top of interface (m)	68.00	1.29E-02	32.00	-1.13E-02	7.11E-04	3.93E-01
FLAC Normal displacement at bottom of interface (m)	50.00	5.30E-02	2.00	-2.06E-04	2.16E-02	1.10E+00
FLAC Normal displacement at top of interface (m)	0.00	6.98E-03	50.00	-2.78E-02	-1.18E-02	6.20E-01
FLAC Relative normal displacement on interface (m)	0.00	-5.22E-03	50.00	-8.08E-02	-3.36E-02	1.71E+00
FLAC Relative shear displacement on interface (m)	38.00	1.23E-02	62.00	-8.24E-03	1.72E-03	3.25E-01
FLAC Total displacement at bottom of interface (m)	50.00	5.30E-02	0.00	1.20E-03	2.69E-02	1.37E+00
FLAC Total displacement at top of interface (m)	50.00	2.78E-02	100.00	1.06E-03	1.51E-02	7.72E-01
FLAC Normal stress at bottom of interface (Pa)	100.00	-6.44E+06	0.00	-6.96E+06	-6.70E+06	3.42E+08
FLAC Normal stress at top of interface (Pa)	100.00	-6.44E+06	0.00	-6.96E+06	-6.70E+06	3.42E+08
FLAC Shear stress at bottom of interface (Pa)	100.00	-1.16E+06	0.00	-1.25E+06	-1.21E+06	6.15E+07
FLAC Shear stress at top of interface (Pa)	100.00	-1.16E+06	0.00	-1.25E+06	-1.21E+06	6.15E+07
FLAC Temperature at bottom of interface (°C)	50.00	207.52	100.00	29.42	75.98	3874.99
FLAC Temperature at top of interface (°C)	50.00	207.11	0.00	29.34	75.73	3862.22
Maximum temperature at source (°C)	50.00	312.46	-	-	-	
Number of Contacts		51		51		
Number of Contacts at Slip Condition		0		0		

Case 7.8 Summary of Results (UDEC, Interpolated)

Parameter	Maximum X	Maximum Value	Minimum X	Minimum Value	Mean Value	Σ Absolute Values
UDEC Shear displacement at bottom of interface (m)	64.00	2.10E-02	36.00	-2.37E-02	-1.13E-03	7.24E-01
UDEC Shear displacement at top of interface (m)	68.00	1.31E-02	34.00	-1.15E-02	6.85E-04	4.02E-01
UDEC Normal displacement at bottom of interface (m)	50.00	5.40E-02	0.00	-1.40E-03	2.15E-02	1.10E+00
UDEC Normal displacement at top of interface (m)	100.00	1.21E-03	50.00	-2.83E-02	-1.21E-02	6.21E-01
UDEC Relative normal displacement on interface (m)	0.00	-5.59E-03	50.00	-8.23E-02	-3.37E-02	1.72E+00
UDEC Relative shear displacement on interface (m)	38.00	1.25E-02	62.00	-8.25E-03	1.84E-03	3.26E-01
UDEC Total displacement at bottom of interface (m)	50.00	5.40E-02	0.00	1.44E-03	2.71E-02	1.38E+00
UDEC Total displacement at top of interface (m)	50.00	2.84E-02	100.00	1.24E-03	1.53E-02	7.78E-01
UDEC Normal stress at bottom of interface (Pa)	54.00	-6.67E+06	68.00	-6.70E+06	-6.69E+06	3.41E+08
UDEC Normal stress at top of interface (Pa)	47.50	-6.65E+06	0.00	-6.69E+06	-6.68E+06	3.40E+08
UDEC Shear stress at bottom of interface (Pa)	56.00	-1.19E+06	0.00	-1.22E+06	-1.20E+06	6.14E+07
UDEC Shear stress at top of interface (Pa)	46.00	-1.19E+06	0.00	-1.21E+06	-1.20E+06	6.13E+07
UDEC Temperature at bottom of interface (°C)	50.00	2.10E+02	100.00	2.93E+01	7.60E+01	3875.62
UDEC Temperature at top of interface (°C)	50.00	2.08E+02	100.00	2.93E+01	7.59E+01	3871.69
Maximum temperature at source (°C)	50.00	326.70	-	-	-	-
Number of Contacts		52		51		
Number of Contacts at Slip Condition		0		0		

Case 7.8 Relative Error between UDEC and FLAC Results*

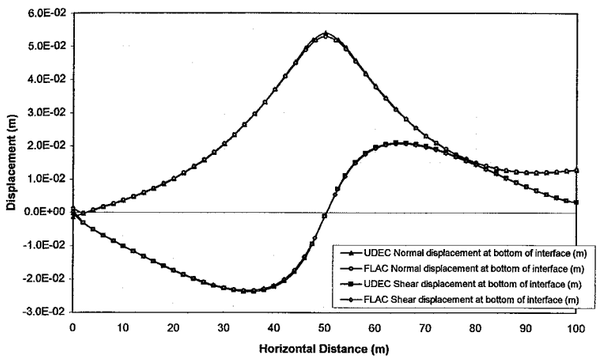
Parameter	Maximum ΔX	Maximum Error	Minimum ΔX	Minimum Error	Mean Error	Total Error
Shear displacement at bottom of interface (m)	0.0	1%	2.0	2%	0%	2%
Shear displacement at top of interface (m)	0.0	1%	2.0	1%	0%	2%
Normal displacement at bottom of interface (m)	0.0	3%	-2.0	4%	0%	0%
Normal displacement at top of interface (m)	100.0	18%	0.0	2%	1%	0%
Relative normal displacement on interface (m)	0.0	1%	0.0	3%	0%	0%
Relative shear displacement on interface (m)	0.0	1%	0.0	0%	0%	0%
Total displacement at bottom of interface (m)	0.0	4%	0.0	1%	1%	1%
Total displacement at top of interface (m)	0.0	2%	0.0	1%	0%	1%
Normal stress at bottom of interface (Pa)	-46.0	87%	68.0	100%	5%	0%
Normal stress at top of interface (Pa)	-52.5	80%	0.0	102%	9%	0%
Shear stress at bottom of interface (Pa)	-44.0	66%	0.0	80%	3%	0%
Shear stress at top of interface (Pa)	-54.0	74%	0.0	89%	8%	0%
Temperature at bottom of interface (°C)	0.0	2%	0.0	0%	0%	0%
Temperature at top of interface (°C)	0.0	1%	100.0	0%	0%	0%
Maximum temperature at source (°C)	0.0	5%	-	-	-	
Number of Contacts		2%		0%		
Number of Contacts at Slip Condition		0%		0%		

* Relative error calculated as difference between UDEC and FLAC values normalized to maximum deviation from mean along interface in either total displacement, stress, or temperature

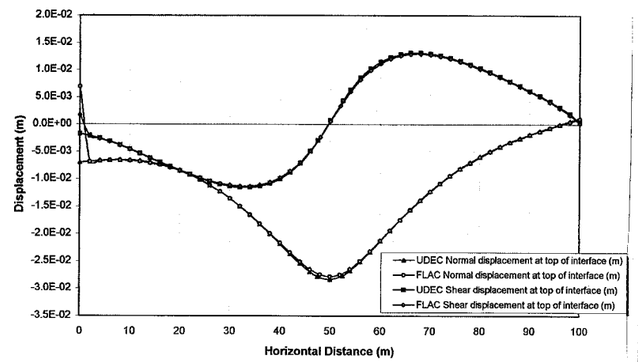
Comparison of UDEC and FLAC results for Case 7.8

SW 673 Vol 1

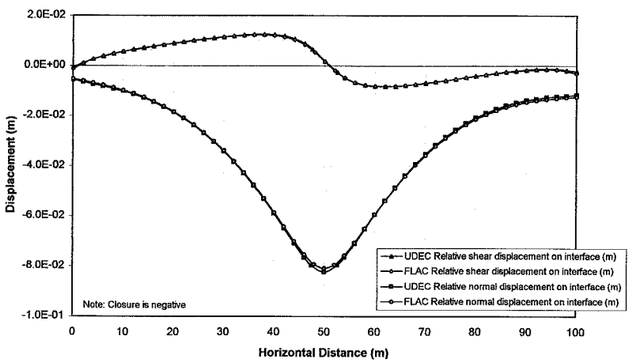
Case 7.8 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (Slip Allowed)



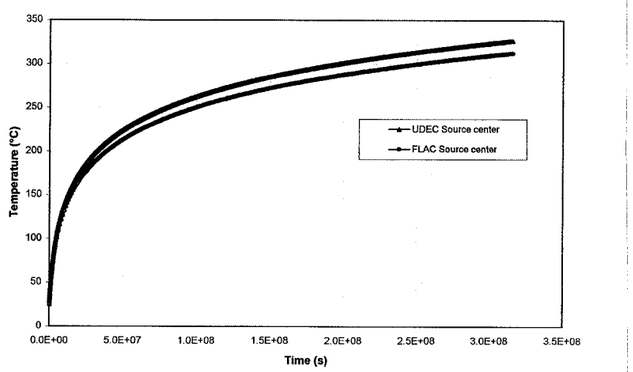
Case 7.8 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (Slip Allowed)



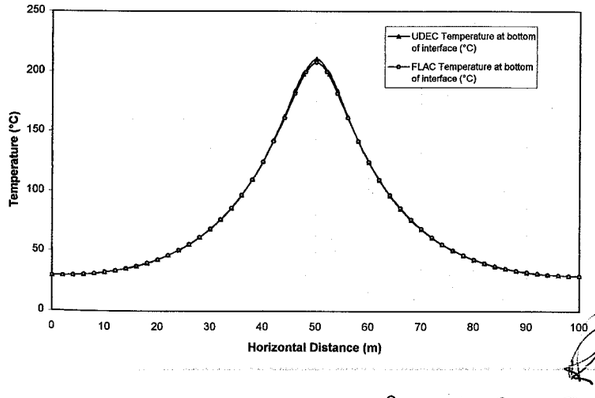
Case 7.8 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (Slip Allowed)



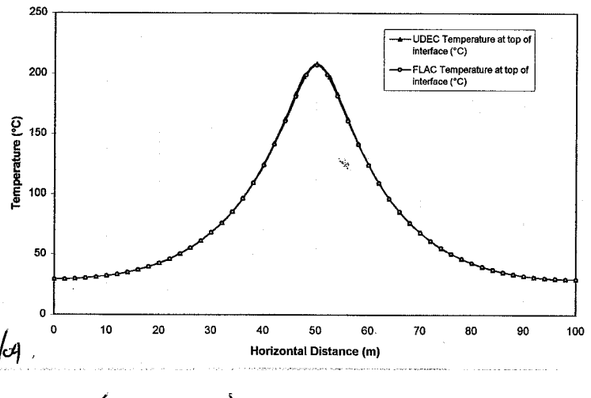
Case 7.8 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (Slip Allowed)



Case 7.8 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (Slip Allowed)



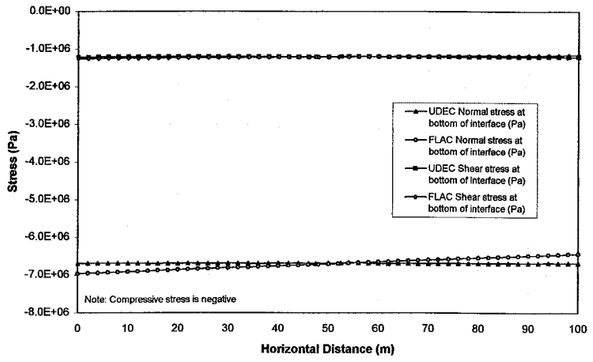
Case 7.8 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (Slip Allowed)



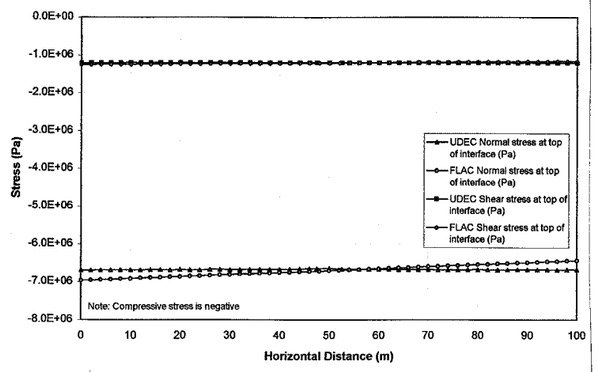
Comparison of Results for Case 7.8. (Pg 1 of 2)

SNG73 Vol 1.

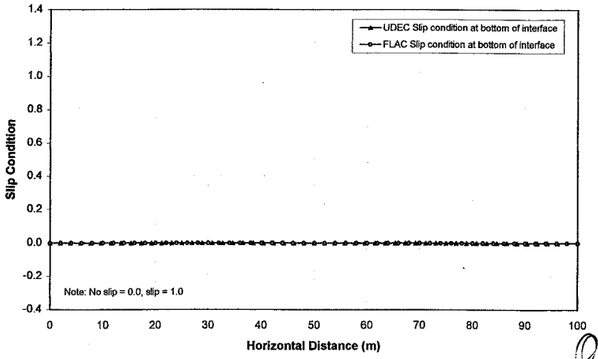
Case 7.8 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (Slip Allowed)



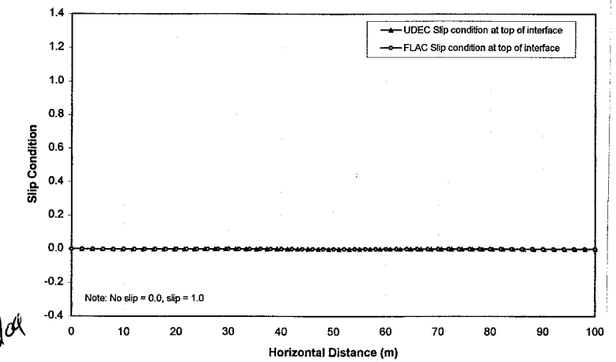
Case 7.8 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (Slip Allowed)



Case 7.8 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (Slip Allowed)



Case 7.8 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (Slip Allowed)



Posted

Comparison of Results for Case 7.8 (Pg 2 of 2)

Summary of Case 7.8 Comparison.

- very close comparison between FLAC and UDEC results, except for temperature at source center and some edge effects at the lateral boundaries.
- very low joint stiffness values used (jkn = jks = $5e^4$ Pa/m) resulted in no slippage, but almost complete stress relaxation along the interface.

Posted 5/04.

SNG73 Vol 1

Case 7.1 Summary of Results (FLAC)

Parameter	Maximum		Minimum		Mean
	X	Value	X	Value	Value
Lateral displacement at bottom of interface (m)	56.00	7.40E-03	44.00	-7.40E-03	5.84E-08
Lateral displacement at top of interface (m)	56.00	7.39E-03	44.00	-7.38E-03	6.02E-08
Normal displacement at bottom of interface (m)	50.00	1.12E-02	0.00	3.92E-04	2.15E-03
Normal displacement at top of interface (m)	50.00	1.12E-02	0.00	3.92E-04	2.15E-03
Relative normal displacement on interface (m)	60.00	3.89E-06	50.00	-2.83E-05	-9.00E-07
Relative shear displacement on interface (m)	46.00	2.32E-05	54.00	-2.32E-05	1.13E-10
Total displacement at bottom of interface (m)	50.00	1.12E-02	0.00	3.92E-04	3.88E-03
Total displacement at top of interface (m)	50.00	1.12E-02	0.00	3.92E-04	3.87E-03
Normal stress at bottom of interface (Pa)	60.00	7.40E+06	50.00	-5.36E+07	-1.72E+06
Normal stress at top of interface (Pa)	60.00	7.40E+06	50.00	-5.36E+07	-1.72E+06
Shear stress at bottom of interface (Pa)	46.00	3.01E+07	54.00	-3.01E+07	2.93E+02
Shear stress at top of interface (Pa)	46.00	3.01E+07	54.00	-3.01E+07	2.93E+02
Temperature at bottom of interface (°C)	50.00	119.30	0.00	34.00	40.90
Temperature at top of interface (°C)	50.00	124.44	0.00	34.00	41.45
Maximum temperature at source (°C)	50.00	425.24	-	-	-
Number of Contacts		51		51	
Number of Contacts at Slip Condition		0		0	

Case 7.1 Summary of Results (UDEC, Interpolated)

Parameter	Maximum		Minimum		Mean
	X	Value	X	Value	Value
Lateral displacement at bottom of interface (m)	56.00	6.49E-03	44.00	-6.47E-03	6.33E-06
Lateral displacement at top of interface (m)	56.00	6.47E-03	44.00	-6.45E-03	6.33E-06
Normal displacement at bottom of interface (m)	50.00	1.07E-02	100.00	3.03E-04	1.91E-03
Normal displacement at top of interface (m)	50.00	1.07E-02	100.00	3.03E-04	1.91E-03
Relative normal displacement on interface (m)	40.00	3.62E-06	50.00	-2.64E-05	-7.56E-07
Relative shear displacement on interface (m)	46.00	1.97E-05	54.00	-1.97E-05	3.85E-11
Total displacement at bottom of interface (m)	50.00	1.09E-02	100.00	3.03E-04	3.42E-03
Total displacement at top of interface (m)	50.00	1.08E-02	100.00	3.03E-04	3.42E-03
Normal stress at bottom of interface (Pa)	60.00	6.89E+06	50.00	-5.02E+07	-1.43E+06
Normal stress at top of interface (Pa)	40.00	6.89E+06	50.00	-5.02E+07	-1.43E+06
Shear stress at bottom of interface (Pa)	46.00	2.56E+07	54.00	-2.56E+07	-1.71E+03
Shear stress at top of interface (Pa)	46.00	2.56E+07	54.00	-2.56E+07	6.41E+02
Temperature at bottom of interface (°C)	50.00	114.50	0.00	34.00	40.97
Temperature at top of interface (°C)	50.00	114.50	0.00	34.00	40.97
Maximum temperature at source (°C)	50.00	428.20	-	-	-
Number of Contacts		51		51	
Number of Contacts at Slip Condition		0		0	

Case 7.1 Relative Error between UDEC and FLAC Results*

Parameter	Maximum		Minimum		Mean
	X	Error	X	Value	Value
Lateral displacement at bottom of interface (m)	56.00	13%	44.00	13%	0%
Lateral displacement at top of interface (m)	56.00	13%	44.00	13%	0%
Normal displacement at bottom of interface (m)	50.00	7%	100.00	1%	-2%
Normal displacement at top of interface (m)	50.00	6%	100.00	1%	-2%
Relative normal displacement on interface (m)	40.00	0%	50.00	0%	0%
Relative shear displacement on interface (m)	46.00	0%	54.00	0%	0%
Total displacement at bottom of interface (m)	50.00	4%	100.00	1%	-4%
Total displacement at top of interface (m)	50.00	4%	100.00	1%	-4%
Normal stress at bottom of interface (Pa)	54.00	1%	46.00	7%	1%
Normal stress at top of interface (Pa)	40.00	1%	50.00	7%	1%
Shear stress at bottom of interface (Pa)	58.00	15%	50.00	15%	0%
Shear stress at top of interface (Pa)	46.00	15%	54.00	15%	0%
Temperature at bottom of interface (°C)	50.00	6%	0.00	0%	0%
Temperature at top of interface (°C)	50.00	12%	0.00	0%	0%
Maximum temperature at source (°C)	50.00	1%	-	-	-
Number of Contacts		0%		0%	
Number of Contacts at Slip Condition		0%		0%	

* Relative error calculated as difference between UDEC and FLAC values normalized to maximum deviation from mean along interface in either total displacement, stress, or temperature

Corrected Case 7.1 summary Tables.

Posted 5/5/04

Case 7.2 Summary of Results (FLAC)

Parameter	Maximum		Minimum		Mean
	X	Value	X	Value	Value
FLAC Lateral displacement at bottom of interface (m)	58.00	1.32E-02	42.00	-1.32E-02	-4.36E-08
FLAC Lateral displacement at top of interface (m)	54.00	7.05E-03	46.00	-7.05E-03	-4.83E-09
FLAC Normal displacement at bottom of interface (m)	50.00	1.32E-02	72.00	-2.38E-03	3.07E-04
FLAC Normal displacement at top of interface (m)	50.00	1.29E-02	100.00	7.38E-04	4.09E-03
FLAC Relative normal displacement on interface (m)	36.00	7.21E-03	50.00	-2.64E-04	3.79E-03
FLAC Relative shear displacement on interface (m)	40.00	1.10E-02	60.00	-1.10E-02	2.67E-08
FLAC Total displacement at bottom of interface (m)	44.00	1.44E-02	0.00	1.33E-03	6.51E-03
FLAC Total displacement at top of interface (m)	47.50	1.30E-02	100.00	7.38E-04	4.29E-03
Normal stress at bottom of interface (Pa)	0.00	0.00E+00	50.00	-5.01E+07	-3.07E+06
Normal stress at top of interface (Pa)	0.00	0.00E+00	50.00	-5.01E+07	-3.07E+06
Shear stress at bottom of interface (Pa)	46.00	6.32E+07	54.00	-6.32E+07	1.15E+01
Shear stress at top of interface (Pa)	46.00	6.32E+07	54.00	-6.32E+07	1.15E+01
FLAC Temperature at bottom of interface (°C)	50.00	119.30	0.00	34.00	40.90
FLAC Temperature at top of interface (°C)	50.00	124.44	0.00	34.00	41.45
Maximum temperature at source (°C)	50.00	425.24	-	-	-
Number of Contacts		51		51	
Number of Contacts at Slip Condition		46		46	

Case 7.2 Summary of Results (UDEC, Interpolated)

Parameter	Maximum		Minimum		Mean
	X	Value	X	Value	Value
UDEC Lateral displacement at bottom of interface (m)	58.00	1.40E-02	42.00	-1.41E-02	-3.57E-06
UDEC Lateral displacement at top of interface (m)	32.00	1.14E-03	68.00	-1.14E-03	4.63E-07
UDEC Normal displacement at bottom of interface (m)	50.00	1.45E-02	30.00	-1.23E-03	1.27E-03
UDEC Normal displacement at top of interface (m)	50.00	1.43E-02	100.00	-3.21E-04	2.90E-03
UDEC Relative normal displacement on interface (m)	36.00	4.75E-03	50.00	-2.52E-04	1.62E-03
UDEC Relative shear displacement on interface (m)	42.00	1.46E-02	58.00	-1.45E-02	4.57E-06
UDEC Total displacement at bottom of interface (m)	46.00	1.61E-02	0.00	3.22E-04	6.41E-03
UDEC Total displacement at top of interface (m)	50.00	1.43E-02	0.00	3.20E-04	3.26E-03
UDEC Normal stress at bottom of interface (Pa)	14.00	1.00E+06	50.00	-4.79E+07	-2.13E+06
UDEC Normal stress at top of interface (Pa)	14.00	1.00E+06	50.00	-4.79E+07	-2.13E+06
UDEC Shear stress at bottom of interface (Pa)	47.50	1.19E+07	52.50	-1.22E+07	8.97E+02
UDEC Shear stress at top of interface (Pa)	47.50	1.22E+07	52.50	-1.19E+07	-1.32E+03
UDEC Temperature at bottom of interface (°C)	50.00	114.50	0.00	34.00	41.12
UDEC Temperature at top of interface (°C)	50.00	114.50	0.00	34.00	41.10
Maximum temperature at source (°C)	50.00	428.20	-	-	-
Number of Contacts		51		51	
Number of Contacts at Slip Condition		51		51	

Case 7.2 Relative Error between UDEC and FLAC Results*

Parameter	Maximum		Minimum		Mean
	X	Error	X	Value	Value
Lateral displacement at bottom of interface (m)	56.00	11%	44.00	11%	0%
Lateral displacement at top of interface (m)	56.00	75%	44.00	75%	0%
Normal displacement at bottom of interface (m)	50.00	17%	100.00	15%	7%
Normal displacement at top of interface (m)	50.00	17%	100.00	13%	-9%
Relative normal displacement on interface (m)	40.00	31%	50.00	0%	-17%
Relative shear displacement on interface (m)	46.00	45%	54.00	44%	0%
Total displacement at bottom of interface (m)	50.00	22%	100.00	13%	-1%
Total displacement at top of interface (m)	50.00	16%	100.00	5%	-8%
Normal stress at bottom of interface (Pa)	54.00	2%	46.00	5%	2%
Normal stress at top of interface (Pa)	40.00	2%	50.00	5%	2%
Shear stress at bottom of interface (Pa)	58.00	81%	50.00	81%	0%
Shear stress at top of interface (Pa)	46.00	81%	54.00	81%	0%
Temperature at bottom of interface (°C)	50.00	6%	0.00	0%	0%
Temperature at top of interface (°C)	50.00	12%	0.00	0%	0%
Maximum temperature at source (°C)	50.00	1%	-	-	-
Number of Contacts		0%		0%	
Number of Contacts at Slip Condition		10%		10%	

* Relative error calculated as difference between UDEC and FLAC values normalized to maximum deviation from mean along interface in either total displacement, stress, or temperature

Corrected Table 7.2

R 2/5/04

Case 7.3 Summary of Results (FLAC)

Parameter	Maximum		Minimum		Mean	Σ Absolute
	X	Value	X	Value	Value	Values
FLAC Lateral displacement at bottom of interface (m)	56.00	7.05E-03	44.00	-6.96E-03	4.89E-05	1.36E-01
FLAC Lateral displacement at top of interface (m)	56.00	6.86E-03	44.00	-6.78E-03	5.02E-05	1.34E-01
FLAC Normal displacement at bottom of interface (m)	50.00	1.13E-02	2.00	-9.56E-05	2.02E-03	1.03E-01
FLAC Normal displacement at top of interface (m)	50.00	1.10E-02	2.00	-9.88E-05	2.01E-03	1.03E-01
FLAC Relative normal displacement on interface (m)	60.00	3.81E-05	50.00	-2.70E-04	-1.05E-05	1.37E-03
FLAC Relative shear displacement on interface (m)	46.00	2.15E-04	54.00	-2.21E-04	1.26E-06	1.96E-03
FLAC Total displacement at bottom of interface (m)	50.00	1.13E-02	0.00	1.79E-04	3.60E-03	1.83E-01
FLAC Total displacement at top of interface (m)	50.00	1.10E-02	0.00	1.81E-04	3.55E-03	1.81E-01
FLAC Normal stress at bottom of interface (Pa)	60.00	7.24E+06	50.00	-5.13E+07	-1.99E+06	2.60E+08
FLAC Normal stress at top of interface (Pa)	60.00	7.24E+06	50.00	-5.13E+07	-1.99E+06	2.60E+08
FLAC Shear stress at bottom of interface (Pa)	46.00	2.80E+07	54.00	-2.87E+07	1.64E+05	2.55E+08
FLAC Shear stress at top of interface (Pa)	46.00	2.80E+07	54.00	-2.87E+07	1.64E+05	2.55E+08
FLAC Temperature at bottom of interface (°C)	50.00	118.14	0.00	34.00	40.95	2088.52
FLAC Temperature at top of interface (°C)	50.00	100.82	0.00	34.00	39.16	1997.40
Maximum temperature at source (°C)	50.00	425.24	-	-	-	
Number of Contacts		51		51		
Number of Contacts at Slip Condition		0		0		

Case 7.3 Summary of Results (UDEC, Interpolated)

Parameter	Maximum		Minimum		Mean	Σ Absolute
	X	Value	X	Value	Value	Values
UDEC Shear displacement at bottom of interface (m)	56.00	7.17E-03	44.00	-7.20E-03	3.43E-05	1.39E-01
UDEC Shear displacement at top of interface (m)	56.00	6.96E-03	44.00	-6.99E-03	3.92E-05	1.37E-01
UDEC Normal displacement at bottom of interface (m)	50.00	1.14E-02	0.00	-1.73E-04	1.99E-03	1.02E-01
UDEC Normal displacement at top of interface (m)	50.00	1.09E-02	0.00	-1.74E-04	1.97E-03	1.01E-01
UDEC Relative normal displacement on interface (m)	58.00	5.51E-05	50.00	-4.94E-04	-1.33E-05	1.93E-03
UDEC Relative shear displacement on interface (m)	46.00	3.75E-04	54.00	-3.73E-04	1.41E-06	2.74E-03
UDEC Total displacement at bottom of interface (m)	50.00	1.14E-02	0.00	1.93E-04	3.62E-03	1.85E-01
UDEC Total displacement at top of interface (m)	50.00	1.11E-02	0.00	1.95E-04	3.58E-03	1.82E-01
UDEC Normal stress at bottom of interface (Pa)	58.00	1.05E+07	50.00	-9.38E+07	-2.51E+06	3.67E+08
UDEC Normal stress at top of interface (Pa)	60.00	5.40E+06	47.50	-1.59E+07	-9.67E+05	1.46E+08
UDEC Shear stress at bottom of interface (Pa)	46.00	4.87E+07	54.00	-4.85E+07	1.83E+05	3.56E+08
UDEC Shear stress at top of interface (Pa)	42.00	1.31E+07	58.00	-1.33E+07	1.95E+05	1.53E+08
UDEC Temperature at bottom of interface (°C)	50.00	1.12E+02	0.00	3.40E+01	4.00E+01	2042.17
UDEC Temperature at top of interface (°C)	50.00	1.06E+02	0.00	3.40E+01	3.99E+01	2033.09
Maximum temperature at source (°C)	50.00	419.20	-	-	-	-
Number of Contacts		56		51		
Number of Contacts at Slip Condition		0		0		

Case 7.3 Relative Error between UDEC and FLAC Results*

Parameter	Maximum		Minimum		Mean	Total
	ΔX	Error	ΔX	Error	Error	Error
Shear displacement at bottom of interface (m)	0.0	2%	0.0	3%	0%	2%
Shear displacement at top of interface (m)	0.0	1%	0.0	3%	0%	2%
Normal displacement at bottom of interface (m)	0.0	1%	-2.0	1%	0%	1%
Normal displacement at top of interface (m)	0.0	1%	-2.0	1%	0%	2%
Relative normal displacement on interface (m)	-2.0	7%	0.0	86%	1%	41%
Relative shear displacement on interface (m)	0.0	62%	0.0	59%	0%	40%
Total displacement at bottom of interface (m)	0.0	1%	0.0	0%	0%	1%
Total displacement at top of interface (m)	0.0	1%	0.0	0%	0%	1%
Normal stress at bottom of interface (Pa)	-2.0	7%	0.0	86%	1%	41%
Normal stress at top of interface (Pa)	0.0	4%	-2.5	72%	2%	44%
Shear stress at bottom of interface (Pa)	0.0	72%	0.0	68%	0%	40%
Shear stress at top of interface (Pa)	-4.0	52%	4.0	53%	0%	40%
Temperature at bottom of interface (°C)	0.0	8%	0.0	0%	1%	2%
Temperature at top of interface (°C)	0.0	7%	0.0	0%	1%	2%
Maximum temperature at source (°C)	0.0	-1%	-	-	-	
Number of Contacts		10%		0%		
Number of Contacts at Slip Condition		0%		0%		

* Relative error calculated as difference between UDEC and FLAC values normalized to maximum deviation from mean along interface in either total displacement, stress, or temperature

Corrected Table 7.3

R 2/5/04

SN 673 Vol 1

Case 7.4 Summary of Results (FLAC)

Parameter	Maximum		Minimum		Mean	Σ Absolute
	X	Value	X	Value	Value	Values
FLAC Shear displacement at bottom of interface (m)	58.00	1.20E-02	42.00	-1.24E-02	-3.51E-04	2.23E-01
FLAC Shear displacement at top of interface (m)	54.00	6.37E-03	46.00	-6.37E-03	1.75E-04	5.18E-02
FLAC Normal displacement at bottom of interface (m)	50.00	1.26E-02	68.00	-1.92E-03	9.17E-04	1.13E-01
FLAC Normal displacement at top of interface (m)	50.00	1.26E-02	92.00	1.62E-04	3.65E-03	1.86E-01
FLAC Relative normal displacement on interface (m)	38.00	6.71E-03	50.00	-2.55E-05	2.75E-03	1.41E-01
FLAC Relative shear displacement on interface (m)	40.00	1.01E-02	58.00	-9.58E-03	5.39E-04	1.95E-01
FLAC Total displacement at bottom of interface (m)	44.00	1.36E-02	100.00	2.97E-04	5.37E-03	2.74E-01
FLAC Total displacement at top of interface (m)	50.00	1.26E-02	90.00	2.50E-04	3.85E-03	1.96E-01
FLAC Normal stress at bottom of interface (Pa)	92.00	7.66E+05	50.00	-4.85E+07	-2.89E+06	1.49E+08
FLAC Normal stress at top of interface (Pa)	92.00	7.66E+05	50.00	-4.85E+07	-2.89E+06	1.49E+08
FLAC Shear stress at bottom of interface (Pa)	46.00	5.65E+07	54.00	-5.65E+07	-6.04E+04	1.65E+08
FLAC Shear stress at top of interface (Pa)	46.00	5.65E+07	54.00	-5.65E+07	-6.04E+04	1.65E+08
FLAC Temperature at bottom of interface (°C)	50.00	118.00	0.00	34.00	40.95	2088.20
FLAC Temperature at top of interface (°C)	50.00	101.00	0.00	34.00	39.17	1997.70
Maximum temperature at source (°C)	50.00	425.24	-	-	-	
Number of Contacts		51		51		
Number of Contacts at Slip Condition		27		27		

Case 7.4 Summary of Results (UDEC, Interpolated)

Parameter	Maximum		Minimum		Mean	Σ Absolute
	X	Value	X	Value	Value	Values
UDEC Shear displacement at bottom of interface (m)	56.00	1.54E-02	44.00	-1.53E-02	-3.56E-04	2.88E-01
UDEC Shear displacement at top of interface (m)	32.00	1.09E-03	66.00	-1.25E-03	-2.06E-05	3.03E-02
UDEC Normal displacement at bottom of interface (m)	50.00	1.53E-02	68.00	-1.29E-03	1.42E-03	1.05E-01
UDEC Normal displacement at top of interface (m)	50.00	1.52E-02	0.00	-1.73E-04	3.12E-03	1.60E-01
UDEC Relative normal displacement on interface (m)	62.00	5.64E-03	50.00	-5.62E-05	1.69E-03	8.63E-02
UDEC Relative shear displacement on interface (m)	42.00	1.51E-02	56.00	-1.54E-02	3.39E-04	3.09E-01
UDEC Total displacement at bottom of interface (m)	54.00	1.75E-02	100.00	3.74E-04	6.51E-03	3.32E-01
UDEC Total displacement at top of interface (m)	50.00	1.52E-02	6.00	9.80E-05	3.30E-03	1.68E-01
UDEC Normal stress at bottom of interface (Pa)	0.00	1.40E+06	50.00	-1.07E+08	-4.75E+06	3.12E+08
UDEC Normal stress at top of interface (Pa)	0.00	2.05E+06	47.50	-1.17E+06	7.67E+05	4.41E+07
UDEC Shear stress at bottom of interface (Pa)	47.50	2.15E+07	52.50	-2.25E+07	-4.99E+04	6.60E+07
UDEC Shear stress at top of interface (Pa)	47.50	5.46E+05	90.00	-2.43E+05	5.51E+03	1.75E+06
UDEC Temperature at bottom of interface (°C)	50.00	1.12E+02	0.00	3.40E+01	4.01E+01	2042.58
UDEC Temperature at top of interface (°C)	50.00	1.06E+02	0.00	3.40E+01	3.99E+01	2032.74
Maximum temperature at source (°C)	50.00	419.20	-	-	-	-
Number of Contacts		56		51		
Number of Contacts at Slip Condition		55		50		

Case 7.4 Relative Error between UDEC and FLAC Results*

Parameter	Maximum		Minimum		Mean	Total
	ΔX	Error	ΔX	Error	Error	Error
Shear displacement at bottom of interface (m)	-2.0	28%	2.0	24%	0%	29%
Shear displacement at top of interface (m)	-22.0	43%	20.0	41%	2%	41%
Normal displacement at bottom of interface (m)	0.0	30%	0.0	7%	6%	7%
Normal displacement at top of interface (m)	0.0	29%	-92.0	4%	6%	14%
Relative normal displacement on interface (m)	24.0	11%	0.0	0%	11%	39%
Relative shear displacement on interface (m)	2.0	49%	-2.0	58%	2%	59%
Total displacement at bottom of interface (m)	10.0	47%	0.0	1%	14%	21%
Total displacement at top of interface (m)	0.0	32%	-84.0	2%	7%	14%
Normal stress at bottom of interface (Pa)	-92.0	1%	0.0	127%	4%	109%
Normal stress at top of interface (Pa)	-92.0	3%	-2.5	104%	8%	70%
Shear stress at bottom of interface (Pa)	1.5	62%	-1.5	60%	0%	60%
Shear stress at top of interface (Pa)	1.5	99%	36.0	100%	0%	99%
Temperature at bottom of interface (°C)	0.0	7%	0.0	0%	1%	2%
Temperature at top of interface (°C)	0.0	7%	0.0	0%	1%	2%
Maximum temperature at source (°C)	0.0	-1%	-	-	-	
Number of Contacts		10%		0%		
Number of Contacts at Slip Condition		55%		45%		

* Relative error calculated as difference between UDEC and FLAC values normalized to maximum deviation from mean along interface in either total displacement, stress, or temperature

Corrected Table 7.4

RE 2/5/09

SN 673 Vol 1.

Case 7.7 Summary of Results (FLAC)

Parameter	Maximum		Minimum		Mean	Σ Absolute
	X	Value	X	Value	Value	Values
FLAC Shear displacement at bottom of interface (m)	66.00	1.10E-02	34.00	-1.10E-02	1.37E-04	3.48E-01
FLAC Shear displacement at top of interface (m)	66.00	1.10E-02	34.00	-1.10E-02	1.38E-04	3.47E-01
FLAC Normal displacement at bottom of interface (m)	50.00	9.71E-03	0.00	2.71E-04	4.48E-03	2.29E-01
FLAC Normal displacement at top of interface (m)	50.00	9.60E-03	0.00	2.69E-04	4.46E-03	2.27E-01
FLAC Relative normal displacement on interface (m)	0.00	-1.49E-06	50.00	-1.06E-04	-2.49E-05	1.27E-03
FLAC Relative shear displacement on interface (m)	44.00	1.99E-05	56.00	-2.00E-05	1.81E-06	4.30E-04
FLAC Total displacement at bottom of interface (m)	38.00	1.23E-02	0.00	2.80E-04	8.52E-03	4.34E-01
FLAC Total displacement at top of interface (m)	36.00	1.23E-02	0.00	2.78E-04	8.50E-03	4.33E-01
FLAC Normal stress at bottom of interface (Pa)	0.00	-7.71E+06	50.00	-5.99E+07	-1.92E+07	9.77E+08
FLAC Normal stress at top of interface (Pa)	0.00	-7.71E+06	50.00	-5.99E+07	-1.92E+07	9.77E+08
FLAC Shear stress at bottom of interface (Pa)	44.00	8.74E+06	56.00	-1.12E+07	-3.03E+05	2.06E+08
FLAC Shear stress at top of interface (Pa)	44.00	8.74E+06	56.00	-1.12E+07	-3.03E+05	2.06E+08
FLAC Temperature at bottom of interface (°C)	50.00	207.52	100.00	29.42	75.98	3874.99
FLAC Temperature at top of interface (°C)	50.00	207.11	0.00	29.34	75.73	3862.22
Maximum temperature at source (°C)	51.21	322.38	-	-	-	
Number of Contacts		51		51		
Number of Contacts at Slip Condition		0		0		

Case 7.7 Summary of Results (UDEC, Interpolated)

Parameter	Maximum		Minimum		Mean	Σ Absolute
	X	Value	X	Value	Value	Values
UDEC Shear displacement at bottom of interface (m)	66.00	1.11E-02	34.00	-1.11E-02	1.48E-04	3.52E-01
UDEC Shear displacement at top of interface (m)	66.00	1.11E-02	34.00	-1.11E-02	1.50E-04	3.52E-01
UDEC Normal displacement at bottom of interface (m)	50.00	9.75E-03	0.00	2.33E-04	4.47E-03	2.28E-01
UDEC Normal displacement at top of interface (m)	50.00	9.59E-03	0.00	2.31E-04	4.45E-03	2.27E-01
UDEC Relative normal displacement on interface (m)	8.00	-1.70E-05	50.00	-1.80E-04	-3.89E-05	1.98E-03
UDEC Relative shear displacement on interface (m)	46.00	8.87E-05	54.00	-9.18E-05	-1.41E-07	1.27E-03
UDEC Total displacement at bottom of interface (m)	64.00	1.24E-02	0.00	2.40E-04	8.58E-03	4.38E-01
UDEC Total displacement at top of interface (m)	64.00	1.24E-02	0.00	2.38E-04	8.56E-03	4.37E-01
UDEC Normal stress at bottom of interface (Pa)	8.00	-8.48E+06	50.00	-8.99E+07	-1.94E+07	9.92E+08
UDEC Normal stress at top of interface (Pa)	6.00	-8.31E+06	56.00	-4.16E+07	-1.88E+07	9.57E+08
UDEC Shear stress at bottom of interface (Pa)	46.00	4.43E+07	54.00	-4.59E+07	-7.05E+04	6.34E+08
UDEC Shear stress at top of interface (Pa)	54.00	2.51E+07	46.00	-2.78E+07	-2.23E+05	2.96E+08
UDEC Temperature at bottom of interface (°C)	50.00	2.10E+02	100.00	2.93E+01	7.60E+01	3874.16
UDEC Temperature at top of interface (°C)	50.00	2.08E+02	100.00	2.93E+01	7.59E+01	3871.56
Maximum temperature at source (°C)	50.00	326.70	-	-	-	-
Number of Contacts		52		51		
Number of Contacts at Slip Condition		0		0		

Case 7.7 Relative Error between UDEC and FLAC Results*

Parameter	Maximum		Minimum		Mean	Total
	ΔX	Error	ΔX	Error	Error	Error
Shear displacement at bottom of interface (m)	0.0	1%	0.0	1%	0%	1%
Shear displacement at top of interface (m)	0.0	1%	0.0	1%	0%	1%
Normal displacement at bottom of interface (m)	0.0	1%	0.0	1%	0%	0%
Normal displacement at top of interface (m)	0.0	0%	0.0	1%	0%	0%
Relative normal displacement on interface (m)	8.0	19%	0.0	90%	17%	56%
Relative shear displacement on interface (m)	2.0	84%	-2.0	88%	2%	195%
Total displacement at bottom of interface (m)	26.0	2%	0.0	0%	1%	1%
Total displacement at top of interface (m)	28.0	2%	0.0	0%	1%	1%
Normal stress at bottom of interface (Pa)	8.0	2%	0.0	74%	1%	2%
Normal stress at top of interface (Pa)	6.0	1%	6.0	45%	1%	2%
Shear stress at bottom of interface (Pa)	2.0	326%	-2.0	317%	2%	208%
Shear stress at top of interface (Pa)	10.0	150%	-10.0	152%	1%	43%
Temperature at bottom of interface (°C)	0.0	2%	0.0	0%	0%	0%
Temperature at top of interface (°C)	0.0	1%	100.0	0%	0%	0%
Maximum temperature at source (°C)	-1.2	1%	-	-	-	
Number of Contacts		2%		0%		
Number of Contacts at Slip Condition		0%		0%		

* Relative error calculated as difference between UDEC and FLAC values normalized to maximum deviation from mean along interface in either total displacement, stress, or temperature

Corrected Table 7.7.

RE 2/5/09

SNG73 Vol 1.

Oct 13/2009

- created UDEC input files u712 input.txt and u713 input.txt and ran UDEC.
- results are shown in Case 7.12 and 7.13 comparisons of FLAC and UDEC results.
- other plots in these cases are contained in files u712 plots.doc and u713 plots.doc in ~~UDEC~~ RECEIVED /Case 7/UDEC

Summary of Results - Case 7.12

- generally good comparison between FLAC and UDEC results
- largest error is in shear stress at top of interface due to relatively small magnitude of shear stress.
- no slip indicated, but tensile bond breakage indicated from x = 0 to 76 m in FLAC comparison → suggests same phenomena in play in UDEC.
- this case is for typical Yucca Mtn conditions with 20° friction and vitrified strata

Summary of Results - Case 7.13

- good comparison between FLAC and UDEC results
- FLAC comparison shows tensile bond breakage in x = 28 to 86 m → similar effect in UDEC suggested by goodness of fit of results
- largest error in shear stress at top of interface.
- this case is for typical Yucca Mtn conditions with 20° friction angle and subhorizontal fractures.

SNG73 Vol 1

Case 7.12 Summary of Results (FLAC)

Parameter	Maximum		Minimum		Mean	Σ Absolute
	X	Value	X	Value	Value	Values
FLAC Shear displacement at bottom of interface (m)	64.00	1.21E-02	34.00	-1.56E-02	-1.35E-03	4.44E-01
FLAC Shear displacement at top of interface (m)	68.00	9.92E-03	34.00	-6.97E-03	1.27E-03	2.69E-01
FLAC Normal displacement at bottom of interface (m)	50.00	1.15E-02	2.00	-7.04E-04	4.72E-03	2.43E-01
FLAC Normal displacement at top of interface (m)	50.00	1.04E-02	2.00	-5.94E-04	4.47E-03	2.30E-01
FLAC Relative normal displacement on interface (m)	0.00	5.79E-04	50.00	-1.05E-03	-2.23E-04	1.28E-02
FLAC Relative shear displacement on interface (m)	34.00	8.59E-03	62.00	-2.46E-03	2.62E-03	1.75E-01
FLAC Total displacement at bottom of interface (m)	36.00	1.67E-02	0.00	1.38E-03	1.05E-02	5.34E-01
FLAC Total displacement at top of interface (m)	62.00	1.13E-02	4.00	5.91E-04	7.30E-03	3.72E-01
FLAC Normal stress at bottom of interface (Pa)	0.00	-9.75E+05	50.00	-5.45E+07	-1.44E+07	7.35E+08
FLAC Normal stress at top of interface (Pa)	0.00	-9.75E+05	50.00	-5.45E+07	-1.44E+07	7.35E+08
FLAC Shear stress at bottom of interface (Pa)	48.00	8.41E+06	54.00	-6.03E+06	9.58E+05	1.29E+08
FLAC Shear stress at top of interface (Pa)	48.00	8.41E+06	54.00	-6.03E+06	9.58E+05	1.29E+08
FLAC Temperature at bottom of interface (°C)	50.00	207.52	100.00	29.42	75.98	3874.99
FLAC Temperature at top of interface (°C)	50.00	207.11	0.00	29.34	75.73	3862.22
Maximum temperature at source (°C)	50.00	322.38	-	-	-	
Number of Contacts		51		51		
Number of Contacts at Slip Condition		0		0		

Oct 13/09

Case 7.12 Summary of Results (UDEC, Interpolated)

Parameter	Maximum		Minimum		Mean	Σ Absolute
	X	Value	X	Value	Value	Values
UDEC Shear displacement at bottom of interface (m)	64.00	1.22E-02	34.00	-1.59E-02	-1.56E-03	4.49E-01
UDEC Shear displacement at top of interface (m)	68.00	1.01E-02	34.00	-6.78E-03	1.51E-03	2.78E-01
UDEC Normal displacement at bottom of interface (m)	50.00	1.17E-02	0.00	-1.32E-03	4.63E-03	2.41E-01
UDEC Normal displacement at top of interface (m)	50.00	1.05E-02	0.00	-9.40E-04	4.39E-03	2.28E-01
UDEC Relative normal displacement on interface (m)	0.00	2.96E-05	50.00	-1.16E-03	-2.49E-04	1.28E-02
UDEC Relative shear displacement on interface (m)	34.00	9.17E-03	62.00	-2.25E-03	3.09E-03	1.92E-01
UDEC Total displacement at bottom of interface (m)	36.00	1.70E-02	0.00	1.37E-03	1.05E-02	5.37E-01
UDEC Total displacement at top of interface (m)	62.00	1.15E-02	4.00	6.42E-04	7.41E-03	3.78E-01
UDEC Normal stress at bottom of interface (Pa)	0.00	1.19E+06	50.00	-5.99E+07	-1.43E+07	7.33E+08
UDEC Normal stress at top of interface (Pa)	0.00	-8.41E+05	50.00	-5.24E+07	-1.43E+07	7.31E+08
UDEC Shear stress at bottom of interface (Pa)	47.50	9.50E+06	54.00	-7.61E+06	7.75E+05	1.34E+08
UDEC Shear stress at top of interface (Pa)	47.50	6.89E+06	54.00	-5.12E+06	8.20E+05	1.07E+08
UDEC Temperature at bottom of interface (°C)	50.00	2.10E+02	100.00	2.93E+01	7.60E+01	3874.57
UDEC Temperature at top of interface (°C)	50.00	2.08E+02	100.00	2.93E+01	7.59E+01	3871.19
Maximum temperature at source (°C)	50.00	326.70	-	-	-	-
Number of Contacts		51		52		
Number of Contacts at Slip Condition		0		0		

Case 7.12 Relative Error between UDEC and FLAC Results*

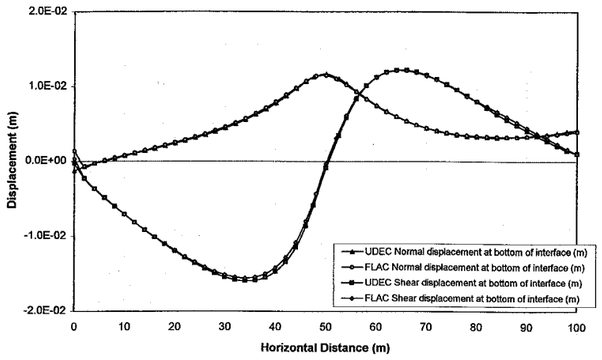
Parameter	Maximum		Minimum		Mean	Total
	ΔX	Error	ΔX	Error	Error	Error
Shear displacement at bottom of interface (m)	0.0	0%	0.0	3%	1%	1%
Shear displacement at top of interface (m)	0.0	2%	0.0	1%	2%	3%
Normal displacement at bottom of interface (m)	0.0	3%	-2.0	9%	1%	1%
Normal displacement at top of interface (m)	0.0	1%	-2.0	5%	1%	1%
Relative normal displacement on interface (m)	0.0	9%	0.0	2%	0%	0%
Relative shear displacement on interface (m)	0.0	10%	0.0	4%	8%	9%
Total displacement at bottom of interface (m)	0.0	4%	0.0	0%	1%	1%
Total displacement at top of interface (m)	0.0	3%	0.0	1%	1%	2%
Normal stress at bottom of interface (Pa)	0.0	5%	0.0	14%	0%	0%
Normal stress at top of interface (Pa)	0.0	0%	0.0	5%	0%	1%
Shear stress at bottom of interface (Pa)	-0.5	15%	0.0	21%	2%	4%
Shear stress at top of interface (Pa)	-0.5	20%	0.0	12%	2%	17%
Temperature at bottom of interface (°C)	0.0	2%	0.0	0%	0%	0%
Temperature at top of interface (°C)	0.0	1%	100.0	0%	0%	0%
Maximum temperature at source (°C)	0.0	1%	-	-	-	
Number of Contacts		0%		2%		
Number of Contacts at Slip Condition		0%		0%		

* Relative error calculated as difference between UDEC and FLAC values normalized to maximum deviation from mean along interface in either total displacement, stress, or temperature

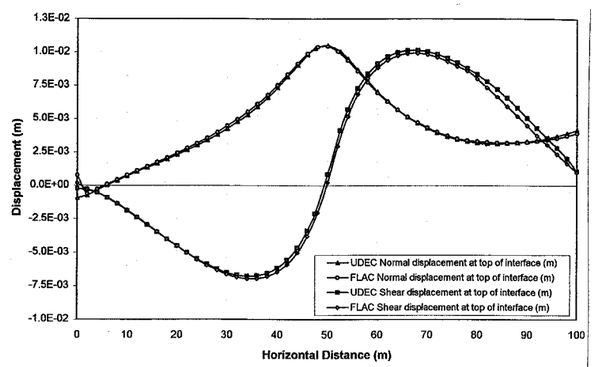
Comparison of FLAC & UDEC - Case 7.12.

SN673 Vol 1

Case 7.12 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (Slip Allowed)

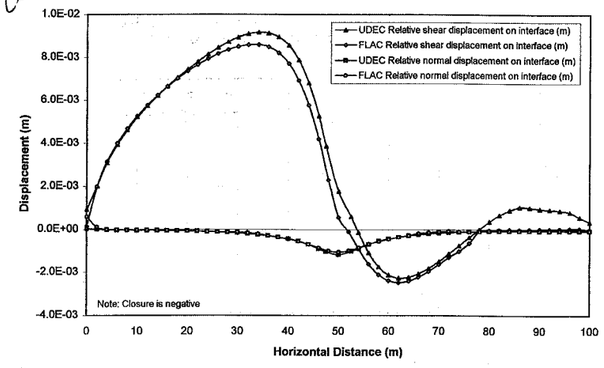


Case 7.12 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (Slip Allowed)

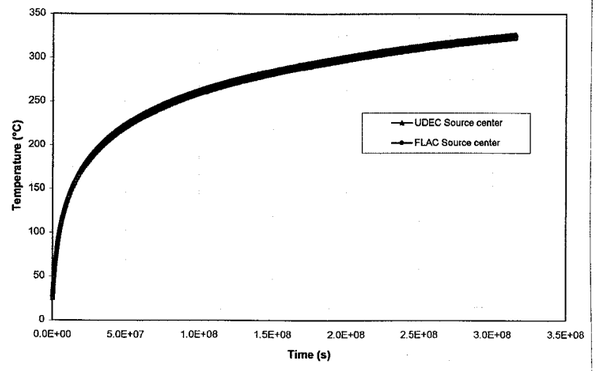


RR Oct 13/09

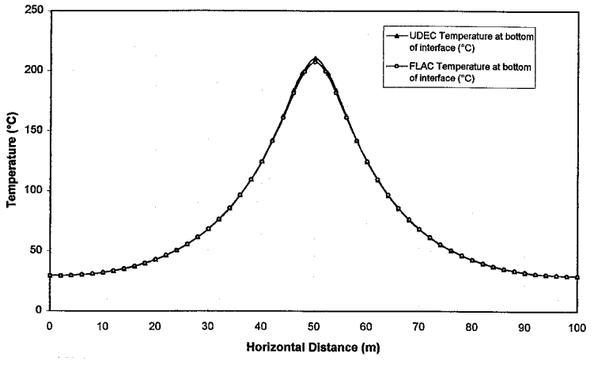
Case 7.12 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (Slip Allowed)



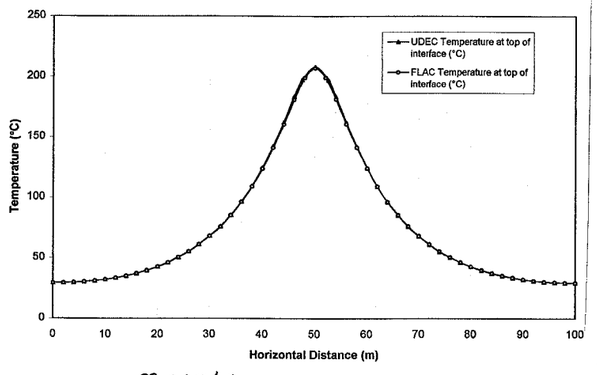
Case 7.12 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (Slip Allowed)



Case 7.12 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (Slip Allowed)



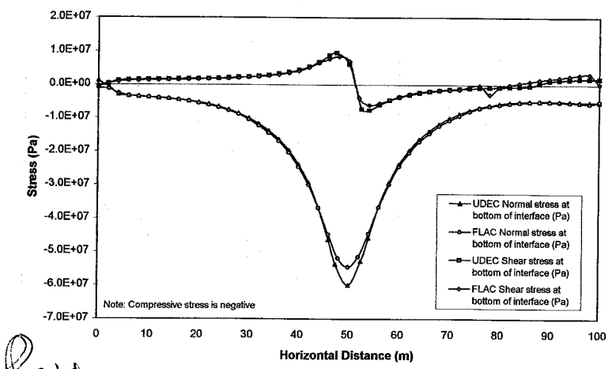
Case 7.12 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (Slip Allowed)



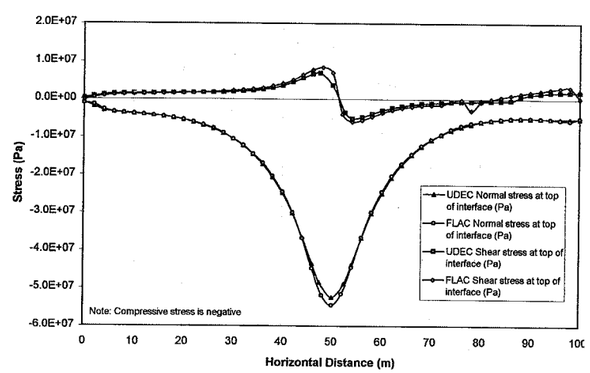
Comparison of FLAC and UDEC - Case ~~7.13~~ RR Oct 13/09 7.12.

SN673 Vol 1

Case 7.12 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (Slip Allowed)



Case 7.12 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (Slip Allowed)



RR Oct 13/09

Case 7.12 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (Slip Allowed)

Case 7.12 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (Slip Allowed)

Comparison of FLAC and UDEC - Case 7.12

Blank..

RR Oct 13/09

SD 673 Vol 1

Case 7.13 Summary of Results (FLAC)

Parameter	Maximum X	Maximum Value	Minimum X	Minimum Value	Mean Value	Σ Absolute Values
FLAC Shear displacement at bottom of interface (m)	64.00	1.33E-02	36.00	-1.14E-02	5.58E-04	3.79E-01
FLAC Shear displacement at top of interface (m)	68.00	8.82E-03	34.00	-1.07E-02	-3.25E-04	3.19E-01
FLAC Normal displacement at bottom of interface (m)	50.00	1.08E-02	0.00	1.98E-04	4.63E-03	2.36E-01
FLAC Normal displacement at top of interface (m)	50.00	9.77E-03	0.00	1.79E-04	4.38E-03	2.24E-01
FLAC Relative normal displacement on interface (m)	0.00	-1.42E-05	50.00	-1.04E-03	-2.48E-04	1.26E-02
FLAC Relative shear displacement on interface (m)	40.00	9.70E-04	62.00	-4.69E-03	-8.84E-04	6.00E-02
FLAC Total displacement at bottom of interface (m)	62.00	1.46E-02	0.00	2.04E-04	9.17E-03	4.68E-01
FLAC Total displacement at top of interface (m)	36.00	1.19E-02	0.00	1.84E-04	8.02E-03	4.09E-01
FLAC Normal stress at bottom of interface (Pa)	0.00	-7.67E+06	50.00	-5.87E+07	-1.91E+07	9.73E+08
FLAC Normal stress at top of interface (Pa)	0.00	-7.67E+06	50.00	-5.87E+07	-1.91E+07	9.73E+08
FLAC Shear stress at bottom of interface (Pa)	46.00	7.95E+06	52.00	-9.83E+06	-8.14E+04	1.73E+08
FLAC Shear stress at top of interface (Pa)	46.00	7.95E+06	52.00	-9.83E+06	-8.14E+04	1.73E+08
FLAC Temperature at bottom of interface (°C)	50.00	207.52	100.00	29.42	75.98	3874.99
FLAC Temperature at top of interface (°C)	50.00	207.11	0.00	29.34	75.73	3862.22
Maximum temperature at source (°C)	50.00	326.70	-	-	-	
Number of Contacts		51		51		
Number of Contacts at Slip Condition		0		0		

Case 7.13 Summary of Results (UDEC, Interpolated)

Parameter	Maximum X	Maximum Value	Minimum X	Minimum Value	Mean Value	Σ Absolute Values
UDEC Shear displacement at bottom of interface (m)	64.00	1.36E-02	36.00	-1.17E-02	5.65E-04	3.88E-01
UDEC Shear displacement at top of interface (m)	68.00	8.79E-03	34.00	-1.07E-02	-3.37E-04	3.21E-01
UDEC Normal displacement at bottom of interface (m)	50.00	1.10E-02	0.00	1.49E-04	4.60E-03	2.35E-01
UDEC Normal displacement at top of interface (m)	50.00	9.87E-03	0.00	1.30E-04	4.35E-03	2.22E-01
UDEC Relative normal displacement on interface (m)	6.00	-4.79E-05	50.00	-1.16E-03	-2.61E-04	1.33E-02
UDEC Relative shear displacement on interface (m)	40.00	1.41E-03	62.00	-5.05E-03	-9.01E-04	6.81E-02
UDEC Total displacement at bottom of interface (m)	62.00	1.48E-02	0.00	1.53E-04	9.30E-03	4.74E-01
UDEC Total displacement at top of interface (m)	36.00	1.18E-02	0.00	1.34E-04	8.02E-03	4.09E-01
UDEC Normal stress at bottom of interface (Pa)	6.00	-8.41E+06	50.00	-6.41E+07	-1.91E+07	9.73E+08
UDEC Normal stress at top of interface (Pa)	6.00	-8.39E+06	50.00	-5.69E+07	-1.90E+07	9.68E+08
UDEC Shear stress at bottom of interface (Pa)	46.00	8.65E+06	52.50	-1.08E+07	8.66E+04	1.86E+08
UDEC Shear stress at top of interface (Pa)	44.00	5.95E+06	52.50	-7.95E+06	7.65E+04	1.54E+08
UDEC Temperature at bottom of interface (°C)	50.00	2.10E+02	100.00	2.93E+01	7.60E+01	3874.34
UDEC Temperature at top of interface (°C)	50.00	2.08E+02	100.00	2.93E+01	7.59E+01	3871.37
Maximum temperature at source (°C)	50.00	326.70	-	-	-	-
Number of Contacts		52		51		
Number of Contacts at Slip Condition		0		0		

Case 7.13 Relative Error between UDEC and FLAC Results*

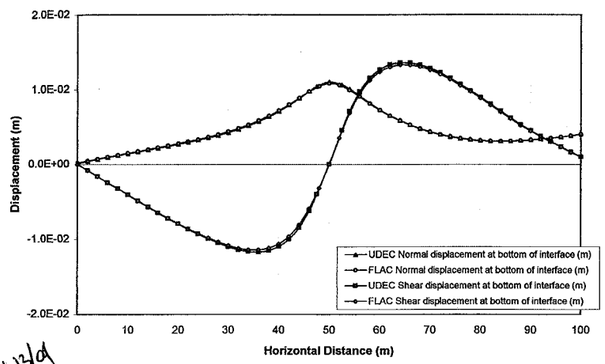
Parameter	Maximum ΔX	Maximum Error	Minimum ΔX	Minimum Error	Mean Error	Total Error
Shear displacement at bottom of interface (m)	0.0	2%	0.0	2%	0%	2%
Shear displacement at top of interface (m)	0.0	0%	0.0	0%	0%	0%
Normal displacement at bottom of interface (m)	0.0	3%	0.0	1%	0%	1%
Normal displacement at top of interface (m)	0.0	2%	0.0	1%	1%	1%
Relative normal displacement on interface (m)	6.0	1%	0.0	3%	0%	5%
Relative shear displacement on interface (m)	0.0	12%	0.0	9%	0%	13%
Total displacement at bottom of interface (m)	0.0	3%	0.0	1%	1%	1%
Total displacement at top of interface (m)	0.0	1%	0.0	1%	0%	0%
Normal stress at bottom of interface (Pa)	6.0	2%	0.0	14%	0%	0%
Normal stress at top of interface (Pa)	6.0	2%	0.0	5%	0%	0%
Shear stress at bottom of interface (Pa)	0.0	7%	0.5	10%	2%	7%
Shear stress at top of interface (Pa)	-2.0	21%	0.5	19%	2%	11%
Temperature at bottom of interface (°C)	0.0	2%	0.0	0%	0%	0%
Temperature at top of interface (°C)	0.0	1%	100.0	0%	0%	0%
Maximum temperature at source (°C)	0.0	0%	-	-	-	
Number of Contacts		2%		0%		
Number of Contacts at Slip Condition		0%		0%		

* Relative error calculated as difference between UDEC and FLAC values normalized to maximum deviation from mean along interface in either total displacement, stress, or temperature

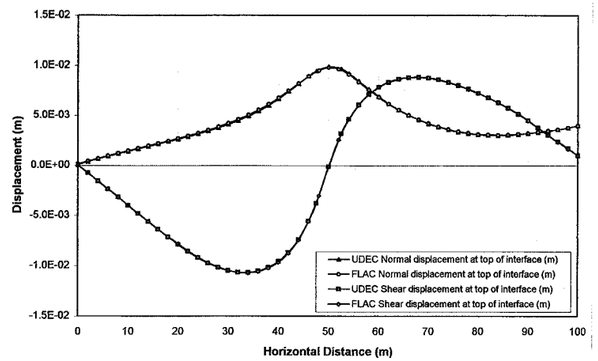
Comparison of FLAC and UDEC - Case 7.13

SD 673 Vol 1

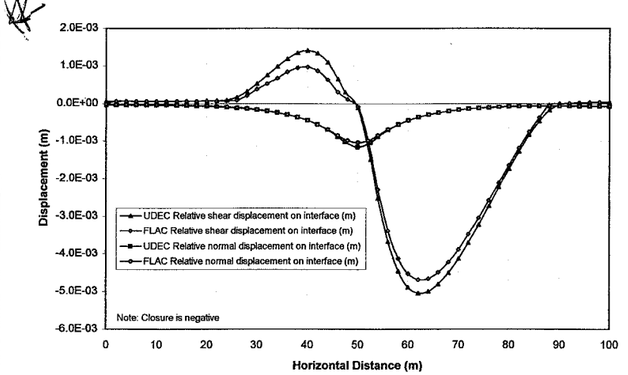
Case 7.13 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (Slip Allowed)



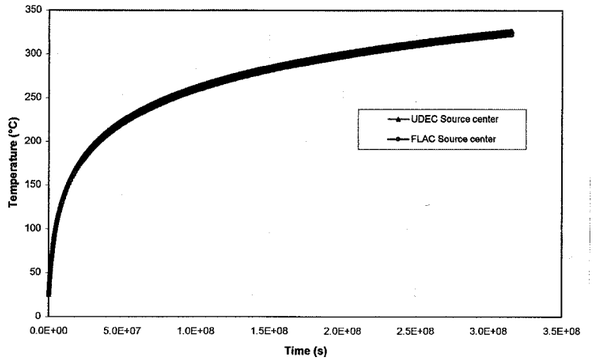
Case 7.13 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (Slip Allowed)



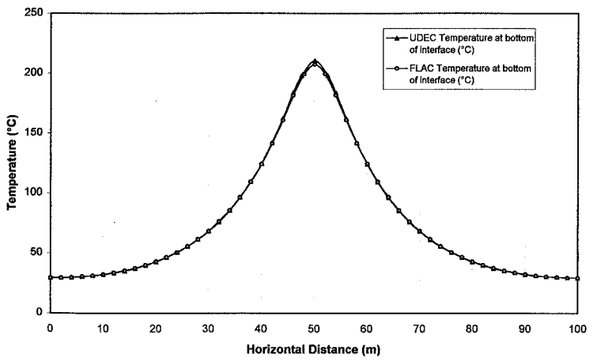
Case 7.13 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (Slip Allowed)



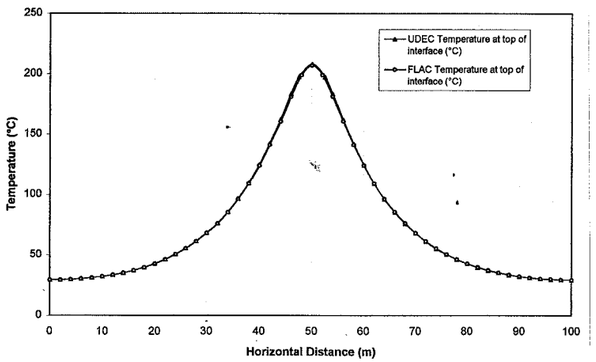
Case 7.13 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (Slip Allowed)



Case 7.13 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (Slip Allowed)



Case 7.13 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (Slip Allowed)

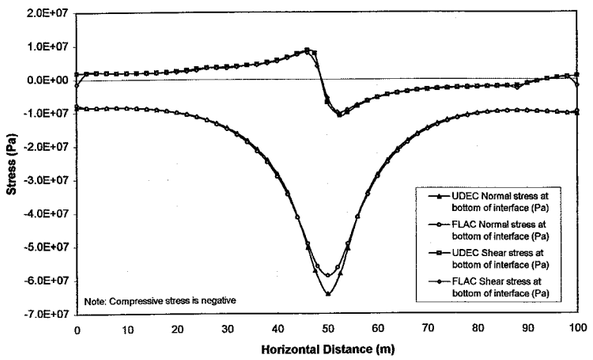


Comparison of FLAC and UDEC - Case 7.13

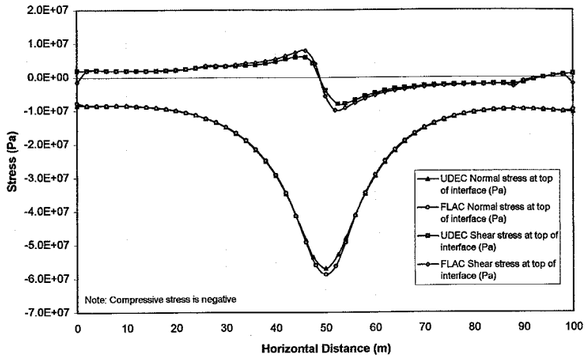
SN 673 Vol 1

Oct 13/04

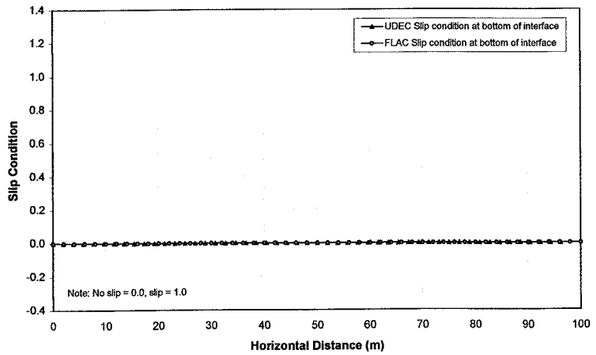
Case 7.13 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (Slip Allowed)



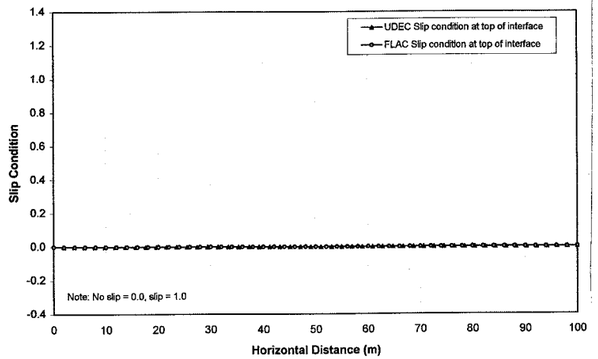
Case 7.13 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (Slip Allowed)



Case 7.13 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (Slip Allowed)



Case 7.13 - Comparison of Results for an Inclined Interface Subjected to a Volumetric Heat Source (Slip Allowed)



Comparison of FLAC and UDEC - Case 7.13

Blank
Oct 13/04

SN 673 Vol 1

Oct 17/2004

Case 2 - Horizontal Joint intersecting a circular opening.

This case is described in the paper entitled "Verification studies on the UDEC computational model of jointed rock" by Brady, Hsiung, Choudhury and Philip (1990) referenced in the software validation test plan.

The theoretical solution for this problem shows that joint slip should occur when the angular coordinate of the joint intersection is equal to the angle of friction of the joint. Once slip occurs, the tangential and normal stress on the joint should go to zero at the tunnel boundary.

Model Set up

- the model geometry for this problem is shown on page ~~99~~ 100 RP/AH 7/2004. The model assumes half symmetry with a 5m radius tunnel on the left boundary. The joint is horizontal and intersects at a height of 4.33 m. This corresponds to an angular coordinate $\theta = 60°$. Therefore, the joint should slip for any friction angle less than 60°.

Cases to Run.

Several cases are required using different friction angles on the joint, as well as an elastic case. Friction angles to run 65°, 61°, 60°, 59°, 55°, 30°, 20°, 16.3°, 10°, 0°. Some of these angles may be skipped depending on outcome 2 11/04

4 CIRCULAR EXCAVATION INTERSECTED BY A JOINT

Information potentially subject to copyright protection was redacted from this location. The redacted material was from a published article whose reference information is on the previous page.

Fig. 5 Joint intersecting a circular excavation, and related UDEC model.

Fig. 6 Polar plot of σ_θ boundary stress.

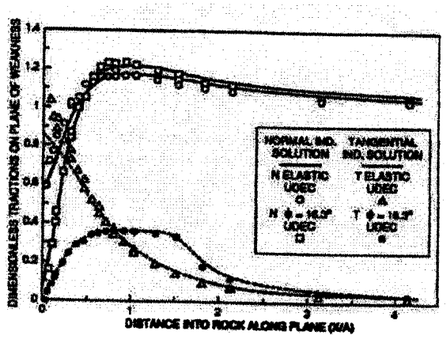


Fig. 7 Stress distribution following slip on joint.

Oct 20/2004

- Development of UDEC routines to run a suite of cases to assess joint stability.

Case			Plots
2.1	Elastic	- high cohesion, high tensile strength.	u21plots.doc
2.2	Mohr-Coulomb	$\phi = 70°$	u22plots.doc
2.3	Mohr-Coulomb	$\phi = 61°$	u23plots.doc
2.4	Mohr-Coulomb	$\phi = 60°$	u24plots.doc
2.5	Mohr-Coulomb	$\phi = 59°$	u25plots.doc
2.6	Mohr-Coulomb	$\phi = 45°$	u26plots.doc
2.7	Mohr-Coulomb	$\phi = 16.3°$	u27plots.doc
2.8	Mohr-Coulomb	$\phi = 58°$	u28plots.doc
2.9	Mohr-Coulomb	$\phi = 57°$	u29plots.doc
2.10	Mohr-Coulomb	$\phi = 55°$	u210plots.doc

- test runs conducted to work out bugs in boundary conditions
- joint stiffnesses selected to minimize displacement under non-critical loading conditions.

RR Oct 20/2004.

Oct 20/2004.

Oct 21/2004

- Created UDEC routines and ran batch models to produce output file Uxxjoint.out and Uxxstress.out. Joint files include stresses and displacements along joint. Stress files are boundary tangential stress at tunnel periphery. Files on following pages for UDEC input.

SN 673 Vol 1

```
; Case 2.1 UDEC Base case with horizontal
; transgressing joint intersecting a
; circular tunnel.
;
;
; Geometry
;
rou 0.0005
bl 0,-60 0,60 60,60 60,-60
arc 0.0 0.0 0.0  -5.0 180 18 ; Inner ring
arc 0.0 0.0 0.0  -6.0 180 18 ; Second ring
arc 0.0 0.0 0.0  -8.0 180 18 ; Third ring
arc 0.0 0.0 0.0 -12.0 180 18 ; Fourth ring
arc 0.0 0.0 0.0 -20.0 180 18 ; Fifth ring
arc 0.0 0.0 0.0 -30.0 180 18 ; Sixth ring
delete range block 818       ; Delete inner ring
crack 0.0 4.3301 60.0 4.3301     ; Horizontal crack
;
gen edge 0.25 range block 15256
gen edge 0.25 range block 3359
gen edge 0.4 range block 15231
gen edge 0.4 range block 5861
gen edge 0.7 range block 15206
gen edge 0.7 range block 8363
gen edge 1.1 range block 15181
gen edge 1.1 range block 10865
gen edge 2.0 range block 818
gen edge 2.0 range block 13367
gen edge 5.0 range block 15281
gen edge 5.0 range block 2
;
;
; Material properties
;
prop  m=1 de=2210.0 k=19.2e9 g=13.6e9
prop jm=1 jkn=3.0e12 jks=3.0e12
prop jm=1 jcoh=1.0e20 jfric=0.0 jten=1.0e20 jd=0
;
prop jm=2 jkn=5.0e12 jks=5.0e12
prop jm=2 jcoh=0.0 jfric=70.0 jten=0.0 jd=0
;
; Initial conditions
;
ini syy -24.0e6
ini sxx -24.0e6
ini sxy  0.0
ini szz  0.0
;
; Boundary conditions
;
bound stress -24.0e6 0.0 -24.0e6 range (-0.01,60.01)
(59.99,60.01)
bound stress -24.0e6 0.0 -24.0e6 range (-0.01,60.01) (-
60.01,-59.99)
bound stress -24.0e6 0.0 -24.0e6 range (59.99,60.01) (-
60.01,60.01)
bound stress -24.0e6 0.0 -24.0e6 range (0,5) (-5,5)
bound xvel 0.0 range (-0.01, 0.01) (-60.01,-4.99)
bound xvel 0.0 range (-0.01, 0.01) (4.99,60.01)
;
hist unbalanced
;
; Equilibrate model
;
set ovtol 0.1
step 500
;
; Alter joint properties
;
; change jmat=2 range 0 60 4.329 4.331
;
; Zero displacements and velocities
;
ini xd 0
ini yd 0
ini nd 0
ini sd 0
ini xv 0
ini yv 0
ini bxv 0
ini byv 0
ini brv 0
ini syy -24.0e6
ini sxx -24.0e6
ini sxy  0.0
ini szz  0.0
;
bound xfree range an 0 0 4.9 5.1
bound yfree range an 0 0 4.9 5.1
bound xvel 0.0 range (-0.01, 0.01) (-60.01,-4.99)
bound xvel 0.0 range (-0.01, 0.01) (4.99,60.01)
;
;
; Mechanical analysis
;
damp auto
step 5000
;
cal dispmag.fis
disp_mag
save u21final.sav
;
set plot emf color
title
Case 2.1 Horizontal Joint Intersecting a Circular Opening
(UDEC, Elastic)
;
; Geometry
;
set out u21grid.emf
set color iw
plo zone green blo iw
copy

; Joint condition plots
;
set out u21jndl.emf
set color iw
plot joint 0 4.33 60 4.33 ndisp 0.5
copy
;
set out u21jnsl.emf
set color iw
plot joint 0 4.33 60 4.33 nstr 0.5
copy
;
set out u21jsdl.emf
set color iw
plot joint 0 4.33 60 4.33 sdisp 0.5
copy
;
set out u21jssl.emf
set color iw
plot joint 0 4.33 60 4.33 sstr
copy
;
set out u21shear.emf
set color iw
plo blo iw shear red
copy
;
set out u21slip.emf
set color iw
plo blo iw slip red
copy
;
; Contour plots
;
set out u21disp.emf
set color iw
plot gp_extra fill alias 'Displacement' gp_extra iw blo iw
copy
;
set out u21xd.emf
set color iw
plot xd fill xd iw blo iw
copy
;
set out u21yd.emf
set color iw
plot yd fill yd iw blo iw
copy
;
set out u21unbal.emf
set color iw
plo hist 1
copy
;
; Create output files for EXCEL
;
set log u21joint.out
print joint 0 4.33 60 4.33 0.01
set log u21stress.out
print zone stress range an 0 0 5.05 5.10
;
ret
```


SN 673 Vol 1

```
; Case 2.2 UDEC Base case with horizontal
; transgressing joint intersecting a
; circular tunnel; friction angle 70 degrees.
;
;
; Geometry
;
rou 0.0005
bl 0,-60 0,60 60,60 60,-60
arc 0.0 0.0 0.0  -5.0 180 18 ; Inner ring
arc 0.0 0.0 0.0  -6.0 180 18 ; Second ring
arc 0.0 0.0 0.0  -8.0 180 18 ; Third ring
arc 0.0 0.0 0.0 -12.0 180 18 ; Fourth ring
arc 0.0 0.0 0.0 -20.0 180 18 ; Fifth ring
arc 0.0 0.0 0.0 -30.0 180 18 ; Sixth ring
delete range block 818       ; Delete inner ring
crack 0.0 4.3301 60.0 4.3301     ; Horizontal crack
;
gen edge 0.25 range block 15256
gen edge 0.25 range block 3359
gen edge 0.4 range block 15231
gen edge 0.4 range block 5861
gen edge 0.7 range block 15206
gen edge 0.7 range block 8363
gen edge 1.1 range block 15181
gen edge 1.1 range block 10865
gen edge 2.0 range block 818
gen edge 2.0 range block 13367
gen edge 5.0 range block 15281
gen edge 5.0 range block 2
;
;
; Material properties
;
prop  m=1 de=2210.0 k=19.2e9 g=13.6e9
prop jm=1 jkn=3.0e12 jks=3.0e12
prop jm=1 jcoh=1.0e20 jfric=0.0 jten=1.0e20 jd=0
;
prop jm=2 jkn=5.0e12 jks=5.0e12
prop jm=2 jcoh=0.0 jfric=70.0 jten=0.0 jd=0
;
; Initial conditions
;
ini syy -24.0e6
ini sxx -24.0e6
ini sxy  0.0
ini szz  0.0
;
; Boundary conditions
;
bound stress -24.0e6 0.0 -24.0e6 range (-0.01,60.01)
(59.99,60.01)
bound stress -24.0e6 0.0 -24.0e6 range (-0.01,60.01) (-
60.01,-59.99)
bound stress -24.0e6 0.0 -24.0e6 range (59.99,60.01) (-
60.01,60.01)
bound stress -24.0e6 0.0 -24.0e6 range (0,5) (-5,5)
bound xvel 0.0 range (-0.01, 0.01) (-60.01,-4.99)
bound xvel 0.0 range (-0.01, 0.01) (4.99,60.01)
;
hist unbalanced
;
; Equilibrate model
;
set ovtol 0.1
step 500
;
; Alter joint properties
;
change jmat=2 range -0.01 60.01 4.329 4.331
;
; Zero displacements and velocities
;
ini xd 0
ini yd 0
ini nd 0
ini sd 0
ini xv 0
ini yv 0
ini bxv 0
ini byv 0
ini brv 0
ini syy -24.0e6
ini sxx -24.0e6
ini sxy  0.0
ini szz  0.0
;
bound xfree range an 0 0 4.9 5.1
bound yfree range an 0 0 4.9 5.1
bound xvel 0.0 range (-0.01, 0.01) (-60.01,-4.99)
bound xvel 0.0 range (-0.01, 0.01) (4.99,60.01)
;
;
; Mechanical analysis
;
damp auto
step 5000
;
cal dispmag.fis
disp_mag
save u22final.sav
;
set plot emf color
title
Case 2.2 Horizontal Joint Intersecting a Circular Opening
(UDEC, phi=70 deg)
;
; Geometry
;
set out u22grid.emf
set color iw
plo zone green blo iw
copy

; Joint condition plots
;
set out u22jndl.emf
set color iw
plot joint 0 4.33 60 4.33 ndisp 0.5
copy
;
set out u22jnsl.emf
set color iw
plot joint 0 4.33 60 4.33 nstr 0.5
copy
;
set out u22jsdl.emf
set color iw
plot joint 0 4.33 60 4.33 sdisp 0.5
copy
;
set out u22jssl.emf
set color iw
plot joint 0 4.33 60 4.33 sstr
copy
;
set out u22shear.emf
set color iw
plo blo iw shear red
copy
;
set out u22slip.emf
set color iw
plo blo iw slip red
copy
;
; Contour plots
;
set out u22disp.emf
set color iw
plot gp_extra fill alias 'Displacement' gp_extra iw blo iw
copy
;
set out u22xd.emf
set color iw
plot xd fill xd iw blo iw
copy
;
set out u22yd.emf
set color iw
plot yd fill yd iw blo iw
copy
;
set out u22unbal.emf
set color iw
plo hist 1
copy
;
; Create output files for EXCEL
;
set log u22joint.out
print joint 0 4.33 60 4.33 0.01
set log u22stress.out
print zone stress range an 0 0 5.05 5.10
;
ret
```

SN 673 Vol 1

```
; Case 2.3 UDEC Base case with horizontal
; transgressing joint intersecting a
; circular tunnel; friction angle 61 degrees.
;
;
; Geometry
;
rou 0.0005
bl 0,-60 0,60 60,60 60,-60
arc 0.0 0.0 0.0  -5.0 180 18 ; Inner ring
arc 0.0 0.0 0.0  -6.0 180 18 ; Second ring
arc 0.0 0.0 0.0  -8.0 180 18 ; Third ring
arc 0.0 0.0 0.0 -12.0 180 18 ; Fourth ring
arc 0.0 0.0 0.0 -20.0 180 18 ; Fifth ring
arc 0.0 0.0 0.0 -30.0 180 18 ; Sixth ring
delete range block 818       ; Delete inner ring
crack 0.0 4.3301 60.0 4.3301     ; Horizontal crack
;
gen edge 0.25 range block 15256
gen edge 0.25 range block 3359
gen edge 0.4 range block 15231
gen edge 0.4 range block 5861
gen edge 0.7 range block 15206
gen edge 0.7 range block 8363
gen edge 1.1 range block 15181
gen edge 1.1 range block 10865
gen edge 2.0 range block 818
gen edge 2.0 range block 13367
gen edge 5.0 range block 15281
gen edge 5.0 range block 2
;
;
; Material properties
;
prop  m=1 de=2210.0 k=19.2e9 g=13.6e9
prop jm=1 jkn=3.0e12 jks=3.0e12
prop jm=1 jcoh=1.0e20 jfric=0.0 jten=1.0e20 jd=0
;
prop jm=2 jkn=5.0e12 jks=5.0e12
prop jm=2 jcoh=0.0 jfric=61.0 jten=0.0 jd=0
;
; Initial conditions
;
ini syy -24.0e6
ini sxx -24.0e6
ini sxy  0.0
ini szz  0.0
;
; Boundary conditions
;
bound stress -24.0e6 0.0 -24.0e6 range (-0.01,60.01)
(59.99,60.01)
bound stress -24.0e6 0.0 -24.0e6 range (-0.01,60.01) (-
60.01,-59.99)
bound stress -24.0e6 0.0 -24.0e6 range (59.99,60.01) (-
60.01,60.01)
bound stress -24.0e6 0.0 -24.0e6 range (0,5) (-5,5)
bound xvel 0.0 range (-0.01, 0.01) (-60.01,-4.99)
bound xvel 0.0 range (-0.01, 0.01) (4.99,60.01)
;
hist unbalanced
;
; Equilibrate model
;
set ovtol 0.1
step 500
;
; Alter joint properties
;
change jmat=2 range -0.01 60.01 4.329 4.331
;
; Zero displacements and velocities
;
ini xd 0
ini yd 0
ini nd 0
ini sd 0
ini xv 0
ini yv 0
ini bxv 0
ini byv 0
ini brv 0
ini syy -24.0e6
ini sxx -24.0e6
ini sxy  0.0
ini szz  0.0
;
bound xfree range an 0 0 4.9 5.1
bound yfree range an 0 0 4.9 5.1
bound xvel 0.0 range (-0.01, 0.01) (-60.01,-4.99)
bound xvel 0.0 range (-0.01, 0.01) (4.99,60.01)
;
;
; Mechanical analysis
;
damp auto
step 5000
;
cal dispmag.fis
disp_mag
save u23final.sav
;
set plot emf color
title
Case 2.3 Horizontal Joint Intersecting a Circular Opening
(UDEC, phi=61 deg)
;
; Geometry
;
set out u23grid.emf
set color iw
plo zone green blo iw
copy

; Joint condition plots
;
set out u23jndl.emf
set color iw
plot joint 0 4.33 60 4.33 ndisp 0.5
copy
;
set out u23jnsl.emf
set color iw
plot joint 0 4.33 60 4.33 nstr 0.5
copy
;
set out u23jsdl.emf
set color iw
plot joint 0 4.33 60 4.33 sdisp 0.5
copy
;
set out u23jssl.emf
set color iw
plot joint 0 4.33 60 4.33 sstr
copy
;
set out u23shear.emf
set color iw
plo blo iw shear red
copy
;
set out u23slip.emf
set color iw
plo blo iw slip red
copy
;
; Contour plots
;
set out u23disp.emf
set color iw
plot gp_extra fill alias 'Displacement' gp_extra iw blo iw
copy
;
set out u23xd.emf
set color iw
plot xd fill xd iw blo iw
copy
;
set out u23yd.emf
set color iw
plot yd fill yd iw blo iw
copy
;
set out u23unbal.emf
set color iw
plo hist 1
copy
;
; Create output files for EXCEL
;
set log u23joint.out
print joint 0 4.33 60 4.33 0.01
set log u23stress.out
print zone stress range an 0 0 5.05 5.10
;
ret
```

2+21/04

SN 673 Vol 1

```
; Case 2.4 UDEC Base case with horizontal
; transgressing joint intersecting a
; circular tunnel; friction angle 60 degrees.
;
;
; Geometry
;
rou 0.0005
bl 0,-60 0,60 60,60 60,-60
arc 0.0 0.0 0.0  -5.0 180 18 ; Inner ring
arc 0.0 0.0 0.0  -6.0 180 18 ; Second ring
arc 0.0 0.0 0.0  -8.0 180 18 ; Third ring
arc 0.0 0.0 0.0 -12.0 180 18 ; Fourth ring
arc 0.0 0.0 0.0 -20.0 180 18 ; Fifth ring
arc 0.0 0.0 0.0 -30.0 180 18 ; Sixth ring
delete range block 818       ; Delete inner ring
crack 0.0 4.3301 60.0 4.3301     ; Horizontal crack
;
gen edge 0.25 range block 15256
gen edge 0.25 range block 3359
gen edge 0.4 range block 15231
gen edge 0.4 range block 5861
gen edge 0.7 range block 15206
gen edge 0.7 range block 8363
gen edge 1.1 range block 15181
gen edge 1.1 range block 10865
gen edge 2.0 range block 818
gen edge 2.0 range block 13367
gen edge 5.0 range block 15281
gen edge 5.0 range block 2
;
;
; Material properties
;
prop  m=1 de=2210.0 k=19.2e9 g=13.6e9
prop jm=1 jkn=3.0e12 jks=3.0e12
prop jm=1 jcoh=1.0e20 jfric=0.0 jten=1.0e20 jd=0
;
prop jm=2 jkn=5.0e12 jks=5.0e12
prop jm=2 jcoh=0.0 jfric=60.0 jten=0.0 jd=0
;
; Initial conditions
;
ini syy -24.0e6
ini sxx -24.0e6
ini sxy  0.0
ini szz  0.0
;
; Boundary conditions
;
bound stress -24.0e6 0.0 -24.0e6 range (-0.01,60.01)
(59.99,60.01)
bound stress -24.0e6 0.0 -24.0e6 range (-0.01,60.01) (-
60.01,-59.99)
bound stress -24.0e6 0.0 -24.0e6 range (59.99,60.01) (-
60.01,60.01)
bound stress -24.0e6 0.0 -24.0e6 range (0,5) (-5,5)
bound xvel 0.0 range (-0.01, 0.01) (-60.01,-4.99)
bound xvel 0.0 range (-0.01, 0.01) (4.99,60.01)
;
hist unbalanced
;
; Equilibrate model
;
set ovtol 0.1
step 500
;
; Alter joint properties
;
change jmat=2 range -0.01 60.01 4.329 4.331
;
; Zero displacements and velocities
;
ini xd 0
ini yd 0
ini nd 0
ini sd 0
ini xv 0
ini yv 0
ini bxv 0
ini byv 0
ini brv 0
ini syy -24.0e6
ini sxx -24.0e6
ini sxy  0.0
ini szz  0.0
;
bound xfree range an 0 0 4.9 5.1
bound yfree range an 0 0 4.9 5.1
bound xvel 0.0 range (-0.01, 0.01) (-60.01,-4.99)
bound xvel 0.0 range (-0.01, 0.01) (4.99,60.01)
;
;
; Mechanical analysis
;
damp auto
step 5000
;
cal dispmag.fis
disp_mag
save u24final.sav
;
set plot emf color
title
Case 2.4 Horizontal Joint Intersecting a Circular Opening
(UDEC, phi=60 deg)
;
; Geometry
;
set out u24grid.emf
set color iw
plo zone green blo iw
copy

; Joint condition plots
;
set out u24jndl.emf
set color iw
plot joint 0 4.33 60 4.33 ndisp 0.5
copy
;
set out u24jnsl.emf
set color iw
plot joint 0 4.33 60 4.33 nstr 0.5
copy
;
set out u24jsdl.emf
set color iw
plot joint 0 4.33 60 4.33 sdisp 0.5
copy
;
set out u24jssl.emf
set color iw
plot joint 0 4.33 60 4.33 sstr
copy
;
set out u24shear.emf
set color iw
plo blo iw shear red
copy
;
set out u24slip.emf
set color iw
plo blo iw slip red
copy
;
; Contour plots
;
set out u24disp.emf
set color iw
plot gp_extra fill alias 'Displacement' gp_extra iw blo iw
copy
;
set out u24xd.emf
set color iw
plot xd fill xd iw blo iw
copy
;
set out u24yd.emf
set color iw
plot yd fill yd iw blo iw
copy
;
set out u24unbal.emf
set color iw
plo hist 1
copy
;
; Create output files for EXCEL
;
set log u24joint.out
print joint 0 4.33 60 4.33 0.01
set log u24stress.out
print zone stress range an 0 0 5.05 5.10
;
ret
```

2+21/04

SN673 Vol I

```
; Case 2.5 UDEC Base case with horizontal
; transgressing joint intersecting a
; circular tunnel; friction angle 59 degrees.
;
;
; Geometry
;
rou 0.0005
bl 0,-60 0,60 60,60 60,-60
arc 0.0 0.0 0.0  -5.0 180 18 ; Inner ring
arc 0.0 0.0 0.0  -6.0 180 18 ; Second ring
arc 0.0 0.0 0.0  -8.0 180 18 ; Third ring
arc 0.0 0.0 0.0 -12.0 180 18 ; Fourth ring
arc 0.0 0.0 0.0 -20.0 180 18 ; Fifth ring
arc 0.0 0.0 0.0 -30.0 180 18 ; Sixth ring
delete range block 818       ; Delete inner ring
crack 0.0 4.3301 60.0 4.3301     ; Horizontal crack
;
gen edge 0.25 range block 15256
gen edge 0.25 range block 3359
gen edge 0.4 range block 15231
gen edge 0.4 range block 5861
gen edge 0.7 range block 15206
gen edge 0.7 range block 8363
gen edge 1.1 range block 15181
gen edge 1.1 range block 10865
gen edge 2.0 range block 818
gen edge 2.0 range block 13367
gen edge 5.0 range block 15281
gen edge 5.0 range block 2
;
;
; Material properties
;
prop  m=1 de=2210.0 k=19.2e9 g=13.6e9
prop jm=1 jkn=3.0e12 jks=3.0e12
prop jm=1 jcoh=1.0e20 jfric=0.0 jten=1.0e20 jd=0
;
prop jm=2 jkn=5.0e12 jks=5.0e12
prop jm=2 jcoh=0.0 jfric=59.0 jten=0.0 jd=0
;
; Initial conditions
;
ini syy -24.0e6
ini sxx -24.0e6
ini sxy  0.0
ini szz  0.0
;
; Boundary conditions
;
bound stress -24.0e6 0.0 -24.0e6 range (-0.01,60.01)
(59.99,60.01)
bound stress -24.0e6 0.0 -24.0e6 range (-0.01,60.01) (-
60.01,-59.99)
bound stress -24.0e6 0.0 -24.0e6 range (59.99,60.01) (-
60.01,60.01)
bound stress -24.0e6 0.0 -24.0e6 range (0,5) (-5,5)
bound xvel 0.0 range (-0.01, 0.01) (-60.01,-4.99)
bound xvel 0.0 range (-0.01, 0.01) (4.99,60.01)
;
hist unbalanced
;
; Equilibrate model
;
set ovtol 0.1
step 500
;
; Alter joint properties
;
change jmat=2 range -0.01 60.01 4.329 4.331
;
; Zero displacements and velocities
;
ini xd 0
ini yd 0
ini nd 0
ini sd 0
ini xv 0
ini yv 0
ini bxv 0
ini byv 0
ini brv 0
ini syy -24.0e6
ini sxx -24.0e6
ini sxy  0.0
ini szz  0.0
;
bound xfree range an 0 0 4.9 5.1
bound yfree range an 0 0 4.9 5.1
bound xvel 0.0 range (-0.01, 0.01) (-60.01,-4.99)
bound xvel 0.0 range (-0.01, 0.01) (4.99,60.01)
;
;
; Mechanical analysis
;
damp auto
step 5000
;
cal dispmag.fis
disp_mag
save u25final.sav
;
set plot emf color
title
Case 2.5 Horizontal Joint Intersecting a Circular Opening
(UDEC, phi=59 deg)
;
; Geometry
;
set out u25grid.emf
set color iw
plo zone green blo iw
copy

; Joint condition plots
;
set out u25jndl.emf
set color iw
plot joint 0 4.33 60 4.33 ndisp 0.5
copy
;
set out u25jnsl.emf
set color iw
plot joint 0 4.33 60 4.33 nstr 0.5
copy
;
set out u25jsdl.emf
set color iw
plot joint 0 4.33 60 4.33 sdisp 0.5
copy
;
set out u25jssl.emf
set color iw
plot joint 0 4.33 60 4.33 sstr
copy
;
set out u25shear.emf
set color iw
plo blo iw shear red
copy
;
set out u25slip.emf
set color iw
plo blo iw slip red
copy
;
; Contour plots
;
set out u25disp.emf
set color iw
plot gp_extra fill alias 'Displacement' gp_extra iw blo iw
copy
;
set out u25xd.emf
set color iw
plot xd fill xd iw blo iw
copy
;
set out u25yd.emf
set color iw
plot yd fill yd iw blo iw
copy
;
set out u25unbal.emf
set color iw
plo hist 1
copy
;
; Create output files for EXCEL
;
set log u25joint.out
print joint 0 4.33 60 4.33 0.01
set log u25stress.out
print zone stress range an 0 0 5.05 5.10
;
ret
```

02/21/04

SN673 Vol I

```
; Case 2.6 UDEC Base case with horizontal
; transgressing joint intersecting a
; circular tunnel; friction angle 45 degrees.
;
;
; Geometry
;
rou 0.0005
bl 0,-60 0,60 60,60 60,-60
arc 0.0 0.0 0.0  -5.0 180 18 ; Inner ring
arc 0.0 0.0 0.0  -6.0 180 18 ; Second ring
arc 0.0 0.0 0.0  -8.0 180 18 ; Third ring
arc 0.0 0.0 0.0 -12.0 180 18 ; Fourth ring
arc 0.0 0.0 0.0 -20.0 180 18 ; Fifth ring
arc 0.0 0.0 0.0 -30.0 180 18 ; Sixth ring
delete range block 818       ; Delete inner ring
crack 0.0 4.3301 60.0 4.3301     ; Horizontal crack
;
gen edge 0.25 range block 15256
gen edge 0.25 range block 3359
gen edge 0.4 range block 15231
gen edge 0.4 range block 5861
gen edge 0.7 range block 15206
gen edge 0.7 range block 8363
gen edge 1.1 range block 15181
gen edge 1.1 range block 10865
gen edge 2.0 range block 818
gen edge 2.0 range block 13367
gen edge 5.0 range block 15281
gen edge 5.0 range block 2
;
;
; Material properties
;
prop  m=1 de=2210.0 k=19.2e9 g=13.6e9
prop jm=1 jkn=3.0e12 jks=3.0e12
prop jm=1 jcoh=1.0e20 jfric=0.0 jten=1.0e20 jd=0
;
prop jm=2 jkn=5.0e12 jks=5.0e12
prop jm=2 jcoh=0.0 jfric=45.0 jten=0.0 jd=0
;
; Initial conditions
;
ini syy -24.0e6
ini sxx -24.0e6
ini sxy  0.0
ini szz  0.0
;
; Boundary conditions
;
bound stress -24.0e6 0.0 -24.0e6 range (-0.01,60.01)
(59.99,60.01)
bound stress -24.0e6 0.0 -24.0e6 range (-0.01,60.01) (-
60.01,-59.99)
bound stress -24.0e6 0.0 -24.0e6 range (59.99,60.01) (-
60.01,60.01)
bound stress -24.0e6 0.0 -24.0e6 range (0,5) (-5,5)
bound xvel 0.0 range (-0.01, 0.01) (-60.01,-4.99)
bound xvel 0.0 range (-0.01, 0.01) (4.99,60.01)
;
hist unbalanced
;
; Equilibrate model
;
set ovtol 0.1
step 500
;
; Alter joint properties
;
change jmat=2 range -0.01 60.01 4.329 4.331
;
; Zero displacements and velocities
;
ini xd 0
ini yd 0
ini nd 0
ini sd 0
ini xv 0
ini yv 0
ini bxv 0
ini byv 0
ini brv 0
ini syy -24.0e6
ini sxx -24.0e6
ini sxy  0.0
ini szz  0.0
;
bound xfree range an 0 0 4.9 5.1
bound yfree range an 0 0 4.9 5.1
bound xvel 0.0 range (-0.01, 0.01) (-60.01,-4.99)
bound xvel 0.0 range (-0.01, 0.01) (4.99,60.01)
;
;
; Mechanical analysis
;
damp auto
step 5000
;
cal dispmag.fis
disp_mag
save u26final.sav
;
set plot emf color
title
Case 2.6 Horizontal Joint Intersecting a Circular Opening
(UDEC, phi=45 deg)
;
; Geometry
;
set out u26grid.emf
set color iw
plo zone green blo iw
copy

; Joint condition plots
;
set out u26jndl.emf
set color iw
plot joint 0 4.33 60 4.33 ndisp 0.5
copy
;
set out u26jnsl.emf
set color iw
plot joint 0 4.33 60 4.33 nstr 0.5
copy
;
set out u26jsdl.emf
set color iw
plot joint 0 4.33 60 4.33 sdisp 0.5
copy
;
set out u26jssl.emf
set color iw
plot joint 0 4.33 60 4.33 sstr
copy
;
set out u26shear.emf
set color iw
plo blo iw shear red
copy
;
set out u26slip.emf
set color iw
plo blo iw slip red
copy
;
; Contour plots
;
set out u26disp.emf
set color iw
plot gp_extra fill alias 'Displacement' gp_extra iw blo iw
copy
;
set out u26xd.emf
set color iw
plot xd fill xd iw blo iw
copy
;
set out u26yd.emf
set color iw
plot yd fill yd iw blo iw
copy
;
set out u26unbal.emf
set color iw
plo hist 1
copy
;
; Create output files for EXCEL
;
set log u26joint.out
print joint 0 4.33 60 4.33 0.01
set log u26stress.out
print zone stress range an 0 0 5.05 5.10
;
ret
```

02/21/04

SNL673 Vol 1

```
; Case 2.7 UDEC Base case with horizontal
; transgressing joint intersecting a
; circular tunnel; friction angle 16.3 degrees.
;
;
; Geometry
;
rou 0.0005
bl 0,-60 0,60 60,60 60,-60
arc 0.0 0.0 0.0  -5.0 180 18 ; Inner ring
arc 0.0 0.0 0.0  -6.0 180 18 ; Second ring
arc 0.0 0.0 0.0  -8.0 180 18 ; Third ring
arc 0.0 0.0 0.0 -12.0 180 18 ; Fourth ring
arc 0.0 0.0 0.0 -20.0 180 18 ; Fifth ring
arc 0.0 0.0 0.0 -30.0 180 18 ; Sixth ring
delete range block 818       ; Delete inner ring
crack 0.0 4.3301 60.0 4.3301     ; Horizontal crack
;
gen edge 0.25 range block 15256
gen edge 0.25 range block 3359
gen edge 0.4 range block 15231
gen edge 0.4 range block 5861
gen edge 0.7 range block 15206
gen edge 0.7 range block 8363
gen edge 1.1 range block 15181
gen edge 1.1 range block 10865
gen edge 2.0 range block 818
gen edge 2.0 range block 13367
gen edge 5.0 range block 15281
gen edge 5.0 range block 2
;
;
; Material properties
;
prop  m=1 de=2210.0 k=19.2e9 g=13.6e9
prop jm=1 jkn=3.0e12 jks=3.0e12
prop jm=1 jcoh=1.0e20 jfric=0.0 jten=1.0e20 jd=0
;
prop jm=2 jkn=5.0e12 jks=5.0e12
prop jm=2 jcoh=0.0 jfric=16.3 jten=0.0 jd=0
;
; Initial conditions
;
ini syy -24.0e6
ini sxx -24.0e6
ini sxy  0.0
ini szz  0.0
;
; Boundary conditions
;
bound stress -24.0e6 0.0 -24.0e6 range (-0.01,60.01)
(59.99,60.01)
bound stress -24.0e6 0.0 -24.0e6 range (-0.01,60.01) (-
60.01,-59.99)
bound stress -24.0e6 0.0 -24.0e6 range (59.99,60.01) (-
60.01,60.01)
bound stress -24.0e6 0.0 -24.0e6 range (0,5) (-5,5)
bound xvel 0.0 range (-0.01, 0.01) (-60.01,-4.99)
bound xvel 0.0 range (-0.01, 0.01) (4.99,60.01)
;
hist unbalanced
;
; Equilibrate model
;
set ovtol 0.1
step 500
;
; Alter joint properties
;
change jmat=2 range -0.01 60.01 4.329 4.331
;
; Zero displacements and velocities
;
ini xd 0
ini yd 0
ini nd 0
ini sd 0
ini xv 0
ini yv 0
ini bxv 0
ini byv 0
ini brv 0
ini syy -24.0e6
ini sxx -24.0e6
ini sxy  0.0
ini szz  0.0
;
bound xfree range an 0 0 4.9 5.1
bound yfree range an 0 0 4.9 5.1
bound xvel 0.0 range (-0.01, 0.01) (-60.01,-4.99)
bound xvel 0.0 range (-0.01, 0.01) (4.99,60.01)
;
;
; Mechanical analysis
;
damp auto
step 5000
;
cal dispmag.fis
disp_mag
save u27final.sav
;
set plot emf color
title
Case 2.7 Horizontal Joint Intersecting a Circular Opening
(UDEC, phi=16.3 deg)
;
; Geometry
;
set out u27grid.emf
set color iw
plo zone green blo iw
copy

; Joint condition plots
;
set out u27jndl.emf
set color iw
plot joint 0 4.33 60 4.33 ndisp 0.5
copy
;
set out u27jnsl.emf
set color iw
plot joint 0 4.33 60 4.33 nstr 0.5
copy
;
set out u27jsdl.emf
set color iw
plot joint 0 4.33 60 4.33 sdisp 0.5
copy
;
set out u27jssl.emf
set color iw
plot joint 0 4.33 60 4.33 sstr
copy
;
set out u27shear.emf
set color iw
plo blo iw shear red
copy
;
set out u27slip.emf
set color iw
plo blo iw slip red
copy
;
; Contour plots
;
set out u27disp.emf
set color iw
plot gp_extra fill alias 'Displacement' gp_extra iw blo iw
copy
;
set out u27xd.emf
set color iw
plot xd fill xd iw blo iw
copy
;
set out u27yd.emf
set color iw
plot yd fill yd iw blo iw
copy
;
set out u27unbal.emf
set color iw
plo hist 1
copy
;
; Create output files for EXCEL
;
set log u27joint.out
print joint 0 4.33 60 4.33 0.01
set log u27stress.out
print zone stress range an 0 0 5.05 5.10
;
ret
```

Oct 21/04

SNL673 Vol 1

```
; Case 2.8 UDEC Base case with horizontal
; transgressing joint intersecting a
; circular tunnel; friction angle 58 degrees.
;
;
; Geometry
;
rou 0.0005
bl 0,-60 0,60 60,60 60,-60
arc 0.0 0.0 0.0  -5.0 180 18 ; Inner ring
arc 0.0 0.0 0.0  -6.0 180 18 ; Second ring
arc 0.0 0.0 0.0  -8.0 180 18 ; Third ring
arc 0.0 0.0 0.0 -12.0 180 18 ; Fourth ring
arc 0.0 0.0 0.0 -20.0 180 18 ; Fifth ring
arc 0.0 0.0 0.0 -30.0 180 18 ; Sixth ring
delete range block 818       ; Delete inner ring
crack 0.0 4.3301 60.0 4.3301     ; Horizontal crack
;
gen edge 0.25 range block 15256
gen edge 0.25 range block 3359
gen edge 0.4 range block 15231
gen edge 0.4 range block 5861
gen edge 0.7 range block 15206
gen edge 0.7 range block 8363
gen edge 1.1 range block 15181
gen edge 1.1 range block 10865
gen edge 2.0 range block 818
gen edge 2.0 range block 13367
gen edge 5.0 range block 15281
gen edge 5.0 range block 2
;
;
; Material properties
;
prop  m=1 de=2210.0 k=19.2e9 g=13.6e9
prop jm=1 jkn=3.0e12 jks=3.0e12
prop jm=1 jcoh=1.0e20 jfric=0.0 jten=1.0e20 jd=0
;
prop jm=2 jkn=5.0e12 jks=5.0e12
prop jm=2 jcoh=0.0 jfric=58 jten=0.0 jd=0
;
; Initial conditions
;
ini syy -24.0e6
ini sxx -24.0e6
ini sxy  0.0
ini szz  0.0
;
; Boundary conditions
;
bound stress -24.0e6 0.0 -24.0e6 range (-0.01,60.01)
(59.99,60.01)
bound stress -24.0e6 0.0 -24.0e6 range (-0.01,60.01) (-
60.01,-59.99)
bound stress -24.0e6 0.0 -24.0e6 range (59.99,60.01) (-
60.01,60.01)
bound stress -24.0e6 0.0 -24.0e6 range (0,5) (-5,5)
bound xvel 0.0 range (-0.01, 0.01) (-60.01,-4.99)
bound xvel 0.0 range (-0.01, 0.01) (4.99,60.01)
;
hist unbalanced
;
; Equilibrate model
;
set ovtol 0.1
step 500
;
; Alter joint properties
;
change jmat=2 range -0.01 60.01 4.329 4.331
;
; Zero displacements and velocities
;
ini xd 0
ini yd 0
ini nd 0
ini sd 0
ini xv 0
ini yv 0
ini bxv 0
ini byv 0
ini brv 0
ini syy -24.0e6
ini sxx -24.0e6
ini sxy  0.0
ini szz  0.0
;
bound xfree range an 0 0 4.9 5.1
bound yfree range an 0 0 4.9 5.1
bound xvel 0.0 range (-0.01, 0.01) (-60.01,-4.99)
bound xvel 0.0 range (-0.01, 0.01) (4.99,60.01)
;
;
; Mechanical analysis
;
damp auto
step 5000
;
cal dispmag.fis
disp_mag
save u28final.sav
;
set plot emf color
title
Case 2.8 Horizontal Joint Intersecting a Circular Opening
(UDEC, phi=58 deg)
;
; Geometry
;
set out u28grid.emf
set color iw
plo zone green blo iw
copy

; Joint condition plots
;
set out u28jndl.emf
set color iw
plot joint 0 4.33 60 4.33 ndisp 0.5
copy
;
set out u28jnsl.emf
set color iw
plot joint 0 4.33 60 4.33 nstr 0.5
copy
;
set out u28jsdl.emf
set color iw
plot joint 0 4.33 60 4.33 sdisp 0.5
copy
;
set out u28jssl.emf
set color iw
plot joint 0 4.33 60 4.33 sstr
copy
;
set out u28shear.emf
set color iw
plo blo iw shear red
copy
;
set out u28slip.emf
set color iw
plo blo iw slip red
copy
;
; Contour plots
;
set out u28disp.emf
set color iw
plot gp_extra fill alias 'Displacement' gp_extra iw blo iw
copy
;
set out u28xd.emf
set color iw
plot xd fill xd iw blo iw
copy
;
set out u28yd.emf
set color iw
plot yd fill yd iw blo iw
copy
;
set out u28unbal.emf
set color iw
plo hist 1
copy
;
; Create output files for EXCEL
;
set log u28joint.out
print joint 0 4.33 60 4.33 0.01
set log u28stress.out
print zone stress range an 0 0 5.05 5.10
;
ret
```

Oct 21/04

SN673 Vol I

```
; Case 2.9 UDEC Base case with horizontal
; transgressing joint intersecting a
; circular tunnel; friction angle 57 degrees.
;
;
; Geometry
;
rou 0.0005
bl 0,-60 0,60 60,60 60,-60
arc 0.0 0.0 0.0  -5.0 180 18 ; Inner ring
arc 0.0 0.0 0.0  -6.0 180 18 ; Second ring
arc 0.0 0.0 0.0  -8.0 180 18 ; Third ring
arc 0.0 0.0 0.0 -12.0 180 18 ; Fourth ring
arc 0.0 0.0 0.0 -20.0 180 18 ; Fifth ring
arc 0.0 0.0 0.0 -30.0 180 18 ; Sixth ring
delete range block 818        ; Delete inner ring
crack 0.0 4.3301 60.0 4.3301     ; Horizontal crack
;
gen edge 0.25 range block 15256
gen edge 0.25 range block 3359
gen edge 0.4 range block 15231
gen edge 0.4 range block 5861
gen edge 0.7 range block 15206
gen edge 0.7 range block 8363
gen edge 1.1 range block 15181
gen edge 1.1 range block 10865
gen edge 2.0 range block 818
gen edge 2.0 range block 13367
gen edge 5.0 range block 15281
gen edge 5.0 range block 2
;
;
; Material properties
;
prop  m=1 de=2210.0 k=19.2e9 g=13.6e9
prop jm=1 jkn=3.0e12 jks=3.0e12
prop jm=1 jcoh=1.0e20 jfric=0.0 jten=1.0e20 jd=0
;
prop jm=2 jkn=5.0e12 jks=5.0e12
prop jm=2 jcoh=0.0 jfric=57 jten=0.0 jd=0
;
; Initial conditions
;
ini syy -24.0e6
ini sxx -24.0e6
ini sxy  0.0
ini szz  0.0
;
; Boundary conditions
;
bound stress -24.0e6 0.0 -24.0e6 range (-0.01,60.01)
(59.99,60.01)
bound stress -24.0e6 0.0 -24.0e6 range (-0.01,60.01) (-
60.01,-59.99)
bound stress -24.0e6 0.0 -24.0e6 range (59.99,60.01) (-
60.01,60.01)
bound stress -24.0e6 0.0 -24.0e6 range (0,5) (-5,5)
bound xvel 0.0 range (-0.01, 0.01) (-60.01,-4.99)
bound xvel 0.0 range (-0.01, 0.01) (4.99,60.01)
;
hist unbalanced
;
; Equilibrate model
;
set ovtol 0.1
step 500
;
; Alter joint properties
;
change jmat=2 range -0.01 60.01 4.329 4.331
;
; Zero displacements and velocities
;
ini xd 0
ini yd 0
ini nd 0
ini sd 0
ini xv 0
ini yv 0
ini bxv 0
ini byv 0
ini brv 0
ini syy -24.0e6
ini sxx -24.0e6
ini sxy  0.0
ini szz  0.0
;
bound xfree range an 0 0 4.9 5.1
bound yfree range an 0 0 4.9 5.1
bound xvel 0.0 range (-0.01, 0.01) (-60.01,-4.99)
bound xvel 0.0 range (-0.01, 0.01) (4.99,60.01)
;
;
; Mechanical analysis
;
damp auto
step 5000
;
cal dispmag.fis
disp_mag
save u29final.sav
;
set plot emf color
title
Case 2.9 Horizontal Joint Intersecting a Circular Opening
(UDEC, phi=57 deg)
;
; Geometry
;
set out u29grid.emf
set color iw
plo zone green blo iw
copy

; Joint condition plots
;
set out u29jndl.emf
set color iw
plot joint 0 4.33 60 4.33 ndisp 0.5
copy
;
set out u29jnsl.emf
set color iw
plot joint 0 4.33 60 4.33 nstr 0.5
copy
;
set out u29jsdl.emf
set color iw
plot joint 0 4.33 60 4.33 sdisp 0.5
copy
;
set out u29jssl.emf
set color iw
plot joint 0 4.33 60 4.33 sstr
copy
;
set out u29shear.emf
set color iw
plo blo iw shear red
copy
;
set out u29slip.emf
set color iw
plo blo iw slip red
copy
;
; Contour plots
;
set out u29disp.emf
set color iw
plot gp_extra fill alias 'Displacement' gp_extra iw blo iw
copy
;
set out u29xd.emf
set color iw
plot xd fill xd iw blo iw
copy
;
set out u29yd.emf
set color iw
plot yd fill yd iw blo iw
copy
;
set out u29unbal.emf
set color iw
plo hist 1
copy
;
; Create output files for EXCEL
;
set log u29joint.out
print joint 0 4.33 60 4.33 0.01
set log u29stress.out
print zone stress range an 0 0 5.05 5.10
;
ret
```

02/21/04

SN673 Vol I

```
; Case 2.10 UDEC Base case with horizontal
; transgressing joint intersecting a
; circular tunnel; friction angle 55 degrees.
;
;
; Geometry
;
rou 0.0005
bl 0,-60 0,60 60,60 60,-60
arc 0.0 0.0 0.0  -5.0 180 18 ; Inner ring
arc 0.0 0.0 0.0  -6.0 180 18 ; Second ring
arc 0.0 0.0 0.0  -8.0 180 18 ; Third ring
arc 0.0 0.0 0.0 -12.0 180 18 ; Fourth ring
arc 0.0 0.0 0.0 -20.0 180 18 ; Fifth ring
arc 0.0 0.0 0.0 -30.0 180 18 ; Sixth ring
delete range block 818        ; Delete inner ring
crack 0.0 4.3301 60.0 4.3301     ; Horizontal crack
;
gen edge 0.25 range block 15256
gen edge 0.25 range block 3359
gen edge 0.4 range block 15231
gen edge 0.4 range block 5861
gen edge 0.7 range block 15206
gen edge 0.7 range block 8363
gen edge 1.1 range block 15181
gen edge 1.1 range block 10865
gen edge 2.0 range block 818
gen edge 2.0 range block 13367
gen edge 5.0 range block 15281
gen edge 5.0 range block 2
;
;
; Material properties
;
prop  m=1 de=2210.0 k=19.2e9 g=13.6e9
prop jm=1 jkn=3.0e12 jks=3.0e12
prop jm=1 jcoh=1.0e20 jfric=0.0 jten=1.0e20 jd=0
;
prop jm=2 jkn=5.0e12 jks=5.0e12
prop jm=2 jcoh=0.0 jfric=55 jten=0.0 jd=0
;
; Initial conditions
;
ini syy -24.0e6
ini sxx -24.0e6
ini sxy  0.0
ini szz  0.0
;
; Boundary conditions
;
bound stress -24.0e6 0.0 -24.0e6 range (-0.01,60.01)
(59.99,60.01)
bound stress -24.0e6 0.0 -24.0e6 range (-0.01,60.01) (-
60.01,-59.99)
bound stress -24.0e6 0.0 -24.0e6 range (59.99,60.01) (-
60.01,60.01)
bound stress -24.0e6 0.0 -24.0e6 range (0,5) (-5,5)
bound xvel 0.0 range (-0.01, 0.01) (-60.01,-4.99)
bound xvel 0.0 range (-0.01, 0.01) (4.99,60.01)
;
hist unbalanced
;
; Equilibrate model
;
set ovtol 0.1
step 500
;
; Alter joint properties
;
change jmat=2 range -0.01 60.01 4.329 4.331
;
; Zero displacements and velocities
;
ini xd 0
ini yd 0
ini nd 0
ini sd 0
ini xv 0
ini yv 0
ini bxv 0
ini byv 0
ini brv 0
ini syy -24.0e6
ini sxx -24.0e6
ini sxy  0.0
ini szz  0.0
;
bound xfree range an 0 0 4.9 5.1
bound yfree range an 0 0 4.9 5.1
bound xvel 0.0 range (-0.01, 0.01) (-60.01,-4.99)
bound xvel 0.0 range (-0.01, 0.01) (4.99,60.01)
;
;
; Mechanical analysis
;
damp auto
step 5000
;
cal dispmag.fis
disp_mag
save u210final.sav
;
set plot emf color
title
Case 2.10 Horizontal Joint Intersecting a Circular Opening
(UDEC, phi=55 deg)
;
; Geometry
;
set out u210grid.emf
set color iw
plo zone green blo iw
copy

; Joint condition plots
;
set out u210jndl.emf
set color iw
plot joint 0 4.33 60 4.33 ndisp 0.5
copy
;
set out u210jnsl.emf
set color iw
plot joint 0 4.33 60 4.33 nstr 0.5
copy
;
set out u210jsdl.emf
set color iw
plot joint 0 4.33 60 4.33 sdisp 0.5
copy
;
set out u210jssl.emf
set color iw
plot joint 0 4.33 60 4.33 sstr
copy
;
set out u210shear.emf
set color iw
plo blo iw shear red
copy
;
set out u210slip.emf
set color iw
plo blo iw slip red
copy
;
; Contour plots
;
set out u210disp.emf
set color iw
plot gp_extra fill alias 'Displacement' gp_extra iw blo iw
copy
;
set out u210xd.emf
set color iw
plot xd fill xd iw blo iw
copy
;
set out u210yd.emf
set color iw
plot yd fill yd iw blo iw
copy
;
set out u210unbal.emf
set color iw
plo hist 1
copy
;
; Create output files for EXCEL
;
set log u210joint.out
print joint 0 4.33 60 4.33 0.01
set log u210stress.out
print zone stress range an 0 0 5.05 5.10
;
ret
```

02/21/04

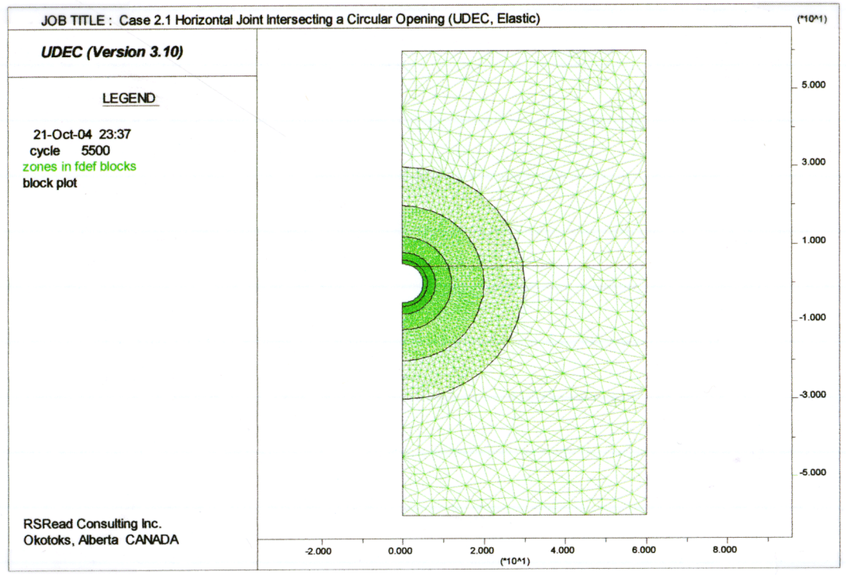
SN673 Vol 1

Oct 21/04

- Results from Case 2.1 - 2.10 imported into EXCEL spreadsheets
  u21.xls – u210.xls using either joint or stress modifiers
  ie u21joint.xls ... u210joint.xls
  u21stress.xls ... u210stress.xls
- Plots in each of these files include -
  - Displacement (normal & shear) vs Distance into Rock along joint (X/A)
  - Stress distribution along horizontal joint (normal/shear traction)
  - Strength Factor along horizontal joint
  - Stress distribution at tunnel periphery (radial/tangential)
- For these plots, distance is expressed as X/A where A is the tunnel radius (= 5m). Angular coordinate is measured anti-clockwise from horizontal. Stresses are normalized to far-field hydrostatic stress of 24 MPa.
- Strength Factor is defined as shear strength/shear stress
  where shear strength = $C_n \tan\phi$, C_n from UDEC
  shear stress → from UDEC

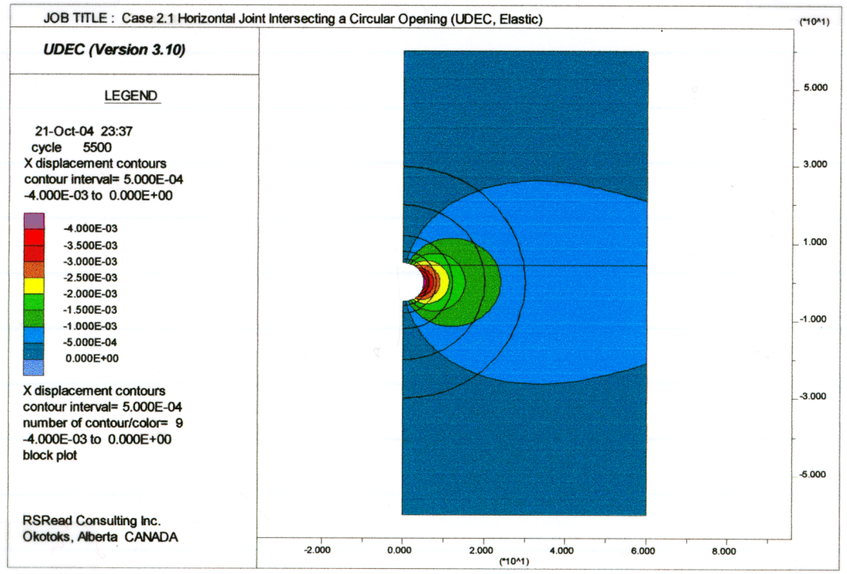
- The grid used for Case 2 is shown on page 113 along with a typical plot of horizontal displacement without slip on the joint.

- A plot of dimensionless shear and normal tractions on the joint under high cohesion and high tensile strength conditions is compared to the analytical solution (Kirsch equations) on page 114. The tractions are calculated as the



Oct 21/04

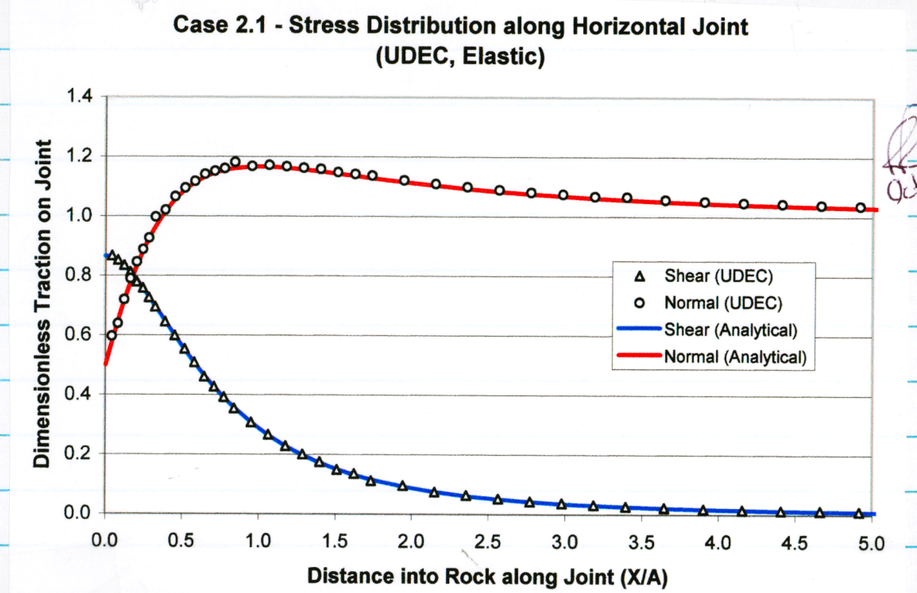
File u21grid.emf Grid used for Case 2.



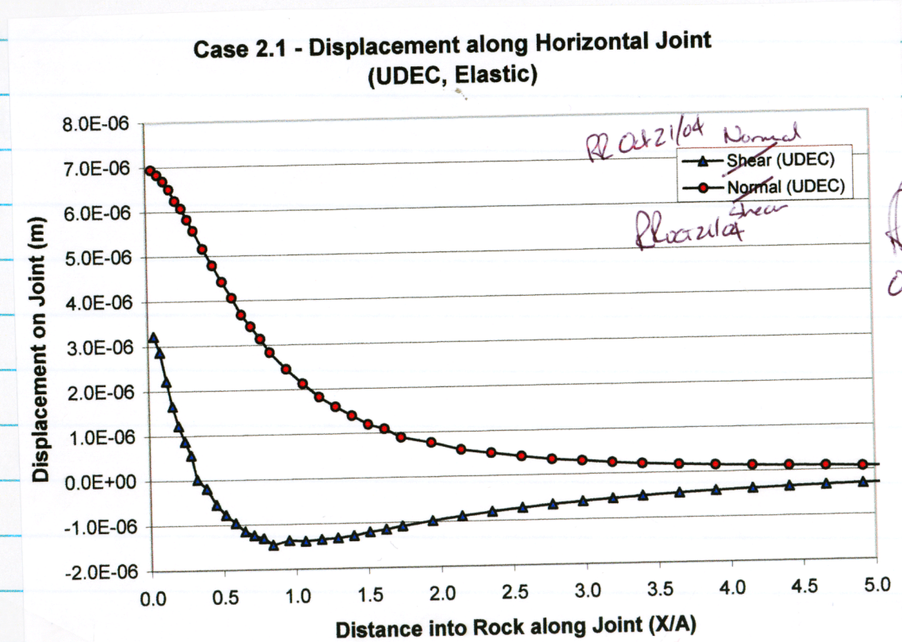
Oct 21/04

File u21xd.emf Typical x-displacement contours prior to joint slip.

SN673 Vol 1



Oct 21/04



Oct 21/04 Normal

Shear

Oct 21/04

From file u21joint.xls

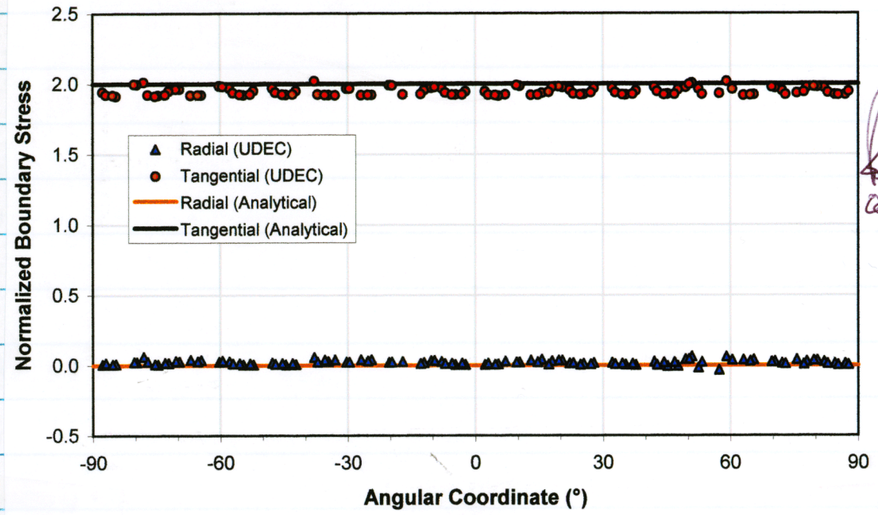
SN 673 Vol 1

ratio of shear and normal stress on the joint to the far-field stress. The displacements on the joint are also shown in the Figure on page 114 – note the very small magnitudes indicating very little relative movement between opposite sides of the joint.

- The stress and displacement plots for Cases 2.2, 2.3, 2.4 & 2.5 were identical to those shown on page 114. No slip was evident in the model using the PLOT SLIP command.
- Although there was no distinguishing change in stresses or displacement along the joint for case 2.8 with a friction angle of 58°, this case did indicate the initiation of slip at the joint-boundary intersection. The change in stress at the boundary was not evident in the plot of stress at the boundary, although these plots were generated searching only for those elements with centroids between 5.05 and 5.10 m from the origin, thus eliminating some elements very close to the boundary – this was done to eliminate some scatter in data due to small elements near the joint-boundary intersection.
- A typical plot of boundary stresses for Case 2.1 and Case 2.8 are shown on page 116.
- Shear and normal stresses along the joint are shown on pg 117 for three different friction angles, compared to the closed-form elastic solution. As friction angle decreases, the joint tractions are relieved near the opening.

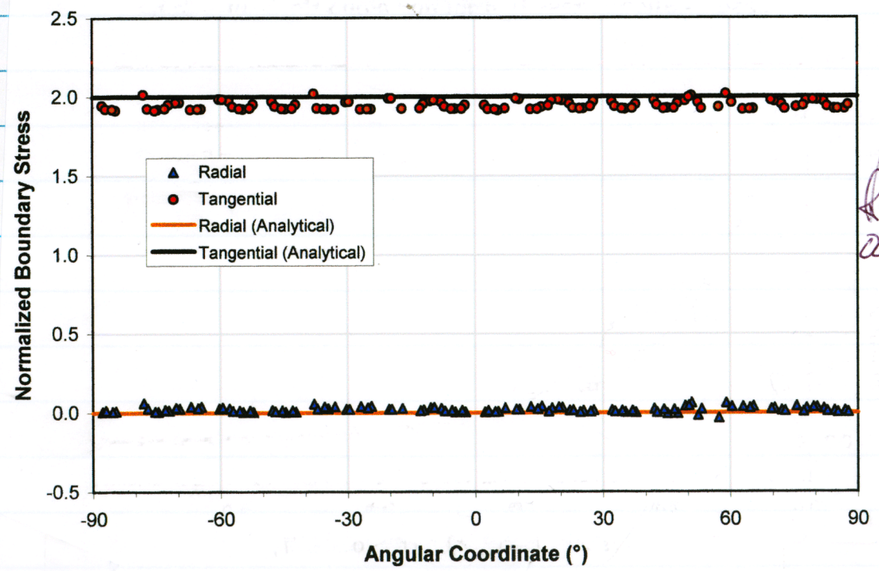
SN 673 Vol 1

Case 2.1 - Stress Distribution at Tunnel Periphery (UDEC, Elastic)



RL 10/21/04

Case 2.8 - Stress Distribution at Tunnel Periphery (UDEC, ϕ=58°)

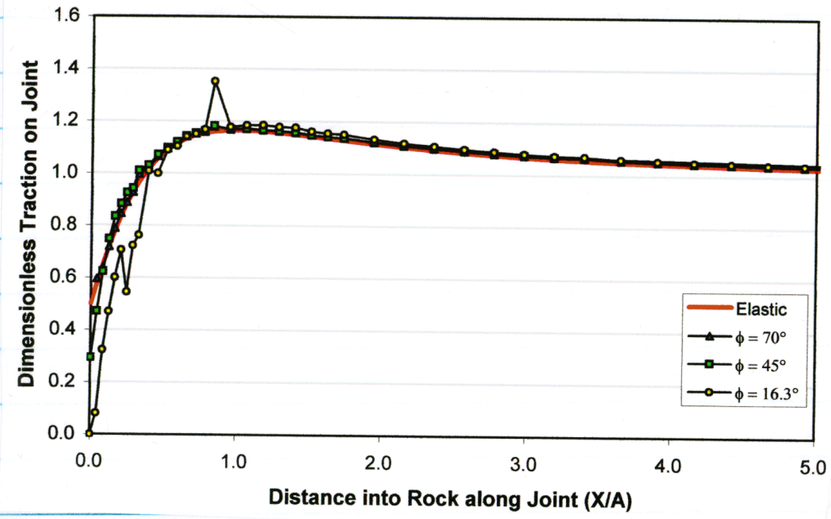


RL 10/21/04

From Files ~~U21jo~~ U21stress1.xls and U28stress1.xls
RL 10/21/04
(Top) (Bottom)

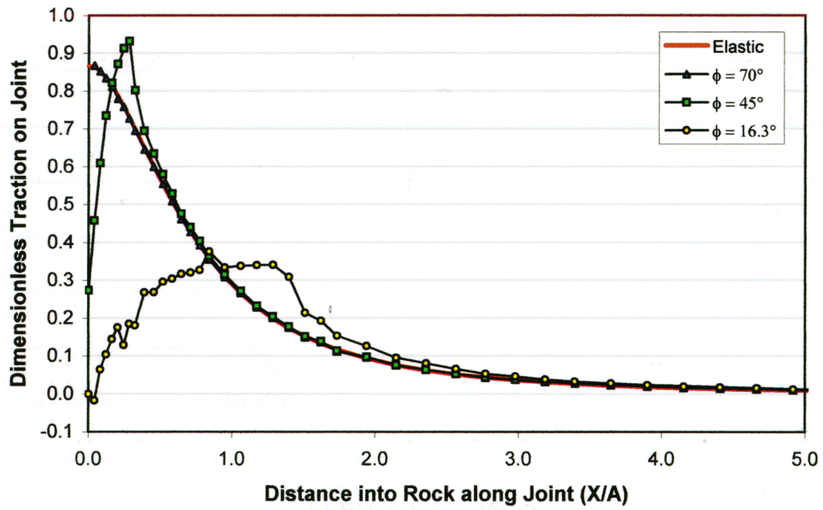
SN 673 Vol 1

Case 2 - Normal Stress Distribution along Horizontal Joint



RL 10/21/04

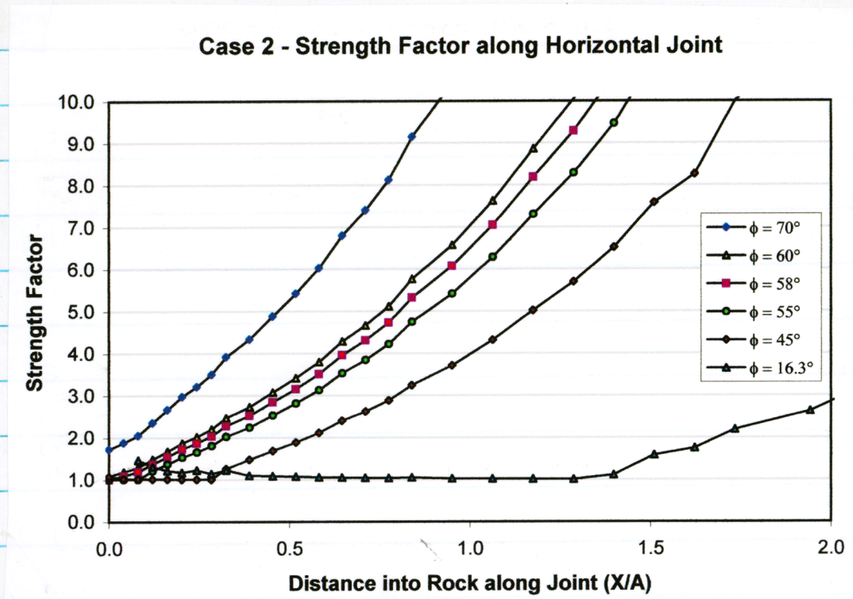
Case 2 - Shear Stress Distribution along Horizontal Joint



RL 10/21/04.

From File U21joint.xls

SN673 Vol 1

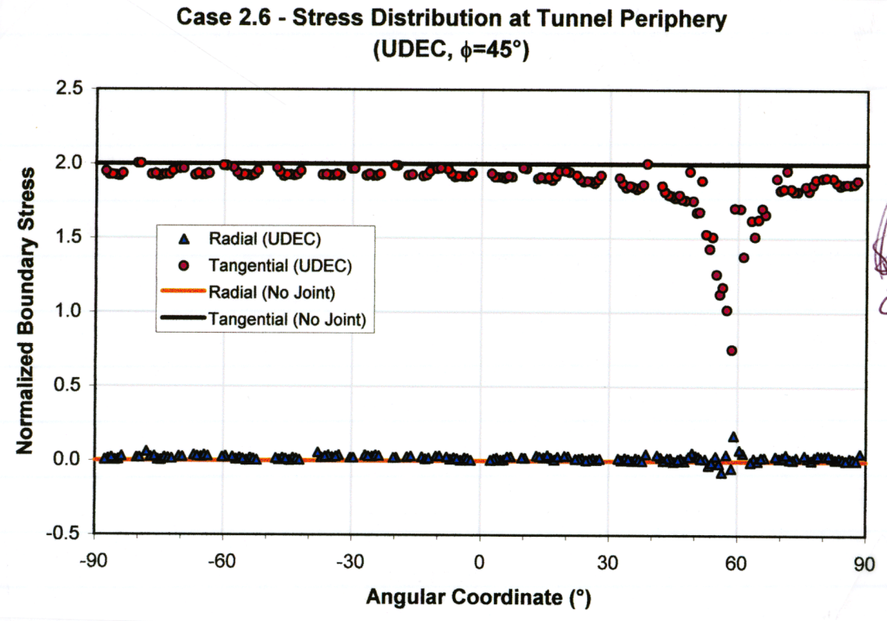


Oct 21/04

From file u21joint.xls

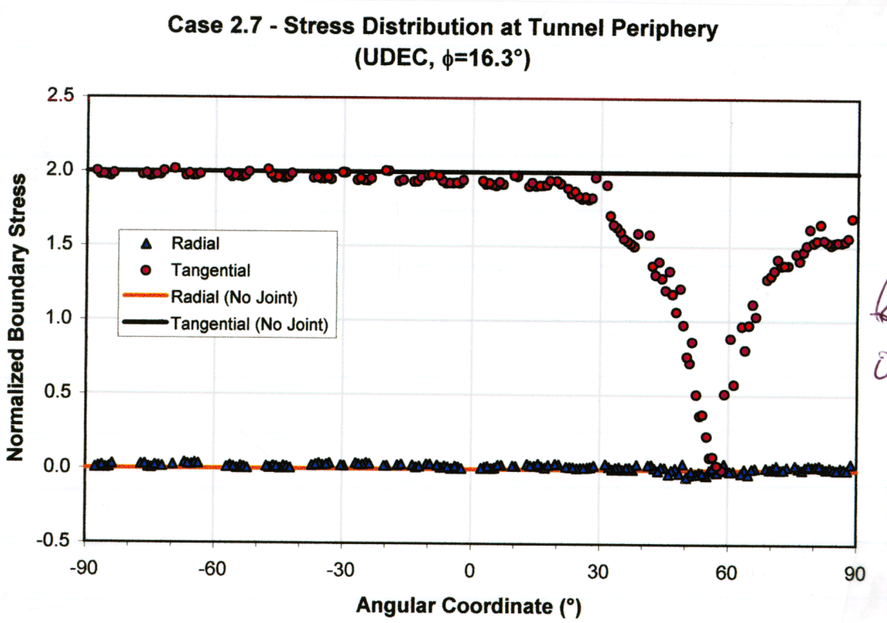
- The summary plot of strength factor above shows the effect of reducing friction angle. At ϕ=58°, slip initiates. For lower friction angles, a portion of the joint slips and reduces strength factor to 1.0. For ϕ=16.3°, the joint slips to 1.5A, and starts to pick up minor load near the opening as ongoing slip occurs.
- The plots on page 119 demonstrate the stress relief that occurs along a portion of the tunnel periphery near θ=60° as a result of joint slip. For ϕ=16.3°, the tangential stress is zero at the tunnel periphery. Note that the stresses above the joint (i.e. θ>60°) are less than elsewhere, suggesting differential movement on the joint.

SN673 Vol 1



Oct 21/04

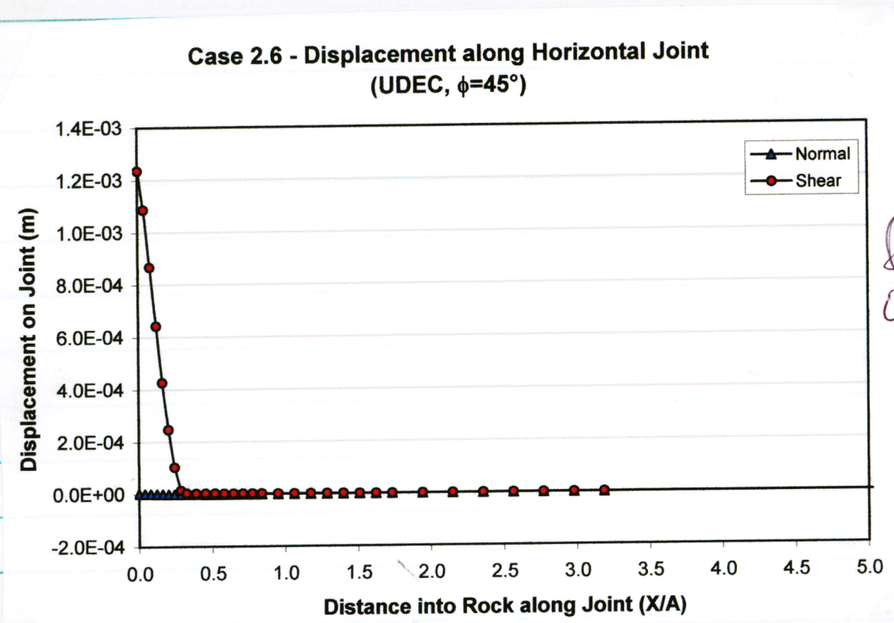
From file u26stress.xls



Oct 21/04.

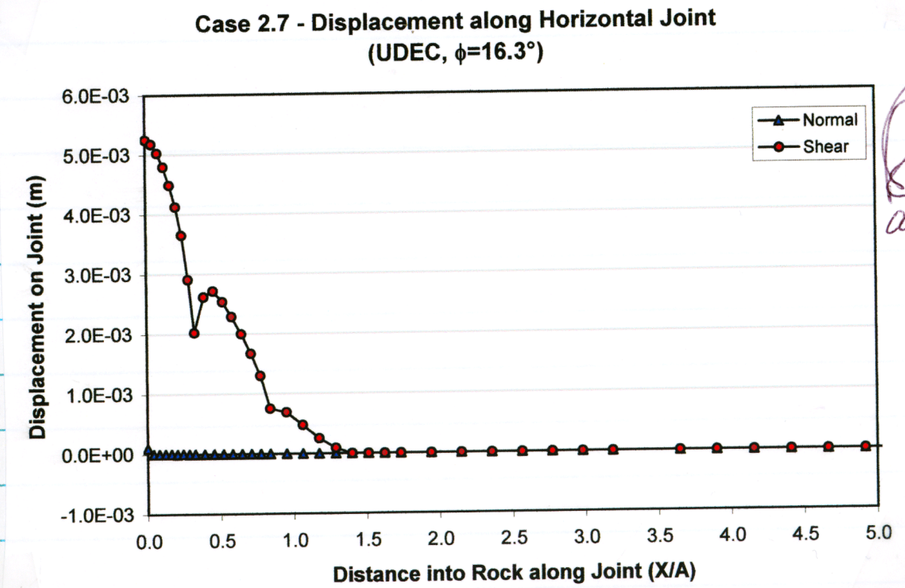
From file u27stress.xls

SN673 Vol 1



Oct 21/04

From file U26joint.xls



Oct 21/04

From file U27joint.XLS

SN673 Vol 1

- Shear displacement on the joint under low friction angles is evident in the plots on page 120. This accounts for the stress relief seen on the previous plots.

Oct 21/04

Oct 25/04.

- start on draft report
- complete outline
- import relevant details from Validation Test Plan.

Oct 27/04

- continue work on report.
- create table of cases.

Oct 28/04

- complete analysis of Case 2 data in EXCEL
- create plots in EXCEL to ~~illu~~ Oct 28/04 illustrate key behaviors.

Oct 29/04.

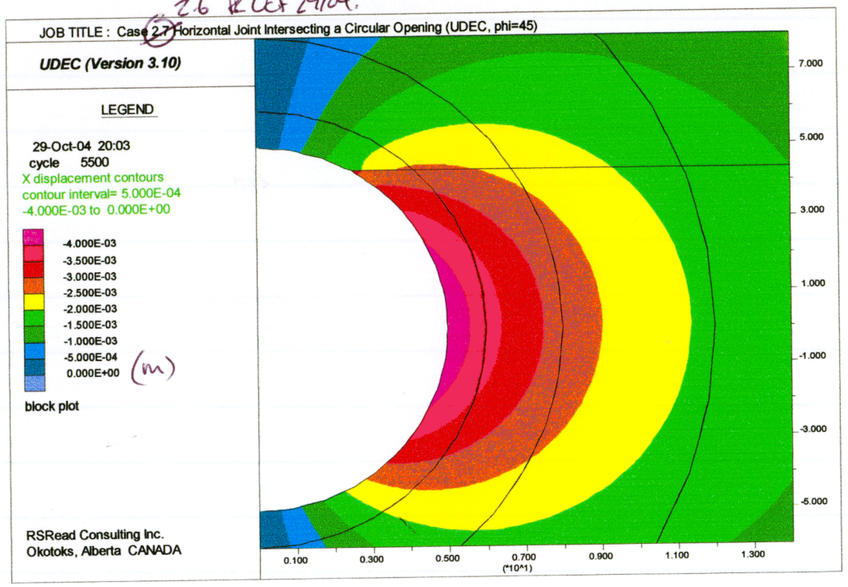
- replot key plots from Case 2 at larger scale
- contour plot of x-displacement
- plot of slip on joint
- see next few pages for these plots

Summary: Case 2 results compare favourably with expected joint behavior. Slip occurs at $\phi = 58°$ instead of $\phi = 59°$.

Oct 29/04.

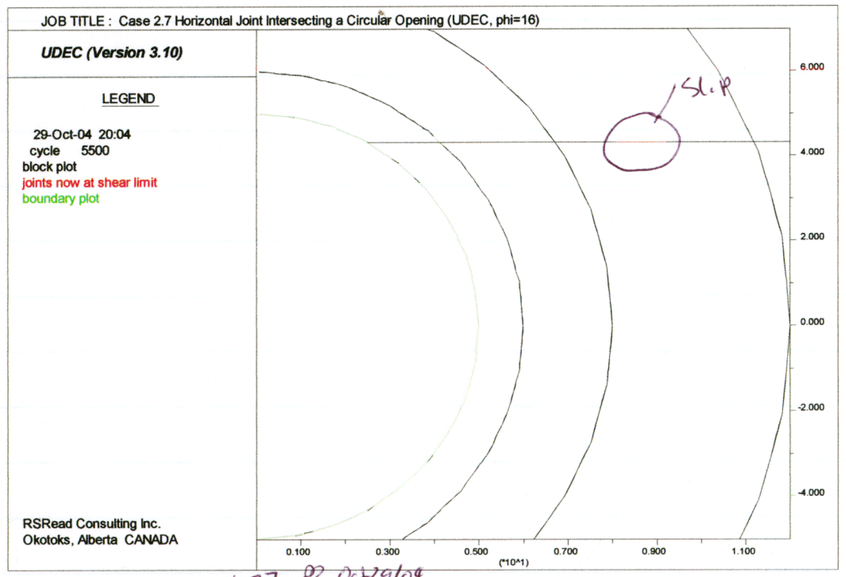
SN673 Vol 1

2.6 R Oct 29/04.



R Oct 29/04

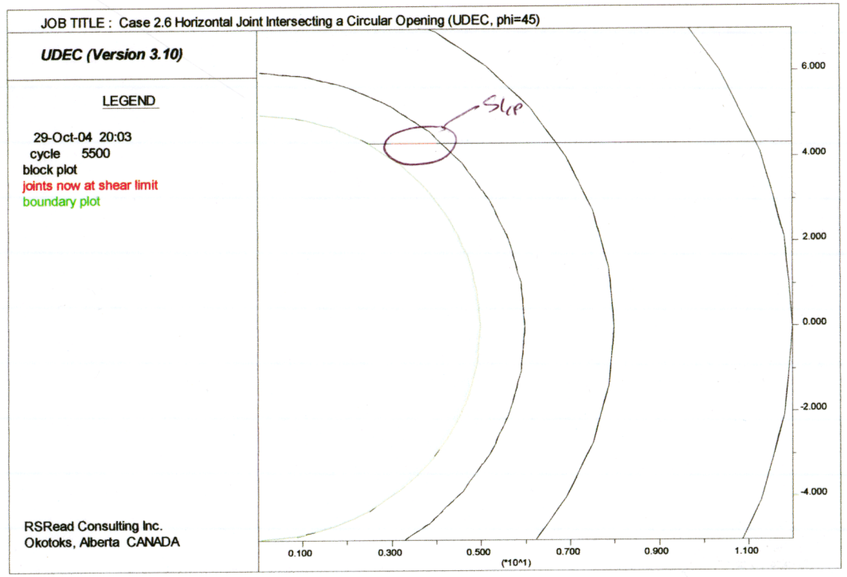
From file u26xdzoom.emf



R Oct 29/04

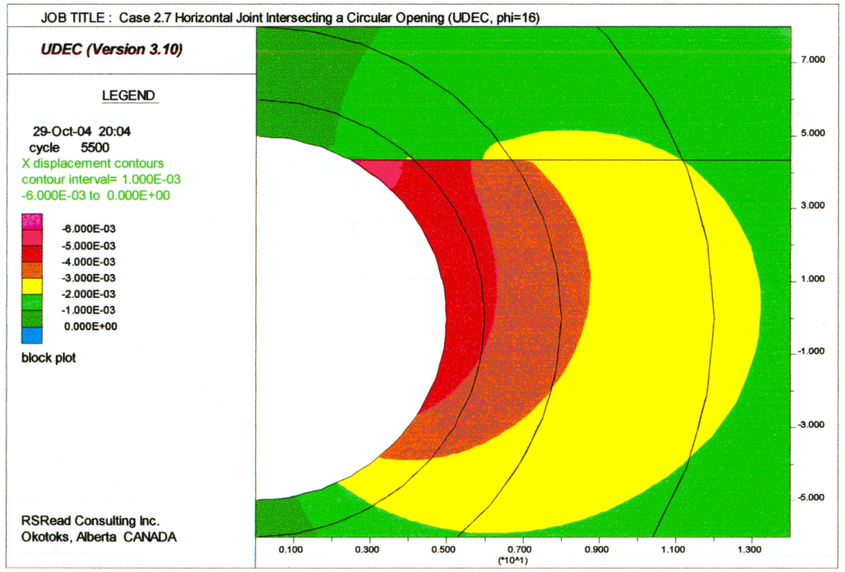
From file ~~u26~~ u27 R Oct 29/04 slip200m.emf

SN673 Vol 1



R Oct 29/04

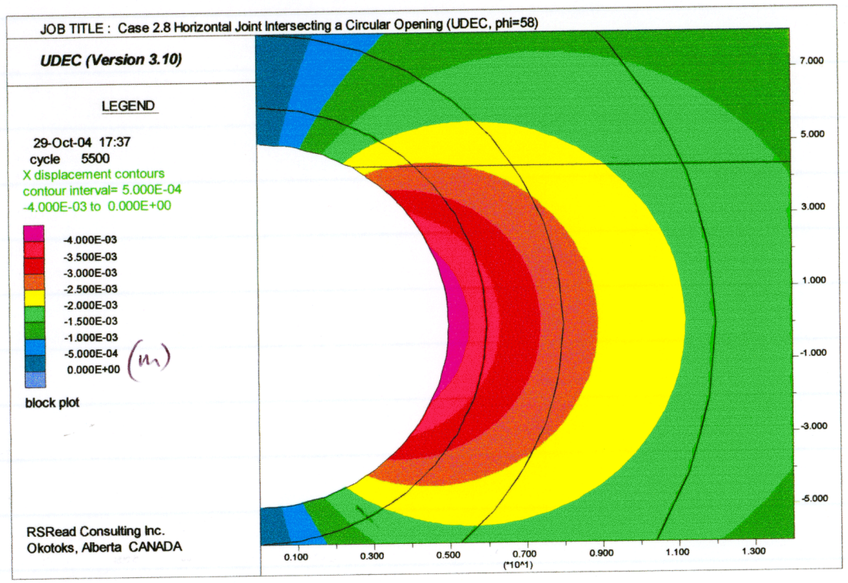
File u26slipzoom.emf



R Oct 29/04

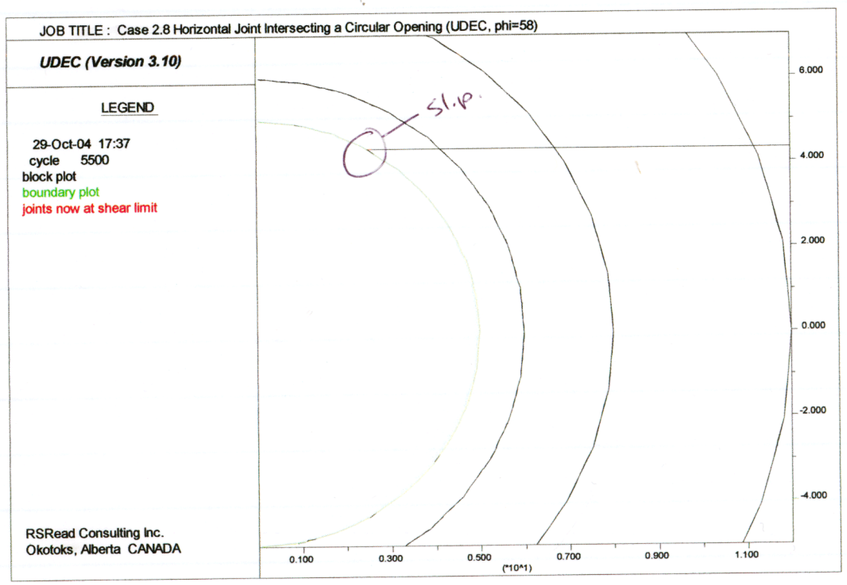
File u27xdzoom.emf

SW 673 V6 1



R Oct 29/04

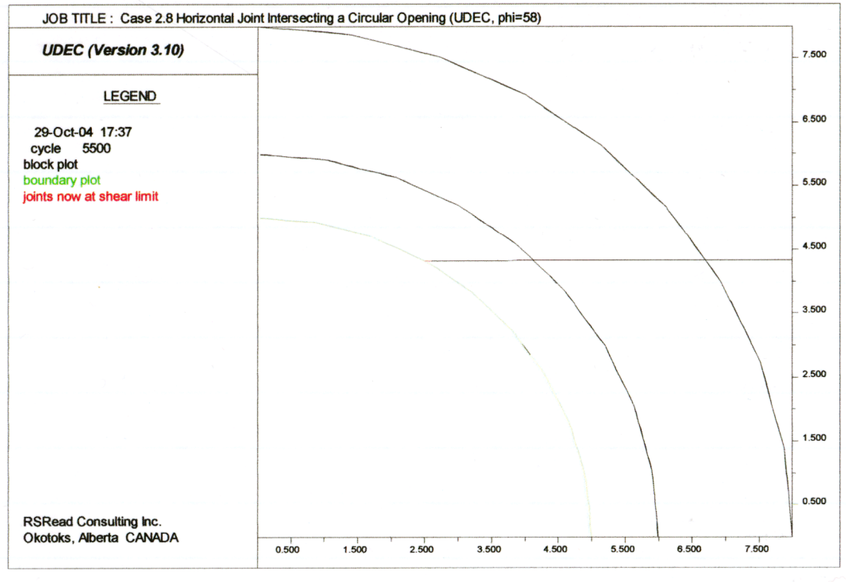
File u28xdzoom.emf



R Oct 29/04

File u28slipzoom.emf

SW 673 V6 1



R Oct 29/04.

Finished Case 2. R Oct 29/04

Oct 30/04 R

- write section 4.1 of validation report.
- created new plot files for case 5 using previously saved files for case 5.1, 5.2, 5.3 and 5.4.
  - u51grid.emf ... u54grid.emf - Grid
  - u51temp.emf ... u54temp.emf - Temperature Contours
  - u51graph.emf ... u54graph.emf - Comparison of UDEC and analytic solution

→ stored in u5plots.doc.

- created new data output files from saved files
  - u51data.out, u52data.out, u53data.out, u54data.out

R Oct 30/04.

SN 673 Vol 1

Oct 31/04

- continue work on draft report. Complete sections 4.1, 4.2, 4.3.
- start sorting files on CD
- identify files for Appendices.

Nov 1/2004

- work on draft report
- modified input files with headers for Appendices
- updated UDEC/FLAC comparison tables (see attachments for Case 7.1, 7.2, 7.3, 7.4, 7.8, 7.7, 7.12 ~~and~~ 7.13 RR Nov 1/04 on pages 127-134.)

Nov 2/2004

- work on draft report
- complete rough draft

Nov 3/2004

- review and edit draft report.
- produce first draft report.

Nov 4/2004

- finish appendices and create PDF version of file to email to CANMET for review - sent @ 10:19 PM.

Nov 5/2004 - Instructions received to create WordPerfect version of document and figures. Converted text to

SN673 V611

Table 4.12 Comparison of UDEC and FLAC Results for Case 7.1

Case 7.1 Summary of Results (FLAC)

Parameter	Maximum X	Maximum Value	Minimum X	Minimum Value	Mean Value	Σ Absolute Values
FLAC Shear displacement at bottom of interface (m)	56.00	7.40E-03	44.00	-7.40E-03	5.84E-08	1.50E-01
FLAC Shear displacement at top of interface (m)	56.00	7.39E-03	44.00	-7.38E-03	6.02E-08	1.50E-01
FLAC Normal displacement at bottom of interface (m)	50.00	1.12E-02	0.00	3.92E-04	2.15E-03	1.10E-01
FLAC Normal displacement at top of interface (m)	50.00	1.12E-02	0.00	3.92E-04	2.15E-03	1.10E-01
FLAC Relative normal displacement on interface (m)	60.00	3.89E-06	50.00	-2.83E-05	-9.00E-07	1.57E-04
FLAC Relative shear displacement on interface (m)	46.00	2.32E-05	54.00	-2.32E-05	1.13E-10	2.21E-04
FLAC Total displacement at bottom of interface (m)	50.00	1.12E-02	0.00	3.92E-04	3.88E-03	1.98E-01
FLAC Total displacement at top of interface (m)	50.00	1.12E-02	0.00	3.92E-04	3.87E-03	1.98E-01
FLAC Normal stress at bottom of interface (Pa)	60.00	7.40E+06	50.00	-5.36E+07	-1.72E+06	2.98E+08
FLAC Normal stress at top of interface (Pa)	60.00	7.40E+06	50.00	-5.36E+07	-1.72E+06	2.98E+08
FLAC Shear stress at bottom of interface (Pa)	46.00	3.01E+07	54.00	-3.01E+07	2.93E+02	2.87E+08
FLAC Shear stress at top of interface (Pa)	46.00	3.01E+07	54.00	-3.01E+07	2.93E+02	2.87E+08
FLAC Temperature at bottom of interface (°C)	50.00	119.30	0.00	34.00	40.90	2085.88
FLAC Temperature at top of interface (°C)	50.00	124.44	0.00	34.00	41.45	2114.20
Maximum temperature at source (°C)	50.00	425.24	-	-	-	
Number of Contacts		51		51		
Number of Contacts at Slip Condition		0		0		

Case 7.1 Summary of Results (UDEC, Interpolated)

Parameter	Maximum X	Maximum Value	Minimum X	Minimum Value	Mean Value	Σ Absolute Values
UDEC Shear displacement at bottom of interface (m)	56.00	6.49E-03	44.00	-6.47E-03	6.33E-06	1.32E-01
UDEC Shear displacement at top of interface (m)	56.00	6.47E-03	44.00	-6.45E-03	6.33E-06	1.32E-01
UDEC Normal displacement at bottom of interface (m)	50.00	1.07E-02	100.00	3.03E-04	1.91E-03	9.91E-02
UDEC Normal displacement at top of interface (m)	50.00	1.07E-02	100.00	3.03E-04	1.91E-03	9.91E-02
UDEC Relative normal displacement on interface (m)	40.00	3.62E-06	50.00	-2.64E-05	-7.56E-07	1.41E-04
UDEC Relative shear displacement on interface (m)	46.00	1.97E-05	54.00	-1.97E-05	3.85E-11	2.03E-04
UDEC Total displacement at bottom of interface (m)	50.00	1.09E-02	100.00	3.03E-04	3.42E-03	1.78E-01
UDEC Total displacement at top of interface (m)	50.00	1.08E-02	100.00	3.03E-04	3.42E-03	1.78E-01
UDEC Normal stress at bottom of interface (Pa)	60.00	6.89E+06	50.00	-5.02E+07	-1.43E+06	2.68E+08
UDEC Normal stress at top of interface (Pa)	40.00	6.89E+06	50.00	-5.02E+07	-1.43E+06	2.68E+08
UDEC Shear stress at bottom of interface (Pa)	46.00	2.56E+07	54.00	-2.56E+07	-1.71E+03	2.64E+08
UDEC Shear stress at top of interface (Pa)	46.00	2.56E+07	54.00	-2.56E+07	6.41E+02	2.64E+08
UDEC Temperature at bottom of interface (°C)	50.00	114.50	0.00	34.00	40.97	2096.44
UDEC Temperature at top of interface (°C)	50.00	114.50	0.00	34.00	40.97	2096.44
Maximum temperature at source (°C)	50.00	428.20	-	-	-	-
Number of Contacts		51		51		
Number of Contacts at Slip Condition		0		0		

Case 7.1 Relative Error between UDEC and FLAC Results*

Nov 1/2004.

Parameter	Maximum X	Maximum Error	Minimum X	Minimum Value	Mean Value	Total Error
Shear displacement at bottom of interface (m)	0.0	12%	0.0	13%	0%	12%
Shear displacement at top of interface (m)	0.0	12%	0.0	13%	0%	12%
Normal displacement at bottom of interface (m)	0.0	5%	100.0	1%	3%	10%
Normal displacement at top of interface (m)	0.0	5%	100.0	1%	3%	10%
Relative normal displacement on interface (m)	-20.0	1%	0.0	7%	1%	10%
Relative shear displacement on interface (m)	0.0	13%	0.0	12%	0%	8%
Total displacement at bottom of interface (m)	0.0	4%	100.0	1%	6%	10%
Total displacement at top of interface (m)	0.0	4%	100.0	1%	6%	10%
Normal stress at bottom of interface (Pa)	0.0	1%	0.0	7%	1%	10%
Normal stress at top of interface (Pa)	-20.0	1%	0.0	7%	1%	10%
Shear stress at bottom of interface (Pa)	0.0	15%	0.0	15%	0%	8%
Shear stress at top of interface (Pa)	0.0	15%	0.0	15%	0%	8%
Temperature at bottom of interface (°C)	0.0	6%	0.0	0%	0%	1%
Temperature at top of interface (°C)	0.0	12%	0.0	0%	1%	1%
Maximum temperature at source (°C)	0.0	1%	-	-	-	-
Number of Contacts		0%		0%		
Number of Contacts at Slip Condition		0%		0%		

* Relative error calculated as difference between UDEC and FLAC values normalized to maximum deviation from mean along interface in either total displacement, stress, or temperature

Final version of Case 7.1 comparison table.

SN 673 V6 1

Table 4.13 Comparison of UDEC and FLAC Results for Case 7.2

Case 7.2 Summary of Results (FLAC)

Parameter	Maximum		Minimum		Mean	Σ Absolute
	X	Value	X	Value	Value	Values
FLAC Shear displacement at bottom of interface (m)	58.00	1.32E-02	42.00	-1.32E-02	-4.36E-08	2.63E-01
FLAC Shear displacement at top of interface (m)	54.00	7.05E-03	46.00	-7.05E-03	-4.83E-09	5.13E-02
FLAC Normal displacement at bottom of interface (m)	50.00	1.32E-02	72.00	-2.38E-03	3.07E-04	1.55E-01
FLAC Normal displacement at top of interface (m)	50.00	1.29E-02	100.00	7.38E-04	4.09E-03	2.09E-01
FLAC Relative normal displacement on interface (m)	36.00	7.21E-03	50.00	-2.64E-04	3.79E-03	1.95E-01
FLAC Relative shear displacement on interface (m)	40.00	1.10E-02	60.00	-1.10E-02	2.67E-08	2.27E-01
FLAC Total displacement at bottom of interface (m)	44.00	1.44E-02	0.00	1.33E-03	6.51E-03	3.32E-01
FLAC Total displacement at top of interface (m)	47.50	1.30E-02	100.00	7.38E-04	4.29E-03	2.19E-01
FLAC Normal stress at bottom of interface (Pa)	0.00	0.00E+00	50.00	-5.01E+07	-3.07E+06	1.57E+08
FLAC Normal stress at top of interface (Pa)	0.00	0.00E+00	50.00	-5.01E+07	-3.07E+06	1.57E+08
FLAC Shear stress at bottom of interface (Pa)	46.00	6.32E+07	54.00	-6.32E+07	1.15E+01	1.81E+08
FLAC Shear stress at top of interface (Pa)	46.00	6.32E+07	54.00	-6.32E+07	1.15E+01	1.81E+08
FLAC Temperature at bottom of interface (°C)	50.00	119.30	0.00	34.00	40.90	2085.88
FLAC Temperature at top of interface (°C)	50.00	124.44	0.00	34.00	41.45	2114.20
Maximum temperature at source (°C)	50.00	425.24	-	-	-	
Number of Contacts		51		51		
Number of Contacts at Slip Condition		46		46		

Case 7.2 Summary of Results (UDEC, Interpolated)

Parameter	Maximum		Minimum		Mean	Σ Absolute
	X	Value	X	Value	Value	Values
UDEC Shear displacement at bottom of interface (m)	58.00	1.40E-02	42.00	-1.41E-02	-3.57E-06	2.79E-01
UDEC Shear displacement at top of interface (m)	32.00	1.14E-03	68.00	-1.14E-03	4.63E-07	3.25E-02
UDEC Normal displacement at bottom of interface (m)	50.00	1.45E-02	30.00	-1.23E-03	1.27E-03	1.14E-01
UDEC Normal displacement at top of interface (m)	50.00	1.43E-02	100.00	-3.21E-04	2.90E-03	1.56E-01
UDEC Relative normal displacement on interface (m)	36.00	4.75E-03	50.00	-2.52E-04	1.62E-03	8.44E-02
UDEC Relative shear displacement on interface (m)	42.00	1.46E-02	58.00	-1.45E-02	4.57E-06	3.06E-01
UDEC Total displacement at bottom of interface (m)	46.00	1.61E-02	0.00	3.22E-04	6.41E-03	3.27E-01
UDEC Total displacement at top of interface (m)	50.00	1.43E-02	0.00	3.20E-04	3.26E-03	1.66E-01
UDEC Normal stress at bottom of interface (Pa)	14.00	1.00E+06	50.00	-4.79E+07	-2.13E+06	1.83E+08
UDEC Normal stress at top of interface (Pa)	14.00	1.00E+06	50.00	-4.79E+07	-2.13E+06	1.83E+08
UDEC Shear stress at bottom of interface (Pa)	47.50	1.19E+07	52.50	-1.22E+07	8.97E+02	3.67E+07
UDEC Shear stress at top of interface (Pa)	47.50	1.22E+07	52.50	-1.19E+07	-1.32E+03	3.67E+07
UDEC Temperature at bottom of interface (°C)	50.00	114.50	0.00	34.00	41.12	2096.94
UDEC Temperature at top of interface (°C)	50.00	114.50	0.00	34.00	41.10	2096.01
Maximum temperature at source (°C)	50.00	428.20	-	-	-	-
Number of Contacts		51		51		
Number of Contacts at Slip Condition		51		51		

Case 7.2 Relative Error between UDEC and FLAC Results*

Parameter	Maximum		Minimum		Mean	Total
	X	Error	X	Value	Value	Error
Shear displacement at bottom of interface (m)	0.0	6%	0.0	6%	0%	6%
Shear displacement at top of interface (m)	-22.0	45%	22.0	45%	0%	37%
Normal displacement at bottom of interface (m)	0.0	10%	-42.0	9%	7%	26%
Normal displacement at top of interface (m)	0.0	10%	0.0	8%	9%	25%
Relative normal displacement on interface (m)	0.0	22%	0.0	0%	20%	57%
Relative shear displacement on interface (m)	2.0	32%	-2.0	32%	0%	35%
Total displacement at bottom of interface (m)	2.0	22%	0.0	13%	1%	1%
Total displacement at top of interface (m)	2.5	16%	-100.0	5%	13%	24%
Normal stress at bottom of interface (Pa)	14.0	2%	0.0	5%	2%	17%
Normal stress at top of interface (Pa)	14.0	2%	0.0	5%	2%	17%
Shear stress at bottom of interface (Pa)	1.5	81%	-1.5	81%	0%	80%
Shear stress at top of interface (Pa)	1.5	81%	-1.5	81%	0%	80%
Temperature at bottom of interface (°C)	0.0	6%	0.0	0%	0%	1%
Temperature at top of interface (°C)	0.0	12%	0.0	0%	0%	1%
Maximum temperature at source (°C)	0.0	1%	-	-	-	
Number of Contacts		0%		0%		
Number of Contacts at Slip Condition		10%		10%		

* Relative error calculated as difference between UDEC and FLAC values normalized to maximum deviation from mean along interface in either total displacement, stress, or temperature

Nov 1/2004

Final results for Case 7.2

SN 673 V6 1

Table 4.14 Comparison of UDEC and FLAC Results for Case 7.3

Case 7.3 Summary of Results (FLAC)

Parameter	Maximum		Minimum		Mean	Σ Absolute
	X	Value	X	Value	Value	Values
FLAC Lateral displacement at bottom of interface (m)	56.00	7.05E-03	44.00	-6.96E-03	4.89E-05	1.36E-01
FLAC Lateral displacement at top of interface (m)	56.00	6.86E-03	44.00	-6.78E-03	5.02E-05	1.34E-01
FLAC Normal displacement at bottom of interface (m)	50.00	1.13E-02	2.00	-9.56E-05	2.02E-03	1.03E-01
FLAC Normal displacement at top of interface (m)	50.00	1.10E-02	2.00	-9.88E-05	2.01E-03	1.03E-01
FLAC Relative normal displacement on interface (m)	60.00	3.81E-05	50.00	-2.70E-04	-1.05E-05	1.37E-03
FLAC Relative shear displacement on interface (m)	46.00	2.15E-04	54.00	-2.21E-04	1.26E-06	1.96E-03
FLAC Total displacement at bottom of interface (m)	50.00	1.13E-02	0.00	1.79E-04	3.60E-03	1.83E-01
FLAC Total displacement at top of interface (m)	50.00	1.10E-02	0.00	1.81E-04	3.55E-03	1.81E-01
FLAC Normal stress at bottom of interface (Pa)	60.00	7.24E+06	50.00	-5.13E+07	-1.99E+06	2.60E+08
FLAC Normal stress at top of interface (Pa)	60.00	7.24E+06	50.00	-5.13E+07	-1.99E+06	2.60E+08
FLAC Shear stress at bottom of interface (Pa)	46.00	2.80E+07	54.00	-2.87E+07	1.64E+05	2.55E+08
FLAC Shear stress at top of interface (Pa)	46.00	2.80E+07	54.00	-2.87E+07	1.64E+05	2.55E+08
FLAC Temperature at bottom of interface (°C)	50.00	118.14	0.00	34.00	40.95	2088.52
FLAC Temperature at top of interface (°C)	50.00	100.82	0.00	34.00	39.16	1997.40
Maximum temperature at source (°C)	50.00	425.24	-	-	-	
Number of Contacts		51		51		
Number of Contacts at Slip Condition		0		0		

Case 7.3 Summary of Results (UDEC, Interpolated)

Parameter	Maximum		Minimum		Mean	Σ Absolute
	X	Value	X	Value	Value	Values
UDEC Shear displacement at bottom of interface (m)	56.00	7.17E-03	44.00	-7.20E-03	3.43E-05	1.39E-01
UDEC Shear displacement at top of interface (m)	56.00	6.96E-03	44.00	-6.99E-03	3.92E-05	1.37E-01
UDEC Normal displacement at bottom of interface (m)	50.00	1.14E-02	0.00	-1.73E-04	1.99E-03	1.02E-01
UDEC Normal displacement at top of interface (m)	50.00	1.09E-02	0.00	-1.74E-04	1.97E-03	1.01E-01
UDEC Relative normal displacement on interface (m)	58.00	5.51E-05	50.00	-4.94E-04	-1.33E-05	1.93E-03
UDEC Relative shear displacement on interface (m)	46.00	3.75E-04	54.00	-3.73E-04	1.41E-06	2.74E-03
UDEC Total displacement at bottom of interface (m)	50.00	1.14E-02	0.00	1.93E-04	3.62E-03	1.85E-01
UDEC Total displacement at top of interface (m)	50.00	1.11E-02	0.00	1.95E-04	3.58E-03	1.82E-01
UDEC Normal stress at bottom of interface (Pa)	58.00	1.05E+07	50.00	-9.38E+07	-2.51E+06	3.67E+08
UDEC Normal stress at top of interface (Pa)	60.00	5.40E+06	47.50	-1.59E+07	-9.67E+05	1.46E+08
UDEC Shear stress at bottom of interface (Pa)	46.00	4.87E+07	54.00	-4.85E+07	1.83E+05	3.56E+08
UDEC Shear stress at top of interface (Pa)	42.00	1.31E+07	58.00	-1.33E+07	1.95E+05	1.53E+08
UDEC Temperature at bottom of interface (°C)	50.00	1.12E+02	0.00	3.40E+01	4.00E+01	2042.17
UDEC Temperature at top of interface (°C)	50.00	1.06E+02	0.00	3.40E+01	3.99E+01	2033.09
Maximum temperature at source (°C)	50.00	419.20	-	-	-	-
Number of Contacts		56		51		
Number of Contacts at Slip Condition		0		0		

Case 7.3 Relative Error between UDEC and FLAC Results*

Parameter	Maximum		Minimum		Mean	Total
	ΔX	Error	ΔX	Error	Error	Error
Shear displacement at bottom of interface (m)	0.0	2%	0.0	3%	0%	2%
Shear displacement at top of interface (m)	0.0	1%	0.0	3%	0%	2%
Normal displacement at bottom of interface (m)	0.0	1%	-2.0	1%	0%	1%
Normal displacement at top of interface (m)	0.0	1%	-2.0	1%	0%	2%
Relative normal displacement on interface (m)	-2.0	7%	0.0	86%	1%	41%
Relative shear displacement on interface (m)	0.0	62%	0.0	59%	0%	40%
Total displacement at bottom of interface (m)	0.0	1%	0.0	0%	0%	1%
Total displacement at top of interface (m)	0.0	1%	0.0	0%	0%	1%
Normal stress at bottom of interface (Pa)	-2.0	7%	0.0	86%	1%	41%
Normal stress at top of interface (Pa)	0.0	4%	-2.5	72%	2%	44%
Shear stress at bottom of interface (Pa)	0.0	72%	0.0	68%	0%	40%
Shear stress at top of interface (Pa)	-4.0	52%	4.0	53%	0%	40%
Temperature at bottom of interface (°C)	0.0	8%	0.0	0%	1%	2%
Temperature at top of interface (°C)	0.0	7%	0.0	0%	1%	2%
Maximum temperature at source (°C)	0.0	-1%	-	-	-	
Number of Contacts		10%		0%		
Number of Contacts at Slip Condition		0%		0%		

* Relative error calculated as difference between UDEC and FLAC values normalized to maximum deviation from mean along interface in either total displacement, stress, or temperature

Nov 1/2004

Final results for Case 7.3

GW GB Vol 1

Table 4.15 Comparison of UDEC and FLAC Results for Case 7.4

Case 7.4 Summary of Results (FLAC)

Parameter	Maximum		Minimum		Mean	Σ Absolute
	X	Value	X	Value	Value	Values
FLAC Shear displacement at bottom of interface (m)	58.00	1.20E-02	42.00	-1.24E-02	-3.51E-04	2.23E-01
FLAC Shear displacement at top of interface (m)	54.00	6.37E-03	46.00	-6.37E-03	1.75E-04	5.18E-02
FLAC Normal displacement at bottom of interface (m)	50.00	1.26E-02	68.00	-1.92E-03	9.17E-04	1.13E-01
FLAC Normal displacement at top of interface (m)	50.00	1.26E-02	92.00	1.62E-04	3.65E-03	1.86E-01
FLAC Relative normal displacement on interface (m)	38.00	6.71E-03	50.00	-2.55E-05	2.75E-03	1.41E-01
FLAC Relative shear displacement on interface (m)	40.00	1.01E-02	58.00	-9.58E-03	5.39E-04	1.95E-01
FLAC Total displacement at bottom of interface (m)	44.00	1.36E-02	100.00	2.97E-04	5.37E-03	2.74E-01
FLAC Total displacement at top of interface (m)	50.00	1.26E-02	90.00	2.50E-04	3.85E-03	1.96E-01
FLAC Normal stress at bottom of interface (Pa)	92.00	7.66E+05	50.00	-4.85E+07	-2.89E+06	1.49E+08
FLAC Normal stress at top of interface (Pa)	92.00	7.66E+05	50.00	-4.85E+07	-2.89E+06	1.49E+08
FLAC Shear stress at bottom of interface (Pa)	46.00	5.65E+07	54.00	-5.65E+07	-6.04E+04	1.65E+08
FLAC Shear stress at top of interface (Pa)	46.00	5.65E+07	54.00	-5.65E+07	-6.04E+04	1.65E+08
FLAC Temperature at bottom of interface (°C)	50.00	118.00	0.00	34.00	40.95	2088.20
FLAC Temperature at top of interface (°C)	50.00	101.00	0.00	34.00	39.17	1997.70
Maximum temperature at source (°C)	50.00	425.24	-	-	-	
Number of Contacts		51		51		
Number of Contacts at Slip Condition		27		27		

Case 7.4 Summary of Results (UDEC, Interpolated)

Parameter	Maximum		Minimum		Mean	Σ Absolute
	X	Value	X	Value	Value	Values
UDEC Shear displacement at bottom of interface (m)	56.00	1.54E-02	44.00	-1.53E-02	-3.56E-04	2.88E-01
UDEC Shear displacement at top of interface (m)	32.00	1.09E-03	66.00	-1.25E-03	-2.06E-05	3.03E-02
UDEC Normal displacement at bottom of interface (m)	50.00	1.53E-02	68.00	-1.29E-03	1.42E-03	1.05E-01
UDEC Normal displacement at top of interface (m)	50.00	1.52E-02	0.00	-1.73E-04	3.12E-03	1.60E-01
UDEC Relative normal displacement on interface (m)	62.00	5.64E-03	50.00	-5.62E-05	1.69E-03	8.63E-02
UDEC Relative shear displacement on interface (m)	42.00	1.51E-02	56.00	-1.54E-02	3.39E-04	3.09E-01
UDEC Total displacement at bottom of interface (m)	54.00	1.75E-02	100.00	3.74E-04	6.51E-03	3.32E-01
UDEC Total displacement at top of interface (m)	50.00	1.52E-02	6.00	9.80E-05	3.30E-03	1.68E-01
UDEC Normal stress at bottom of interface (Pa)	0.00	1.40E+06	50.00	-1.07E+08	-4.75E+06	3.12E+08
UDEC Normal stress at top of interface (Pa)	0.00	2.05E+06	47.50	-1.17E+06	7.67E+05	4.41E+07
UDEC Shear stress at bottom of interface (Pa)	47.50	2.15E+07	52.50	-2.25E+07	-4.99E+04	6.60E+07
UDEC Shear stress at top of interface (Pa)	47.50	5.46E+05	90.00	-2.43E+05	5.51E+03	1.75E+06
UDEC Temperature at bottom of interface (°C)	50.00	1.12E+02	0.00	3.40E+01	4.01E+01	2042.58
UDEC Temperature at top of interface (°C)	50.00	1.06E+02	0.00	3.40E+01	3.99E+01	2032.74
Maximum temperature at source (°C)	50.00	419.20	-	-	-	-
Number of Contacts		56		51		
Number of Contacts at Slip Condition		55		50		

Oct 1/2009

Case 7.4 Relative Error between UDEC and FLAC Results*

Parameter	Maximum		Minimum		Mean	Total
	ΔX	Error	ΔX	Error	Error	Error
Shear displacement at bottom of interface (m)	-2.0	28%	2.0	24%	0%	29%
Shear displacement at top of interface (m)	-22.0	43%	20.0	41%	2%	41%
Normal displacement at bottom of interface (m)	0.0	30%	0.0	7%	6%	7%
Normal displacement at top of interface (m)	0.0	29%	-92.0	4%	6%	14%
Relative normal displacement on interface (m)	24.0	11%	0.0	0%	11%	39%
Relative shear displacement on interface (m)	2.0	49%	-2.0	58%	2%	59%
Total displacement at bottom of interface (m)	10.0	47%	0.0	1%	14%	21%
Total displacement at top of interface (m)	0.0	32%	-84.0	2%	7%	14%
Normal stress at bottom of interface (Pa)	-92.0	1%	0.0	127%	4%	109%
Normal stress at top of interface (Pa)	-92.0	3%	-2.5	104%	8%	70%
Shear stress at bottom of interface (Pa)	1.5	62%	-1.5	60%	0%	60%
Shear stress at top of interface (Pa)	1.5	99%	36.0	100%	0%	99%
Temperature at bottom of interface (°C)	0.0	7%	0.0	0%	1%	2%
Temperature at top of interface (°C)	0.0	7%	0.0	0%	1%	2%
Maximum temperature at source (°C)	0.0	-1%	-	-	-	
Number of Contacts		10%		0%		
Number of Contacts at Slip Condition		55%		45%		

* Relative error calculated as difference between UDEC and FLAC values normalized to maximum deviation from mean along interface in either total displacement, stress, or temperature

Final results for Case 7.4

GW GB Vol 1

Table 4.16 Comparison of UDEC and FLAC Results for Case 7.7

Case 7.7 Summary of Results (FLAC)

Parameter	Maximum		Minimum		Mean	Σ Absolute
	X	Value	X	Value	Value	Values
FLAC Shear displacement at bottom of interface (m)	66.00	1.10E-02	34.00	-1.10E-02	1.37E-04	3.48E-01
FLAC Shear displacement at top of interface (m)	66.00	1.10E-02	34.00	-1.10E-02	1.38E-04	3.47E-01
FLAC Normal displacement at bottom of interface (m)	50.00	9.71E-03	0.00	2.71E-04	4.48E-03	2.29E-01
FLAC Normal displacement at top of interface (m)	50.00	9.60E-03	0.00	2.69E-04	4.46E-03	2.27E-01
FLAC Relative normal displacement on interface (m)	0.00	-1.49E-06	50.00	-1.06E-04	-2.49E-05	1.27E-03
FLAC Relative shear displacement on interface (m)	44.00	1.99E-05	56.00	-2.00E-05	1.81E-06	4.30E-04
FLAC Total displacement at bottom of interface (m)	38.00	1.23E-02	0.00	2.80E-04	8.52E-03	4.34E-01
FLAC Total displacement at top of interface (m)	36.00	1.23E-02	0.00	2.78E-04	8.50E-03	4.33E-01
FLAC Normal stress at bottom of interface (Pa)	0.00	-7.71E+06	50.00	-5.99E+07	-1.92E+07	9.77E+08
FLAC Normal stress at top of interface (Pa)	0.00	-7.71E+06	50.00	-5.99E+07	-1.92E+07	9.77E+08
FLAC Shear stress at bottom of interface (Pa)	44.00	8.74E+06	56.00	-1.12E+07	-3.03E+05	2.06E+08
FLAC Shear stress at top of interface (Pa)	44.00	8.74E+06	56.00	-1.12E+07	-3.03E+05	2.06E+08
FLAC Temperature at bottom of interface (°C)	50.00	207.52	100.00	29.42	75.98	3874.99
FLAC Temperature at top of interface (°C)	50.00	207.11	0.00	29.34	75.73	3862.22
Maximum temperature at source (°C)	51.21	322.38	-	-	-	
Number of Contacts		51		51		
Number of Contacts at Slip Condition		0		0		

Case 7.7 Summary of Results (UDEC, Interpolated)

Parameter	Maximum		Minimum		Mean	Σ Absolute
	X	Value	X	Value	Value	Values
UDEC Shear displacement at bottom of interface (m)	66.00	1.11E-02	34.00	-1.11E-02	1.48E-04	3.52E-01
UDEC Shear displacement at top of interface (m)	66.00	1.11E-02	34.00	-1.11E-02	1.50E-04	3.52E-01
UDEC Normal displacement at bottom of interface (m)	50.00	9.75E-03	0.00	2.33E-04	4.47E-03	2.28E-01
UDEC Normal displacement at top of interface (m)	50.00	9.59E-03	0.00	2.31E-04	4.45E-03	2.27E-01
UDEC Relative normal displacement on interface (m)	8.00	-1.70E-05	50.00	-1.80E-04	-3.89E-05	1.98E-03
UDEC Relative shear displacement on interface (m)	46.00	8.87E-05	54.00	-9.18E-05	-1.41E-07	1.27E-03
UDEC Total displacement at bottom of interface (m)	64.00	1.24E-02	0.00	2.40E-04	8.58E-03	4.38E-01
UDEC Total displacement at top of interface (m)	64.00	1.24E-02	0.00	2.38E-04	8.56E-03	4.37E-01
UDEC Normal stress at bottom of interface (Pa)	8.00	-8.48E+06	50.00	-8.99E+07	-1.94E+07	9.92E+08
UDEC Normal stress at top of interface (Pa)	6.00	-8.31E+06	56.00	-4.16E+07	-1.88E+07	9.57E+08
UDEC Shear stress at bottom of interface (Pa)	46.00	4.43E+07	54.00	-4.59E+07	-7.05E+04	6.34E+08
UDEC Shear stress at top of interface (Pa)	54.00	2.51E+07	46.00	-2.78E+07	-2.23E+05	2.96E+08
UDEC Temperature at bottom of interface (°C)	50.00	2.10E+02	100.00	2.93E+01	7.60E+01	3874.16
UDEC Temperature at top of interface (°C)	50.00	2.08E+02	100.00	2.93E+01	7.59E+01	3871.56
Maximum temperature at source (°C)	50.00	326.70	-	-	-	-
Number of Contacts		52		51		
Number of Contacts at Slip Condition		0		0		

Oct 1/2009

Case 7.7 Relative Error between UDEC and FLAC Results*

Parameter	Maximum		Minimum		Mean	Total
	ΔX	Error	ΔX	Error	Error	Error
Shear displacement at bottom of interface (m)	0.0	1%	0.0	1%	0%	1%
Shear displacement at top of interface (m)	0.0	1%	0.0	1%	0%	1%
Normal displacement at bottom of interface (m)	0.0	1%	0.0	1%	0%	0%
Normal displacement at top of interface (m)	0.0	0%	0.0	1%	0%	0%
Relative normal displacement on interface (m)	8.0	19%	0.0	90%	17%*	56%
Relative shear displacement on interface (m)	2.0	84%	-2.0	88%	2%	195%
Total displacement at bottom of interface (m)	26.0	2%	0.0	0%	1%	1%
Total displacement at top of interface (m)	28.0	2%	0.0	0%	1%	1%
Normal stress at bottom of interface (Pa)	8.0	2%	0.0	74%	1%	2%
Normal stress at top of interface (Pa)	6.0	1%	6.0	45%	1%	2%
Shear stress at bottom of interface (Pa)	2.0	326%	-2.0	317%	2%	208%
Shear stress at top of interface (Pa)	10.0	150%	-10.0	152%	1%	43%
Temperature at bottom of interface (°C)	0.0	2%	0.0	0%	0%	0%
Temperature at top of interface (°C)	0.0	1%	100.0	0%	0%	0%
Maximum temperature at source (°C)	-1.2	1%	-	-	-	
Number of Contacts		2%		0%		
Number of Contacts at Slip Condition		0%		0%		

* Relative error calculated as difference between UDEC and FLAC values normalized to maximum deviation from mean along interface in either total displacement, stress, or temperature

Final results for Case 7.7

Table 4.17 Comparison of UDEC and FLAC Results for Case 7.8

Case 7.8 Summary of Results (FLAC)

Parameter	Maximum		Minimum		Mean	Σ Absolute
	X	Value	X	Value	Value	Values
FLAC Shear displacement at bottom of interface (m)	64.00	2.07E-02	34.00	-2.34E-02	-1.06E-03	7.11E-01
FLAC Shear displacement at top of interface (m)	68.00	1.29E-02	32.00	-1.13E-02	7.11E-04	3.93E-01
FLAC Normal displacement at bottom of interface (m)	50.00	5.30E-02	2.00	-2.06E-04	2.16E-02	1.10E+00
FLAC Normal displacement at top of interface (m)	0.00	6.98E-03	50.00	-2.78E-02	-1.18E-02	6.20E-01
FLAC Relative normal displacement on interface (m)	0.00	-5.22E-03	50.00	-8.08E-02	-3.36E-02	1.71E+00
FLAC Relative shear displacement on interface (m)	38.00	1.23E-02	62.00	-8.24E-03	1.72E-03	3.25E-01
FLAC Total displacement at bottom of interface (m)	50.00	5.30E-02	0.00	1.20E-03	2.69E-02	1.37E+00
FLAC Total displacement at top of interface (m)	50.00	2.78E-02	100.00	1.06E-03	1.51E-02	7.72E-01
FLAC Normal stress at bottom of interface (Pa)	100.00	-6.44E+06	0.00	-6.96E+06	-6.70E+06	3.42E+08
FLAC Normal stress at top of interface (Pa)	100.00	-6.44E+06	0.00	-6.96E+06	-6.70E+06	3.42E+08
FLAC Shear stress at bottom of interface (Pa)	100.00	-1.16E+06	0.00	-1.25E+06	-1.21E+06	6.15E+07
FLAC Shear stress at top of interface (Pa)	100.00	-1.16E+06	0.00	-1.25E+06	-1.21E+06	6.15E+07
FLAC Temperature at bottom of interface (°C)	50.00	207.52	100.00	29.42	75.98	3874.99
FLAC Temperature at top of interface (°C)	50.00	207.11	0.00	29.34	75.73	3862.22
Maximum temperature at source (°C)	50.00	312.46	-	-	-	
Number of Contacts		51		51		
Number of Contacts at Slip Condition		0		0		

Case 7.8 Summary of Results (UDEC, Interpolated)

Parameter	Maximum		Minimum		Mean	Σ Absolute
	X	Value	X	Value	Value	Values
UDEC Shear displacement at bottom of interface (m)	64.00	2.10E-02	36.00	-2.37E-02	-1.13E-03	7.24E-01
UDEC Shear displacement at top of interface (m)	68.00	1.31E-02	34.00	-1.15E-02	6.85E-04	4.02E-01
UDEC Normal displacement at bottom of interface (m)	50.00	5.40E-02	0.00	-1.40E-03	2.15E-02	1.10E+00
UDEC Normal displacement at top of interface (m)	100.00	1.21E-03	50.00	-2.83E-02	-1.21E-02	6.21E-01
UDEC Relative normal displacement on interface (m)	0.00	-5.59E-03	50.00	-8.23E-02	-3.37E-02	1.72E+00
UDEC Relative shear displacement on interface (m)	38.00	1.25E-02	62.00	-8.25E-03	1.84E-03	3.26E-01
UDEC Total displacement at bottom of interface (m)	50.00	5.40E-02	0.00	1.44E-03	2.71E-02	1.38E+00
UDEC Total displacement at top of interface (m)	50.00	2.84E-02	100.00	1.24E-03	1.53E-02	7.78E-01
UDEC Normal stress at bottom of interface (Pa)	54.00	-6.67E+06	68.00	-6.70E+06	-6.69E+06	3.41E+08
UDEC Normal stress at top of interface (Pa)	47.50	-6.65E+06	0.00	-6.69E+06	-6.68E+06	3.40E+08
UDEC Shear stress at bottom of interface (Pa)	56.00	-1.19E+06	0.00	-1.22E+06	-1.20E+06	6.14E+07
UDEC Shear stress at top of interface (Pa)	46.00	-1.19E+06	0.00	-1.21E+06	-1.20E+06	6.13E+07
UDEC Temperature at bottom of interface (°C)	50.00	2.10E+02	100.00	2.93E+01	7.60E+01	3875.62
UDEC Temperature at top of interface (°C)	50.00	2.08E+02	100.00	2.93E+01	7.59E+01	3871.69
Maximum temperature at source (°C)	50.00	326.70	-	-	-	-
Number of Contacts		52		51		
Number of Contacts at Slip Condition		0		0		

Nov 1/2004

Case 7.8 Relative Error between UDEC and FLAC Results*

Parameter	Maximum		Minimum		Mean	Total
	ΔX	Error	ΔX	Error	Error	Error
Shear displacement at bottom of interface (m)	0.0	1%	2.0	2%	0%	2%
Shear displacement at top of interface (m)	0.0	1%	2.0	1%	0%	2%
Normal displacement at bottom of interface (m)	0.0	3%	-2.0	4%	0%	0%
Normal displacement at top of interface (m)	100.0	18%	0.0	2%	1%	0%
Relative normal displacement on interface (m)	0.0	1%	0.0	3%	0%	0%
Relative shear displacement on interface (m)	0.0	1%	0.0	0%	0%	0%
Total displacement at bottom of interface (m)	0.0	4%	0.0	1%	1%	1%
Total displacement at top of interface (m)	0.0	2%	0.0	1%	0%	1%
Normal stress at bottom of interface (Pa)	-46.0	87%	68.0	100%	5%	0%
Normal stress at top of interface (Pa)	-52.5	80%	0.0	102%	9%	0%
Shear stress at bottom of interface (Pa)	-44.0	66%	0.0	80%	3%	0%
Shear stress at top of interface (Pa)	-54.0	74%	0.0	89%	8%	0%
Temperature at bottom of interface (°C)	0.0	2%	0.0	0%	0%	0%
Temperature at top of interface (°C)	0.0	1%	100.0	0%	0%	0%
Maximum temperature at source (°C)	0.0	5%	-	-	-	
Number of Contacts		2%		0%		
Number of Contacts at Slip Condition		0%		0%		

* Relative error calculated as difference between UDEC and FLAC values normalized to maximum deviation from mean along interface in either total displacement, stress, or temperature

Final results for Case 7.8

Table 4.18 Comparison of UDEC and FLAC Results for Case 7.12

Case 7.12 Summary of Results (FLAC)

Parameter	Maximum		Minimum		Mean	Σ Absolute
	X	Value	X	Value	Value	Values
FLAC Shear displacement at bottom of interface (m)	64.00	1.21E-02	34.00	-1.56E-02	-1.35E-03	4.44E-01
FLAC Shear displacement at top of interface (m)	68.00	9.92E-03	34.00	-6.97E-03	1.27E-03	2.69E-01
FLAC Normal displacement at bottom of interface (m)	50.00	1.15E-02	2.00	-7.04E-04	4.72E-03	2.43E-01
FLAC Normal displacement at top of interface (m)	50.00	1.04E-02	2.00	-5.94E-04	4.47E-03	2.30E-01
FLAC Relative normal displacement on interface (m)	0.00	5.79E-04	50.00	-1.05E-03	-2.23E-04	1.28E-02
FLAC Relative shear displacement on interface (m)	34.00	8.59E-03	62.00	-2.46E-03	2.62E-03	1.75E-01
FLAC Total displacement at bottom of interface (m)	36.00	1.67E-02	0.00	1.38E-03	1.05E-02	5.34E-01
FLAC Total displacement at top of interface (m)	62.00	1.13E-02	4.00	5.91E-04	7.30E-03	3.72E-01
FLAC Normal stress at bottom of interface (Pa)	0.00	-9.75E+05	50.00	-5.45E+07	-1.44E+07	7.35E+08
FLAC Normal stress at top of interface (Pa)	0.00	-9.75E+05	50.00	-5.45E+07	-1.44E+07	7.35E+08
FLAC Shear stress at bottom of interface (Pa)	48.00	8.41E+06	54.00	-6.03E+06	9.58E+05	1.29E+08
FLAC Shear stress at top of interface (Pa)	48.00	8.41E+06	54.00	-6.03E+06	9.58E+05	1.29E+08
FLAC Temperature at bottom of interface (°C)	50.00	207.52	100.00	29.42	75.98	3874.99
FLAC Temperature at top of interface (°C)	50.00	207.11	0.00	29.34	75.73	3862.22
Maximum temperature at source (°C)	50.00	322.38	-	-	-	
Number of Contacts		51		51		
Number of Contacts at Slip Condition		0		0		

Case 7.12 Summary of Results (UDEC, Interpolated)

Parameter	Maximum		Minimum		Mean	Σ Absolute
	X	Value	X	Value	Value	Values
UDEC Shear displacement at bottom of interface (m)	64.00	1.22E-02	34.00	-1.59E-02	-1.56E-03	4.49E-01
UDEC Shear displacement at top of interface (m)	68.00	1.01E-02	34.00	-6.78E-03	1.51E-03	2.78E-01
UDEC Normal displacement at bottom of interface (m)	50.00	1.17E-02	0.00	-1.32E-03	4.63E-03	2.41E-01
UDEC Normal displacement at top of interface (m)	50.00	1.05E-02	0.00	-9.40E-04	4.39E-03	2.28E-01
UDEC Relative normal displacement on interface (m)	0.00	2.96E-05	50.00	-1.16E-03	-2.49E-04	1.28E-02
UDEC Relative shear displacement on interface (m)	34.00	9.17E-03	62.00	-2.25E-03	3.09E-03	1.92E-01
UDEC Total displacement at bottom of interface (m)	36.00	1.70E-02	0.00	1.37E-03	1.05E-02	5.37E-01
UDEC Total displacement at top of interface (m)	62.00	1.15E-02	4.00	6.42E-04	7.41E-03	3.78E-01
UDEC Normal stress at bottom of interface (Pa)	0.00	1.19E+06	50.00	-5.99E+07	-1.43E+07	7.33E+08
UDEC Normal stress at top of interface (Pa)	0.00	-8.41E+05	50.00	-5.24E+07	-1.43E+07	7.31E+08
UDEC Shear stress at bottom of interface (Pa)	47.50	9.50E+06	54.00	-7.61E+06	7.75E+05	1.34E+08
UDEC Shear stress at top of interface (Pa)	47.50	6.89E+06	54.00	-5.12E+06	8.20E+05	1.07E+08
UDEC Temperature at bottom of interface (°C)	50.00	2.10E+02	100.00	2.93E+01	7.60E+01	3874.57
UDEC Temperature at top of interface (°C)	50.00	2.08E+02	100.00	2.93E+01	7.59E+01	3871.19
Maximum temperature at source (°C)	50.00	326.70	-	-	-	-
Number of Contacts		51		52		
Number of Contacts at Slip Condition		0		0		

Nov 1/2004

Case 7.12 Relative Error between UDEC and FLAC Results*

Parameter	Maximum		Minimum		Mean	Total
	ΔX	Error	ΔX	Error	Error	Error
Shear displacement at bottom of interface (m)	0.0	0%	0.0	3%	1%	1%
Shear displacement at top of interface (m)	0.0	2%	0.0	1%	2%	3%
Normal displacement at bottom of interface (m)	0.0	3%	-2.0	9%	1%	1%
Normal displacement at top of interface (m)	0.0	1%	-2.0	5%	1%	1%
Relative normal displacement on interface (m)	0.0	9%	0.0	2%	0%	0%
Relative shear displacement on interface (m)	0.0	10%	0.0	4%	8%	9%
Total displacement at bottom of interface (m)	0.0	4%	0.0	0%	1%	1%
Total displacement at top of interface (m)	0.0	3%	0.0	1%	1%	2%
Normal stress at bottom of interface (Pa)	0.0	5%	0.0	14%	0%	0%
Normal stress at top of interface (Pa)	0.0	0%	0.0	5%	0%	1%
Shear stress at bottom of interface (Pa)	-0.5	15%	0.0	21%	2%	4%
Shear stress at top of interface (Pa)	-0.5	20%	0.0	12%	2%	17%
Temperature at bottom of interface (°C)	0.0	2%	0.0	0%	0%	0%
Temperature at top of interface (°C)	0.0	1%	100.0	0%	0%	0%
Maximum temperature at source (°C)	0.0	1%	-	-	-	
Number of Contacts		0%		2%		
Number of Contacts at Slip Condition		0%		0%		

* Relative error calculated as difference between UDEC and FLAC values normalized to maximum deviation from mean along interface in either total displacement, stress, or temperature

Final results for Case 7.12

Table 4.19 Comparison of UDEC and FLAC Results for Case 7.13

Case 7.13 Summary of Results (FLAC)

Parameter	Maximum		Minimum		Mean	Σ Absolute
	X	Value	X	Value	Value	Values
FLAC Shear displacement at bottom of interface (m)	64.00	1.33E-02	36.00	-1.14E-02	5.58E-04	3.79E-01
FLAC Shear displacement at top of interface (m)	68.00	8.82E-03	34.00	-1.07E-02	-3.25E-04	3.19E-01
FLAC Normal displacement at bottom of interface (m)	50.00	1.08E-02	0.00	1.98E-04	4.63E-03	2.36E-01
FLAC Normal displacement at top of interface (m)	50.00	9.77E-03	0.00	1.79E-04	4.38E-03	2.24E-01
FLAC Relative normal displacement on interface (m)	0.00	-1.42E-05	50.00	-1.04E-03	-2.48E-04	1.26E-02
FLAC Relative shear displacement on interface (m)	40.00	9.70E-04	62.00	-4.69E-03	-8.84E-04	6.00E-02
FLAC Total displacement at bottom of interface (m)	62.00	1.46E-02	0.00	2.04E-04	9.17E-03	4.68E-01
FLAC Total displacement at top of interface (m)	36.00	1.19E-02	0.00	1.84E-04	8.02E-03	4.09E-01
FLAC Normal stress at bottom of interface (Pa)	0.00	-7.67E+06	50.00	-5.87E+07	-1.91E+07	9.73E+08
FLAC Normal stress at top of interface (Pa)	0.00	-7.67E+06	50.00	-5.87E+07	-1.91E+07	9.73E+08
FLAC Shear stress at bottom of interface (Pa)	46.00	7.95E+06	52.00	-9.83E+06	-8.14E+04	1.73E+08
FLAC Shear stress at top of interface (Pa)	46.00	7.95E+06	52.00	-9.83E+06	-8.14E+04	1.73E+08
FLAC Temperature at bottom of interface (°C)	50.00	207.52	100.00	29.42	75.98	3874.99
FLAC Temperature at top of interface (°C)	50.00	207.11	0.00	29.34	75.73	3862.22
Maximum temperature at source (°C)	50.00	326.70	-	-	-	
Number of Contacts		51		51		
Number of Contacts at Slip Condition		0		0		

Case 7.13 Summary of Results (UDEC, Interpolated)

Parameter	Maximum		Minimum		Mean	Σ Absolute
	X	Value	X	Value	Value	Values
UDEC Shear displacement at bottom of interface (m)	64.00	1.36E-02	36.00	-1.17E-02	5.65E-04	3.88E-01
UDEC Shear displacement at top of interface (m)	68.00	8.79E-03	34.00	-1.07E-02	-3.37E-04	3.21E-01
UDEC Normal displacement at bottom of interface (m)	50.00	1.10E-02	0.00	1.49E-04	4.60E-03	2.35E-01
UDEC Normal displacement at top of interface (m)	50.00	9.87E-03	0.00	1.30E-04	4.35E-03	2.22E-01
UDEC Relative normal displacement on interface (m)	6.00	-4.79E-05	50.00	-1.16E-03	-2.61E-04	1.33E-02
UDEC Relative shear displacement on interface (m)	40.00	1.41E-03	62.00	-5.05E-03	-9.01E-04	6.81E-02
UDEC Total displacement at bottom of interface (m)	62.00	1.48E-02	0.00	1.53E-04	9.30E-03	4.74E-01
UDEC Total displacement at top of interface (m)	36.00	1.18E-02	0.00	1.34E-04	8.02E-03	4.09E-01
UDEC Normal stress at bottom of interface (Pa)	6.00	-8.41E+06	50.00	-6.41E+07	-1.91E+07	9.73E+08
UDEC Normal stress at top of interface (Pa)	6.00	-8.39E+06	50.00	-5.69E+07	-1.90E+07	9.68E+08
UDEC Shear stress at bottom of interface (Pa)	46.00	8.65E+06	52.50	-1.08E+07	8.66E+04	1.86E+08
UDEC Shear stress at top of interface (Pa)	44.00	5.95E+06	52.50	-7.95E+06	7.65E+04	1.54E+08
UDEC Temperature at bottom of interface (°C)	50.00	2.10E+02	100.00	2.93E+01	7.60E+01	3874.34
UDEC Temperature at top of interface (°C)	50.00	2.08E+02	100.00	2.93E+01	7.59E+01	3871.37
Maximum temperature at source (°C)	50.00	326.70	-	-	-	-
Number of Contacts		52		51		
Number of Contacts at Slip Condition		0		0		

NW 1/2004.

Case 7.13 Relative Error between UDEC and FLAC Results*

Parameter	Maximum		Minimum		Mean	Total
	ΔX	Error	ΔX	Error	Error	Error
Shear displacement at bottom of interface (m)	0.0	2%	0.0	2%	0%	2%
Shear displacement at top of interface (m)	0.0	0%	0.0	0%	0%	0%
Normal displacement at bottom of interface (m)	0.0	3%	0.0	1%	0%	1%
Normal displacement at top of interface (m)	0.0	2%	0.0	1%	1%	1%
Relative normal displacement on interface (m)	6.0	1%	0.0	3%	0%	5%
Relative shear displacement on interface (m)	0.0	12%	0.0	9%	0%	13%
Total displacement at bottom of interface (m)	0.0	3%	0.0	1%	1%	1%
Total displacement at top of interface (m)	0.0	1%	0.0	1%	0%	0%
Normal stress at bottom of interface (Pa)	6.0	2%	0.0	14%	0%	0%
Normal stress at top of interface (Pa)	6.0	2%	0.0	5%	0%	0%
Shear stress at bottom of interface (Pa)	0.0	7%	0.5	10%	2%	7%
Shear stress at top of interface (Pa)	-2.0	21%	0.5	19%	2%	11%
Temperature at bottom of interface (°C)	0.0	2%	0.0	0%	0%	0%
Temperature at top of interface (°C)	0.0	1%	100.0	0%	0%	0%
Maximum temperature at source (°C)	0.0	0%	-	-	-	
Number of Contacts		2%		0%		
Number of Contacts at Slip Condition		0%		0%		

* Relative error calculated as difference between UDEC and FLAC values normalized to maximum deviation from mean along interface in either total displacement, stress, or temperature

Final results for Case 7.13

WordPerfect Format. Software used was -
WordPerfect 11.0.0.233 ((c) 2003 Corel Corporation).

- Conversion required removal of all figures and section by section cut & paste to get the right formatting.
- A separate collection of figures in WordPerfect Graphic file (.wpg) format was created for insertion in the report by CNWRA.
- Final document files created were as follows under directory /Task 02 UDEC Modelling/Final Report Files/WordPerfect Files/
  - UDEC Validation Report Text WP (Rev. 1).wpd.
  - UDEC Validation Report Figures (Rev. 1).wpd.
  - UDEC Validation Report Captions.wpd.
  - UDEC Validation Figure Thumbs.wpd.
  - numerous figure files named fig4_xx.wpg where xx is 1 to 50 with some modifiers such as top, middle, bottom for figures with multiple files. R Nw 5/04

Nw 6/04.

- The final directory structure used retained the previous structure referenced in this scientific notebook, but with an overarching directory /Task 02 UDEC Modelling/.

Sub directories are as follows:

/Background - background documents for Task 02
/Case 2 - all UDEC and associated files for Case 02.
/Case 5 - all UDEC and associated files for Case 05

SN 673 Vol 1

/Case 6 - all UDEC and associated files for Case 6
/Case 7/ - general case 7 files.
/Comparison - UDEC & FLAC comparison files.
/FLAC - all FLAC and associated files for Case 7
/UDEC - all UDEC and associated files for Case 7
/Final Report Files/
/PDF files - pdf version of draft report
/WORD Files - MS WORD files of draft report
/WordPerfect Files - WordPerfect files of report.
Nov 6/04.

Nov 7/04 - Compiled all files in hardcopy and on 3 CD's for shipment to CNWRA.

Nov 8/04 - couriered report hard copy and CDs to CNWRA via Fedex. overnight service.

Nov 10/2004 Received copy of CNWRA Non-conformance report 2004-21 about Scientific Notebooks SN654 and SN673. No initial entry in Notebook 673 on objectives and approach, qualification requirements. Information is contained on SN654 and is reproduced on pages 137 and 138.

This should satisfy the requirements for completion. Target date for completion is Dec 31/04.

Nov 10/04.

SN673 Vol 1

Nov 10/2004. Supplemental initial entries for this scientific notebook areas follows:

1
SN 654 Vol.1

Title: Validation of Universal Distinct Element Code (UDEC) Ver. 3.1

Principal Investigator: Dr. Rodney S. Read, RSRead Consulting Inc.

CNWRA Personnel: Dr. Goodluck Ofoegbu, Dr. Asadul H. Chowdhury, Dr. Sui-Min Hsiung

Objectives and Approach: The objectives of this software validation exercise are to conduct a series of validation tests using UDEC and the code Fast Lagrangian Analysis of Continua (FLAC) version 4.0, and to summarize the findings of these exercises in a report to CNWRA. The plan for these exercises is contained in the document entitled "Software Validation Test Plan for the Universal Distinct Element Code (UDEC) Version 3.1" (CNWRA, May 2002).

Nov 10/04

Qualification Requirements: Familiarity with software codes from HCItasca (Itasca Consulting Group, Inc.).

Description of Analyses: There are seven analyses detailed in the validation test plan. Three of these (Cases 1, 3 and 4) are discussed in the UDEC online manual, and are covered in sufficient detail in that document. The other four cases are as follows:

Case 2 - Joint slip intersected by a circular excavation
Case 5 - Heat conduction through a composite wall
Case 6 - Validate cable bolt performance
Case 7 - Mechanical response of a joint subject to heat load

These cases will be examined individually as described in the test plan.

Initial entry addition to SN673 Vol. 1 as per NCR No. 2004-21, (Pg 1 of 2)
- these entries were intended as part of entries on Page 1.

SN 673 Vol 1
- the entries below were intended to be on Page 1

2

SN654 Vol 1

Computer Platform: Analyses will be conducted on a DELL 8200 personal computer running Microsoft Windows XP (Version 5.1.2600 Service Pack 1 Build 2600) unless otherwise identified.

Nov 10/04.

Computer Software: UDEC Version 3.10.112 was leased from Itasca Consulting Group on July 23, 2004. FLAC Version 4.0 will be leased at a later date. Specific version number will be recorded at that time under individual validation exercises.

Nov 10/04

FLAC 4.0 Version 4.00.314, Serial number 213-001-0521-11415

Additional Initial Entries: Additional initial entries specific to each individual validation exercise will be listed separately under each exercise.

Aug 1/2004

Initial entry addition to SN 673 Vol 1 as per NCR No. 2004-21 (Pg 2 of 2).

Nov 10/04

Feb 05/2005

- Draft report received November 8/2004.
- Comments from CNWRA received January 10/2005.
- Comments addressed Feb 5/2005.

Clarification on calculation of error in Case 7. required along with check of data input in Table 4-10. Details of calculations on Pg 139.

SN 673 Vol 1.

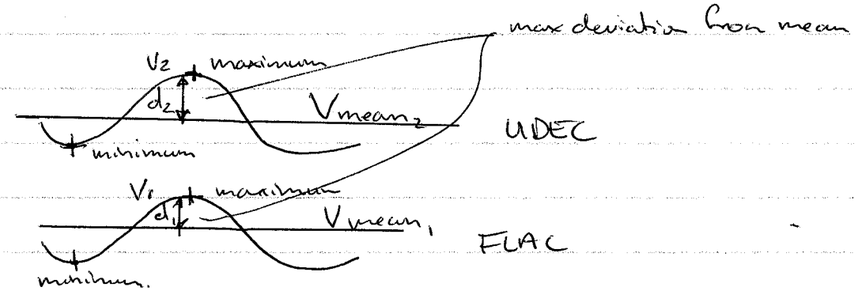
Calculation of Error in Case 7

The standard calculation of error between two values is generally given

$E = (V_2 - V_1)/V_1$ where V_2 is the value of calculation 2 and V_1 is the value of calculation 1 (the base calculation).

Where V_1 is a very small number relative to the variability in V_2, very large error values are calculated using the above method. Where V_1 is zero, the value of E is meaningless.

For case 7, the mean value of some responses was zero. Therefore, the calculated error using the above method was not meaningful in trying to assess goodness-of-fit. An alternate method was devised using the maximum deviation from the mean for a particular response as the denominator to avoid division by zero problems (see diagram below).



To calculate error using this method,

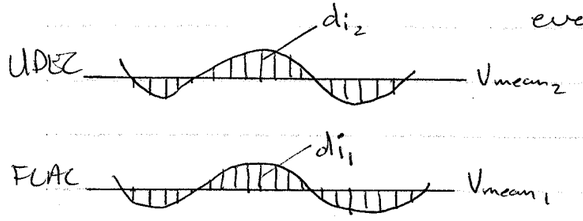
$$E = \frac{V_2 - V_1}{d_1}$$

Another method used was to calculate the difference in

mean values and normalize them to the maximum deviation from the mean. ie

$$E_{mean} = (V_{mean_2} - V_{mean_1})/d_1$$

The third way used to calculate error was to sum the absolute differences between a given response (at evenly spaced points) and the ~~me~~ abscissa. (ie. y=0 line), and compare UDEC/FLAC. Referring to the diagram to the left,



$$E_{Total} = \frac{\sum_{i=1}^{n} abs(di_2) - \sum_{i=1}^{n} abs(di_1)}{\sum_{i=1}^{n} abs(di_1)}$$

This latter method provides the advantage of comparing the response along the entire interface, not just at select points. This method differs from comparing mean responses in that all deviations from zero are treated as absolute values, and therefore do not cancel one another out to give a total of zero.

A note clarifying this approach was added to the draft report.

Checked table 4-10. Values corrected

Scientific notebook sent to CNWRA Feb 5/2005.

I have reviewed this scientific notebook and find it in agreement with QAP-001.

4-15-05