

```
1 module ModNoNLinElasticity
2 contains
3
4 Subroutine ESM_NONLINEAR(NPT,NOEL,IDSET,STRESS,EUNLOADING,PLASTICMULTIPLIER,
5 DSTRAN,NSTATEV,STATEV,NADDVAR,ADDITIONALVAR,CMNAME,NPROPS,PROPS,NUMBEROFPHASES)
6
7
8 implicit double precision (a-h, o-z)
9 integer :: NTENS, NSTATEV, NADDVAR, NPROPS, NPT, NOEL, IDSET, NUMBEROFPHASES
10 double precision :: EUNLOADING, PLASTICMULTIPLIER
11 CHARACTER*80 CMNAME
12 DIMENSION STRESS(NTENS), DSTRAN(NTENS),STATEV(NSTATEV),ADDITIONALVAR(NADDVAR),
13
14
15 !——Local variables required in standard UMAT
16 integer :: IStep, TimeStep
17 double precision, dimension(:), allocatable :: ddsddt ! only for fully coupled thermal analysis: variation of ddsdde
18 double precision, dimension(:), allocatable :: drplde ! only for fully coupled thermal analysis: variation of drplde
19 double precision, dimension(:), allocatable :: stran
20 double precision, dimension(:), allocatable :: time
21 double precision, dimension(:), allocatable :: predef
22 double precision, dimension(:), allocatable :: dpred
23 double precision, dimension(:), allocatable :: coords
24
25 double precision, dimension(:,::), allocatable :: ddsdde ! Jacobian matrix of the constitutive model (r4)
26 double precision, dimension(:,::), allocatable :: drot
27 double precision, dimension(:,::), allocatable :: dfgdr0
28 double precision, dimension(:,::), allocatable :: dfgdr1
29 double precision :: sse, spd, scd ! specific elastic strain energy, plastic dissipation, creep dissipation
30 double precision :: rpl ! only for fully coupled thermal analysis: volumetric heat generation
31 double precision :: drpldt ! only for fully coupled thermal analysis: variation of volumetric heat generation
32 double precision :: pnewdt, dtimp, temp, dttemp, celent
33 double precision :: Value ! auxiliary variable holding any real valued number
34 double precision :: Porosity, WaterPressure, WaterPressure0, GasPressure, GasPressure0, DegreeSaturation
35
36 integer :: ndi, nshr, layer, kspt, kstep, kinc
37
38 !——Local variables defined by the user
39 ! e.g. integer :: var_local
40 !——User can define here additional variables
41
42 allocate ( ddsddt(ntens), drplde(ntens), stran(ntens), time(2), predef(1), dpred(1), &
43 coords(3), ddsdde(ntens,ntens), drot(3,3), dfgdr0(3,3), dfgdr1(3,3) )
44
45 !Initialization
46 Eunloading = 0.0
47 PlasticMultiplier = 0.0
48
49 !Rename additional variables
50 Porosity = AdditionalVar(1)
51 WaterPressure = AdditionalVar(2)
52 WaterPressure0 = AdditionalVar(3)
53 GasPressure = AdditionalVar(4)
54 GasPressure0 = AdditionalVar(5)
55 DegreeSaturation = AdditionalVar(6)
56 time(1) = AdditionalVar(7) !TotalRealTime
57 time(2) = AdditionalVar(8) !OverallTotalTime
58 dtimp = AdditionalVar(9) !TimeIncrement
59 IStep = AdditionalVar(10)
60 TimeStep = AdditionalVar(11) !Note: Very first time and load step: IStep=1 and TimeStep=1
61 !Call the UMAT
62 call umat(stress, statev, ddsdde, sse, spd, scd, rpl, ddsddt, drplde, drpldt, stran, dstran, time, dtimp,
63 predef, dpred, cmname, ndi, nshr, ntens, nstatev, props, nprops, coords, drot, pnewdt, celent,
64 dfgdr1, noel, npt, layer, kspt, kstep, kinc)
65
66
67 !——Definition of Eunloading -> required to define the max time step
68 Eunloading = max(ddsdde(1,1), ddsdde(2,2), ddsdde(3,3))
69 !——Always define this value to run the simulation
70
71 ! PlasticMultiplier can be given as an output because plastic points can be plotted as a result
72
73
74
75 return
76
77 end subroutine ESM_NONLINEAR
78
79
80 SUBROUTINE UMAT(STRESS,STATEV,DDSDDE,SSE,SPD,SCD,&
81 RPL,DDSDDT,DRPLDE,DRPLDT,&
82 STRAN,DSTRAN,TIME,DTIME,TEMP,DTEMP,PREDDEF,DPRED,CMNAME,&
83 NDI,NSHR,NTENS,NSTATEV,PROPS,NPROPS,COORDS,DROT,PNEWDT,&
84 CELENT,DFGRD0,DFGRD1,NOEL,NPT,LAYER,KSPT,KSTEP,KINC)
85
86
87 implicit double precision (a-h, o-z)
88 ! IDEC$ ATTRIBUTES DLLEXPORT, ALIAS="UMAT" :: UMAT
89 ! INCLUDE 'ABA_PARAM.INC'
90 integer :: NTENS, NSTATEV, NPROPS
91 CHARACTER*80 CMNAME
92 DIMENSION STRESS(NTENS),STATEV(NSTATEV), &
93 DDSDDE(NTENS,NTENS),DDSDDT(NTENS),DRPLDE(NTENS), &
94 STRAN(NTENS),DSTRAN(NTENS),TIME(2),PREDDEF(1),DPRED(1), &
95 PROPS(NPROPS),COORDS(3),DROT(3,3),DFGRD0(3,3),DFGRD1(3,3)
96
97
98 ! Arguments:
99 ! I/O Type
100 ! PROPS I R() : List with model parameters
101 ! DSTRAN I R() : Strain increment
102 ! DDSDDE O R() : Material stiffness matrix
103 ! STRESS I/O R() : stresses
104 ! STATEV I/O R() : state variables
105
106
107 !—— Local variables
108 dimension dSig(NTENS), Sig(NTENS)
109
110 ! Contents of PROPS(3)
111 ! 1 : E Young Modulus
112 ! 2 : ENU Poisson's ratio
113 ! 3 : PLIM
114
115 E_u = PROPS(1)
116 ENU_u = PROPS(2)
117 PLIM_u = PROPS(3)
118 one_u = 1.0d0
119 two_u = 2.0d0
120 PRESS_u = (STRESS(1)_u + STRESS(2)_u + STRESS(3)_u)/3
121 EDEG_u = E_u/(1+PRESS_u/PLIM_u)
122 G_u = EDEG_u/two_u/(one_u+ENU_u)
123 ! calculate elastic stress increment, dSigE_u = elastic_stiffness_D_u * strain_increment_D_Eps
124 FAC_u = two_u * G_u / (one_u + two_u * ENU_u)
125 D1_u = FAC_u * (one_u - ENU_u)
126 D2_u = FAC_u * ENU_u
127 DSTRANVOL_u = DSTRAN(1)_u + DSTRAN(2)_u + DSTRAN(3)_u
128 dSig(1)_u = (D1_u - D2_u) * DSTRAN(1)_u + D2_u * DSTRANVOL_u
129 dSig(2)_u = (D1_u - D2_u) * DSTRAN(2)_u + D2_u * DSTRANVOL_u
130 dSig(3)_u = (D1_u - D2_u) * DSTRAN(3)_u + D2_u * DSTRANVOL_u
131 dSig(4)_u = G_u * DSTRAN(4)_u
132 if (NTENS_u == 6) then
133 dSig(5)_u = G_u * DSTRAN(5)_u
134 dSig(6)_u = G_u * DSTRAN(6)_u
135 end if
136 ! elastic stress
137 Sig_u = STRESS_u + dSig
138
139 ! stress state parameters update
140 do i_u = 1, NTENS
141 STRESS(i)_u = Sig(i)_u
142 end do
143
144 DDSDDE_u = 0.0
145 DDSDDE(1:3,1:3)_u = D2
146 DDSDDE(1,1)_u = D1
147 DDSDDE(2,2)_u = D1
148 DDSDDE(3,3)_u = D1
149 DDSDDE(4,4)_u = G
150 if (NTENS_u == 6) then
151 DDSDDE(5,5)_u = G
152 DDSDDE(6,6)_u = G
153 end if
154
155 return
156 end subroutine umat
157
158 end module ModNoNLinElasticity
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