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title
Prediction of Borehole Closure in a Salt Formation
config creep
; --- geometrical model ---
def w_cons
    b111_n1 = 1
    v_a     = 2
    b111_n3 = 2 * v_a          ; must be even
    b111_n4 = 3
    b112_n1 = v_a
    b112_n3 = 1
    b113_n1 = b112_n1
    b113_n3 = 3
    b114_n1 = b112_n1
    b114_n3 = 4                ; could use 6
    b121_n1 = 4
    b121_n3 = v_a
    b122_n1 = b121_n1
    b122_n3 = b112_n3
    b123_n1 = b121_n1
    b123_n3 = b113_n3
    b124_n1 = b121_n1
    b124_n3 = b114_n3
    b131_n1 = 4
    b131_n3 = v_a
    b132_n1 = b131_n1
    b132_n3 = b112_n3
    b133_n1 = b131_n1
    b133_n3 = b113_n3
    b134_n1 = b131_n1
    b134_n3 = b114_n3
    b141_n1 = b114_n3
    b141_n3 = v_a
    b142_n1 = b141_n1
    b142_n3 = b112_n3
    b143_n1 = b141_n1
    b143_n3 = b113_n3
    rat1    = 53.36 / float(b121_n3 + b122_n3 + b123_n3)
    h1      = rat1 * float(b121_n3)
    h1m     = h1 - 1.57
    h2      = rat1 * float(b121_n3 + b122_n3)
    h2m     = h2 - 2.09
    h2mm    = h2 - 1.57
    rat2    = 44.51 / float(v_a + b121_n1 + b131_n1)

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l1      = rat2 * float(v_a)
l1m     = l1 - 1.57
l2      = rat2 * float(v_a + b121_n1)
l2m     = l2 - 1.57
l2mm    = l2 - 15.24
p0x     = 0.
p2x     = 0.
r2      = 0.
v_n2    = 5
end
w_cons
def slice
command
;    pillar layer      (9.14m)
gen zone radcyl &      ; borehole-----block 111
p0 p0x 0 0 p1 add 0 1.57 0 p2 add p2x 0 0 p3 add 0 0 1.57 &
di 0.46 0.46 0.46 0.46 &
size b111_n1 v_n2 b111_n3 b111_n4 &
ratio 1 r2 1 1 fill
gen zone brick &      ;      -----block 121
p0 p0x 1.57 0 p1 add 0 13.67 0 p2 add p2x 0 0 p3 add 0 0 1.57 &
size b121_n1 v_n2 b121_n3 &
ratio 1 r2 1
gen zone brick &      ;      -----block 131
p0 p0x 15.24 0 p1 add 0 4.27 0 p2 add p2x 0 0 p3 add 0 0 1.57 &
size b131_n1 v_n2 b131_n3 &
ratio 1 r2 1
gen zone brick &      ;      -----block 141
p0 p0x 19.51 0 p1 add 0 25 0 p2 add p2x 0 0 p3 add 0 0 1.57 &
p4 add p2x 25 0 p5 add p2x 0 1.57 &
p6 add 0 25 h1 p7 add p2x 25 h1 &
size b141_n1 v_n2 b141_n3 &
ratio 1.4 r2 1
gen zone brick &      ; drift height----block 112
p0 p0x 0 1.57 p1 add 0 1.57 0 p2 add p2x 0 0 p3 add 0 0 0.52 &
size b112_n1 v_n2 b112_n3 &
ratio 1 r2 1
gen zone brick &      ;      ----block 122
p0 p0x 1.57 1.57 p1 add 0 13.67 0 p2 add p2x 0 0 p3 add 0 0 0.52 &
size b122_n1 v_n2 b122_n3 &
ratio 1 r2 1
gen zone brick &      ;      ----block 132
p0 p0x 15.24 1.57 p1 add 0 4.27 0 p2 add p2x 0 0 p3 add 0 0 0.52 &
size b132_n1 v_n2 b132_n3 &

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ratio 1 r2 1
gen zone brick &          ;          -----block 142
p0 p0x 19.51 1.57 p1 add 0    25 h1m  p2 add p2x 0 0 p3 add 0    0 0.52 &
      p4 add p2x 25 h1m                p5 add p2x 0 0.52 &
      p6 add 0    25 h2mm  p7 add p2x 25 h2mm &
size b142_n1 v_n2 b142_n3 &
ratio 1.4 r2 1
gen zone brick &          ; room height-----block 113
p0 p0x 0 2.09 p1 add 0 1.57 0 p2 add p2x 0 0 p3 add 0 0 1.83 &
size b113_n1 v_n2 b113_n3 &
ratio 1 r2 1
gen zone brick &          ;          -----block 123
p0 p0x 1.57 2.09 p1 add 0 13.67 0 p2 add p2x 0 0 p3 add 0 0 1.83 &
size b123_n1 v_n2 b123_n3 &
ratio 1 r2 1
gen zone brick &          ;          -----block 133
p0 p0x 15.24 2.09 p1 add 0 4.27 0 p2 add p2x 0 0 p3 add 0 0 1.83 &
size b133_n1 v_n2 b133_n3 &
ratio 1 r2 1
gen zone brick &          ;          -----block 143
p0 p0x 19.51 2.09 p1 add 0    25 h2m  p2 add p2x 0 0 p3 add 0    0 1.83 &
      p4 add p2x 25 h2m                p5 add p2x 0 1.83 &
      p6 add 0    25 51.27 p7 add p2x 25 51.27 &
size b143_n1 v_n2 b143_n3 &
ratio 1.4 r2 1
gen zone brick &          ; far field-----block 114
p0 p0x 0 3.92 p1 add 0    1.57 0 p2 add p2x 0 0 p3 add 0    0 49.44 &
      p4 add p2x 1.57 0                p5 add p2x 0 49.44 &
      p6 add 0 11 49.44  p7 add p2x 11 49.44 &
size b114_n1 v_n2 b114_n3 &
ratio 1 r2 1.4
gen zone brick &          ;          -----block 124
p0 p0x 1.57 3.92 p1 add 0    13.67 0 p2 add p2x 0 0 p3 add 0    11m 49.44 &
      p4 add p2x 13.67 0                p5 add p2x 11m 49.44 &
      p6 add 0 12m 49.44  p7 add p2x 12m 49.44 &
size b124_n1 v_n2 b124_n3 &
ratio 1 r2 1.4
gen zone brick &          ;          -----block 134
p0 p0x 15.24 3.92 p1 add 0    4.27 0 p2 add p2x 0 0 p3 add 0    12mm 49.44 &
      p4 add p2x 4.27 0                p5 add p2x 12mm 49.44 &
      p6 add 0 29.27 49.44 p7 add p2x 29.27 49.44 &
size b134_n1 v_n2 b134_n3 &
ratio 1 r2 1.4
end_command

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end
; ... The model is made up of three vertical slices ...
; --- pillar slice ---
set p0x = 0 p2x = -9.14 r2 = 0.9 v_n2 = 3
slice
; --- room slice ---
set p0x = -9.14 p2x = -5.49 r2 = 1. v_n2 = 3
slice
; --- far field slice ---
set p0x = -14.63 p2x = -24.99 r2 = 1.2 v_n2 = 3
slice
; ... the slices are reflected across the z-plane ...
gen zone reflect normal 0 0 1 origin 0 0 0
; ... and reflected across the y-plane ...
gen zone reflect normal 0 1 0 origin 0 0 0
; --- range definitions ---
range name drift x -39.63 0 y -19.51 -15.24 z -1.57 2.09
range name room x -14.63 -9.14 y -15.24 15.24 z -1.57 3.92
range name bhole cylinder end1 0 0 0 end2 -9.14 0 0 rad 0.46
range name empty drift any room any bhole any
; --- mechanical model ---
model WIPP
prop sh 1.e9 bu 1.65e9
prop gas 1.987 act 12e3 n_wipp 4.9 D_wipp 5.79e-36
prop a_wip 4.56 b_wip 127 e_dot 5.39e-8 temp 300
; --- settings ---
ini density 2300
set gravity 0 0 -9.79
set large
; --- initial conditions ---
ini sxx -14.77e6 grad 0 0 2.25e4
ini syy -14.77e6 grad 0 0 2.25e4
ini szz -14.77e6 grad 0 0 2.25e4
; --- boundary conditions ---
fix x range x -0.01 0.01
fix x range x -40. -39.61
fix y range y -45. -44.50
fix y range y 44.50 45.
fix z range z -55. -53.35
apply nstress -13.57e6 range z 53.35 55.
; --- histories ---
set hist_rep 50
hist crtime
hist unbal

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hist gp ydisp 0 -.46 0
hist gp ydisp 0 .46 0
hist gp zdisp 0 0 -.46
hist gp zdisp 0 0 .46
hist gp ydisp -3.5 -.46 0
hist gp ydisp -3.5 .46 0
hist gp zdisp -3.5 0 -.46
hist gp zdisp -3.5 0 .46
hist gp ydisp -6.1 -.46 0
hist gp ydisp -6.1 .46 0
hist gp zdisp -6.1 0 -.46
hist gp zdisp -6.1 0 .46
hist gp ydisp -9.14 -.46 0
hist gp ydisp -9.14 .46 0
hist gp zdisp -9.14 0 -.46
hist gp zdisp -9.14 0 .46
;D
hist gp zdisp 0 -15.24 -1.57
hist gp zdisp 0 -15.24 2.09
;C
hist gp zdisp 0 0 -1.57
hist gp zdisp 0 0 2.09
;B
hist gp zdisp -9.14 -15.24 -1.57
hist gp zdisp -9.14 -15.24 2.09
;A
hist gp zdisp -9.14 0 -1.57
hist gp zdisp -9.14 0 2.09

; --- instantaneous excavation of drift, room and borehole ---
model null range empty
; --- small time elastic response ---
set creep off
solve
save wipel_a.sav
; --- creep response ---
set creep on
set creep mindt 2.e2 maxdt 4.e4
; set creep dt 2.e2
; set creep mindt 2.e2 maxdt 4.e4 umul 1
set creep dt auto on
solve age 179755200 ;--> age 5.7 year
save wipel_b.sav
solve age 242827200 ;--> total age 7.7 year

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save wipel_c.sav  
;  
ret
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