

APPENDIX A1: “ANSYS” PROGRAM COMMAND CODES

1. Crack retardation due to two overloads (80MPa – 100MPa)

```
/TITLE, Crack Retardation Simulation (Mapped Mesh for two overloads: 80MPa -
100MPa)
/PREP7
!*
ET,1,PLANE82
!*
KEYOPT,1,3,0
KEYOPT,1,5,0
KEYOPT,1,6,0
!*
TOFFST,273
MPTEMP,,,,,,,,
MPTEMP,1,0
MPDATA,EX,1,,70000
MPDATA,PRXY,1,,0.33
TB,BISO,1,1,2,
TBTEMP,20
TBDATA,,200,0.0,,,
/AXLAB,X,Total Strain
/AXLAB,Y,Stress
/GTHK,AXIS,1
/GRTYP,0
/XRANGE,DEFAULT
/YRANGE,DEFAULT,,1
!*
WPSTYLE,,,,,,,,1
wpstyle,10,10,0,100,0.003,0,0,,5

FLST,3,9,8
FITEM,3,0,0,0
FITEM,3,10,0,0
FITEM,3,50,0,0
FITEM,3,50,20,0
FITEM,3,10,20,0
FITEM,3,0,20,0
FITEM,3,0,60,0
FITEM,3,10,60,0
FITEM,3,50,60,0
K, ,P51X
LSTR, 1, 2
LSTR, 2, 3
LSTR, 3, 4
```

LSTR, 2, 5
LSTR, 1, 6
LSTR, 6, 5
LSTR, 5, 4
LSTR, 4, 9
LSTR, 5, 8
LSTR, 6, 7
LSTR, 7, 8
LSTR, 8, 9
FLST,2,4,4
FITEM,2,5
FITEM,2,4
FITEM,2,6
FITEM,2,1
AL,P51X
FLST,2,4,4
FITEM,2,4
FITEM,2,7
FITEM,2,2
FITEM,2,3
AL,P51X
FLST,2,4,4
FITEM,2,12
FITEM,2,9
FITEM,2,8
FITEM,2,7
AL,P51X
FLST,2,4,4
FITEM,2,10
FITEM,2,11
FITEM,2,9
FITEM,2,6
AL,P51X
FLST,2,4,5,ORDE,2
FITEM,2,1
FITEM,2,-4
AGLUE,P51X
WPSTYLE,,,,,,,,,0
LPLOT
FLST,5,3,4,ORDE,3
FITEM,5,2
FITEM,5,7
FITEM,5,12
CM,_Y,LINE
LSEL, , , P51X
CM,_Y1,LINE

```

CMSEL,,_Y
!*
LESIZE,_Y1, , ,80, , , ,1
!*
FLST,5,3,4,ORDE,2
FITEM,5,3
FITEM,5,-5
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
!*
LESIZE,_Y1, , ,40, , , ,1
!*
FLST,5,3,4,ORDE,3
FITEM,5,1
FITEM,5,6
FITEM,5,11
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
!*
LESIZE,_Y1, , ,20, , , ,1
!*
FLST,5,3,4,ORDE,2
FITEM,5,8
FITEM,5,-10
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
!*
LESIZE,_Y1, , ,20, , , ,1
!*
MSHAPE,0,2D
MSHKEY,1
!*
FLST,5,4,5,ORDE,2
FITEM,5,1
FITEM,5,-4
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y

```

```

!*
AMESH,_Y1
!*
CMDELE,_Y
CMDELE,_Y1
CMDELE,_Y2
!*
SAVE
FINISH
/SOLU
!*
FLST,2,3,4,ORDE,3
FITEM,2,2
FITEM,2,5
FITEM,2,10
DL,P51X, ,SYMM

FLST,3,1,1
FITEM,3,2961
MONITOR,VAR1,P51X,UX
FLST,3,1,1
FITEM,3,2961
MONITOR,VAR2,P51X,UY
FLST,3,1,1
FITEM,3,2961
MONITOR,VAR3,P51X,FY
FINISH
/POST1
FINISH
/SOLU
!*
TIME,0
AUTOTS,-1
NSUBST,5,25,3,1
KBC,0
!*
TSRES,ERASE
FLST,2,2,4,ORDE,2
FITEM,2,11
FITEM,2,-12
/GO
!*
SFL,P51X,PRES,-30,
/STATUS,SOLU
SOLVE
EPLOTT

```

```

FLST,2,2,4,ORDE,2
FITEM,2,11
FITEM,2,-12
/GO
!*
SFL,P51X,PRES,30,
/STATUS,SOLU
SOLVE
EPLOT
FLST,2,2,4,ORDE,2
FITEM,2,11
FITEM,2,-12
/GO
!*
SFL,P51X,PRES,-30,
/STATUS,SOLU
SOLVE
EPLOT
FLST,2,2,4,ORDE,2
FITEM,2,11
FITEM,2,-12
/GO
!*
SFL,P51X,PRES,30,
/STATUS,SOLU
SOLVE
EPLOT
FLST,2,2,4,ORDE,2
FITEM,2,11
FITEM,2,-12
/GO
!*
SFL,P51X,PRES,-80,
/STATUS,SOLU
!*
TIME,0
AUTOTS,-1
NSUBST,10,50,5,1
KBC,0
!*
TSRES,ERASE
/STATUS,SOLU
SOLVE
EPLOT
FLST,2,2,4,ORDE,2
FITEM,2,11

```



```
SFL,P51X,PRES,30,  
/STATUS,SOLU  
SOLVE  
EPlot  
FLST,2,2,4,ORDE,2  
FITEM,2,11  
FITEM,2,-12  
/GO
```

```
!*
```

```
SFL,P51X,PRES,-30,  
/STATUS,SOLU  
SOLVE  
EPlot  
FLST,2,2,4,ORDE,2  
FITEM,2,11  
FITEM,2,-12  
/GO
```

```
!*
```

```
SFL,P51X,PRES,30,  
/STATUS,SOLU  
SOLVE  
EPlot  
FLST,2,2,4,ORDE,2  
FITEM,2,11  
FITEM,2,-12  
/GO
```

```
!*
```

```
SFL,P51X,PRES,-30,  
/STATUS,SOLU  
SOLVE  
EPlot  
FLST,2,2,4,ORDE,2  
FITEM,2,11  
FITEM,2,-12  
/GO
```

```
!*
```

```
SFL,P51X,PRES,30,  
/STATUS,SOLU  
SOLVE  
EPlot
```

```
FLST,2,2,4,ORDE,2  
FITEM,2,11  
FITEM,2,-12  
/GO
```

```
!*
```

```

SFL,P51X,PRES,-100,
/STATUS,SOLU
!*
TIME,0
AUTOTS,-1
NSUBST,20,70,10,1
KBC,0
!*
TSRES,ERASE
/STATUS,SOLU
SOLVE
EPLOT
FLST,2,2,4,ORDE,2
FITEM,2,11
FITEM,2,-12
/GO
!*
SFL,P51X,PRES,100,
/STATUS,SOLU
SOLVE
!*

TIME,0
AUTOTS,-1
NSUBST,5,25,3,1
KBC,0
!*
TSRES,ERASE
EPLOT
FLST,2,2,4,ORDE,2
FITEM,2,11
FITEM,2,-12
/GO
!*
SFL,P51X,PRES,-30,
/STATUS,SOLU
SOLVE
EPLOT
FLST,2,2,4,ORDE,2
FITEM,2,11
FITEM,2,-12
/GO
!*
SFL,P51X,PRES,30,
/STATUS,SOLU
SOLVE

```

```
EPlot
FLST,2,2,4,ORDE,2
FITEM,2,11
FITEM,2,-12
/GO
!*
SFL,P51X,PRES,-30,
/STATUS,SOLU
SOLVE
EPlot
FLST,2,2,4,ORDE,2
FITEM,2,11
FITEM,2,-12
/GO
!*
SFL,P51X,PRES,30,
/STATUS,SOLU
SOLVE
EPlot
FLST,2,2,4,ORDE,2
FITEM,2,11
FITEM,2,-12
/GO
!*
SFL,P51X,PRES,-30,
/STATUS,SOLU
SOLVE
EPlot
FLST,2,2,4,ORDE,2
FITEM,2,11
FITEM,2,-12
/GO
!*
SFL,P51X,PRES,30,
/STATUS,SOLU
SOLVE
EPlot
FLST,2,2,4,ORDE,2
FITEM,2,11
FITEM,2,-12
/GO
!*
SFL,P51X,PRES,-30,
/STATUS,SOLU
SOLVE
EPlot
```

```

FLST,2,2,4,ORDE,2
FITEM,2,11
FITEM,2,-12
/GO
!*
SFL,P51X,PRES,30,
/STATUS,SOLU
SOLVE
EPlot

FINISH
/POST1
FINISH
/POST26

FORCE,TOTAL
SHELL, TOP
LAYERP26,0
ESOL,2,801,2961,S,Y,
!*
FORCE,TOTAL
SHELL, TOP
LAYERP26,0
ESOL,3,801,2961,EPEL,Y,
!*
FORCE,TOTAL
SHELL, TOP
LAYERP26,0
ESOL,4,801,2961,EPPL,Y,
!*
!*
ADD,5,3,4, , , , 1,1,1,
VARNAM, ,
!*
/AXLAB,X,Total Strain(Elastic+Plastic)
/AXLAB,Y,Stress(FY)
!*
PLTIME,0,0
XVAR,5
SPREAD,0
PLCPLX,0
!*
PLVAR,2, , , , , , , ,
!*
FINISH

```

2. Stress intensity factor in 2-D modeling

```
/prep7
smart,off
/title,Fracture mechanics stress intensity factor 2-D modeling
/com,
et,1,plane82,,,2
mp,ex,1,70e9
mp,nuxy,1,0.3
*set,a,0.004
*set,b,0.02
*set,c,0.005
*set,h,0.025
csys,0
k,1
k,2,b
k,3,b,h
k,4,-c,h
k,5,-c
l,1,2
l,2,3
lesize,2,,,16
l,3,4
lesize,3,,,16
l,4,5
lesize,4,,,24,0.2
l,5,1
esize,,,0.001
KSCON,1,0.00075,0,12
al,1,2,3,4,5
dl,1,1,symm
dl,4,1,symm
sfl,3,pres,-100e6
amesh,1
outpr,all
finish
/com
/output,scratch
/solu
solve
finish
/output
/post1
etable,sene,sene
etable,volu,volu
nsl,s,loc,y,0
```

```

nselect,r,loc,x,0
*get,nod1,node,,num,min
nselect,a,loc,y
nselect,r,loc,x,-0.000025,-0.000725
*get,nod2,node,,num,min
nselect,a,loc,y
nselect,r,loc,x,-0.000725,-0.000775
*get,nod3,node,,num,min
nselect,all
path,KI1,3,,48
ppath,1,nod1
ppath,2,nod2
ppath,3,nod3
kcalc,,,1
*get,KI1,kcalc,,k,1
*status

```

3. Stress intensity factor in 3-D modeling

```

/PREP7
SMART,OFF
/TITLE, FRACTURE MECHANICS STRESS INTENSITY-CRACK IN A FINITE
WIDTH PLATE in 3-D modeling
antype,static
et,1,solid95
mp,ex,1,70e9
mp,nuxy,1,0.3
csys,1
*SET,a,0.0038
*SET,b,0.02
*SET,c,0.005
*SET,h,0.025
*SET,t,0.005
n,1
ngen,9,20,1
n,11,a
n,171,a,180
fill,11,171,7,31,20
csys,0
fill,1,11,9,2,1,9,20,3
n,15,b
n,75,b,h
fill,15,75,2,35,20
n,155,-c,h
fill,75,155,3,95,20
n,172,-c

```

```

fill,155,172,5,177,-1,,,.15
fill,11,15,3,,.7,20,3
ngen,2,200,1,177,,,.t
type,1
e,2,22,1,1,202,222,201,201
egen,8,20,-1
e,2,3,23,22,202,203,223,222
egen,8,20,-1
egen,9,1,-8
egen,5,1,73,78
e,171,151,173,172,371,351,373,372
e,151,131,174,173,351,331,374,373
e,131,132,175,174,331,332,375,374
egen,3,1,-1
e,134,135,155,177,334,335,355,377
SAVE
nset,s,loc,x,-c
dsym,symm,x
nset,s,loc,x,0,b
nset,r,loc,y,0
dsym,symm,y
nset,s,loc,x,-c,b
nset,r,loc,z,0
d,all,uz
nset,s,loc,y,h
sf,all,pres,-100e6
nset,all
esel,all
finish
/output,scratch
/solu
solve
finish
/output
/post1
etable,sene,sene
etable,volu,volu
path,ki1,3,,48
ppath,1,1
ppath,2,163
ppath,3,168
kcalc,,.1
*get,ki1,kcalc,,k,1
*status

```

APPENDIX A2: COPIES OF THE PAPER PUBLISHED

- (1) **“Finite Element Analysis on the Influence of Overload Induced Residual Stress Field on Fatigue Crack Growth in Aluminum Alloy”**, Dr. M.A. Wahab and J.H. Park, 10th ICCE conference in New Orleans, July 20-26, 2003.
- (2) **“Experimental Study on the Influence of Overload Induced Residual Stress Field on Fatigue Crack Growth in Aluminum Alloy”**, Dr. M.A. Wahab, G.R. Rohrsheim and J.H. Park, Journal of Material Processing Technology, AMPT 2003-Paper#357 in Dublin, Ireland, July 8-11, 2003.
- (3) **“Effects of Overload and Corrosion Preventatives on Fatigue Life in Aluminum Alloy”**, Dr. M. A. Wahab and J.H. Park, 11th ICCE conference in S. Carolina, August 8-14, 2004 (Manuscript Submitted).