Neste anexo encontra-se a subrotina *Usermat* do modelo constitutivo EPVP.

1

1. \*deck,usermat3d USERDISTRIB parallel gal
2. **subroutine** usermat3d\_EPVP **(**
3. & matId**,** elemId**,**kDomIntPt**,** kLayer**,** kSectPt**,**
4. & ldstep**,**isubst**,**keycut**,**
5. & nDirect**,**nShear**,**ncomp**,**nStatev**,**nProp**,**
6. & Time**,**dTime**,**Temp**,**dTemp**,**
7. & stress**,**ustatev**,**dsdePl**,**sedEl**,**sedPl**,**epseq**,**
8. & Strain**,**dStrain**,** epsPl**,** prop**,** coords**,**
9. & var0**,** defGrad\_t**,** defGrad**,**
10. & tsstif**,** epsZZ**,** cutFactor**,**
11. & var1**,** var2**,** var3**,** var4**,** var5**,**
12. & var6**,** var7**)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 14 #include **"impcom.inc"** | | | | | | | |
| 15 |  | | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | |
| 16 |  | | !\*\* SUBROTINA: USERMAT3D\_EPVP \*\*! | | | | |
| 17 |  | | !\*\* \*\*! | | | | |
| 18 |  | | !\*\* Objetivo: atualiza as tensões, variáveis de estado e matriz \*\*! | | | | |
| 19 |  | | !\*\* constitutiva para o modelo constitutivo EPVP \*\*! | | | | |
| 20 |  | | !\*\* \*\*! | | | | |
| 21 |  | | !\*\* Situação: OK (10/11/2021) \*\*! | | | | |
| 22 |  | | !\*\* \*\*! | | | | |
| 23 |  | | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | |
| 24 |  | | ! | | | | |
| 25 |  | | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | |
| 26 |  | | ! Declaração variáveis de entrada e saída da subrotina ! | | | | |
| 27 |  | | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | |
| 28 |  | | **INTEGER** | | | | |
| 29 | & | | matId**,** elemId**,** | | | | |
| 30 | & | | kDomIntPt**,** kLayer**,** kSectPt**,** | | | | |
| 31 | & | | ldstep**,**isubst**,**keycut**,** | | | | |
| 32 | & | | nDirect**,**nShear**,**ncomp**,**nStatev**,**nProp | | | | |
| 33 |  | | **DOUBLE** | **PRECISION** |  |  |  |
| 34 | & | |  |  | Time**,** dTime**,** Temp**,** | dTemp**,** |  |
| 35 | & | |  |  | sedEl**,** sedPl**,** epseq**,** | epsZZ**,** | cutFactor |
| 36 |  | | **DOUBLE** | **PRECISION** |  |  |  |
| 37 & stress **(**ncomp **),** ustatev **(**nStatev**),** | | | | | | | |
| 38 | & | |  |  | dsdePl **(**ncomp**,**ncomp**),** | | |
| 39 | & | |  |  | Strain **(**ncomp **),** dStrain **(**ncomp **),** | | |
| 40 | & | |  |  | epsPl **(**ncomp **),** prop **(**nProp **),** | | |
| 41 | & | |  |  | coords **(**3**),** | | |
| 42 | & | |  |  | defGrad **(**3**,**3**),** defGrad\_t**(**3**,**3**),** | | |
| 43 | & | |  |  | tsstif **(**2**)** | | |
| 44 |  | | **DOUBLE** | **PRECISION** | var0**,** var1**,** var2**,** var3**,** var4**,** var5**,** | | |
| 45 | & | |  |  | var6**,** var7 | | |
| 46 |  | | ! |  |  | | |
| 47 |  | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | |
| 48 |  | ! Informações sobre as variáveis locais (precisão, tipo, escopo) ! | | | | | |
| 49 |  | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | |
| 50 | c | ! aux1 (dp,sc,l) denominador no dlambdaVP | | | | | |
| 51 | c | ! c (dp,sc,l) coesão | | | | | |
| 52 | c | ! c1,c2,c3 (dp,sc,l) cs do vetor de fluxo | | | | | |
| 53 | c | ! cp,ci,cr (dp,sc,l) coesão inicial, pico e residual | | | | | |
| 54 | c | ! czao (dp,sc,l) constante para def. plast. equiv. | | | | | |
| 55 | c | ! czaoVP (dp,sc,l) constante para def. viscop. equiv. | | | | | |
| 56 | c | ! cVP (dp,sc,l) coesão do modelo viscoplástio | | | | | |
| 57 | c | ! ddlam (dp,sc,l) ddlam pelo NR do corretor plástico | | | | | |
| 58 | c | ! dfds (dp,ar(ncomp),l) df/dsigma | | | | | |
| 59 | c | ! dfds\_m (dp,ar(1,ncomp),l) df/dsigma^T para aplicar MATMUL | | | | | |
| 60 | c | ! dgds (dp,ar(ncomp),l) dg/dsigma | | | | | |
| 61 | c | ! dgdsVP (dp,ar(ncomp),l) dg/dsigma viscoplástico | | | | | |
| 62 | c | ! dgds\_m (dp,ar(ncomp,1),l) dg/dsigma para aplicar MATMUL | | | | | |
| 63 | c | ! dgdsVP\_m (dp,ar(ncomp,1),l) dg/dsigmaVP para aplicar MATMUL | | | | | |
| 64 | c | ! dhdq,dfdq,dfdc,dcde (dp,sc,l) dh/dq, df/dq, df/dc, dc/de | | | | | |
| 65 | c | ! dgPHItD (dp,ar(ncomp,ncomp),l) produto dg/dsigma\*PHI^T\*D | | | | | |
| 66 | c | ! dlam (dp,sc,l) delta lambda elastoplastico | | | | | |
| 67 | c | ! dlambdaVP (dp,sc,l) delta lambda viscoplastico | | | | | |
| 68 | c | ! depsEP (dp,ar(ncomp),l) incremento deformações plásticas | | | | | |
| 69 | c | ! depsVP (dp,ar(ncomp),l) incremento deformações viscoplásticas | | | | | |
| 70 | c | ! depsEPeq (dp,sc,l) incremen. defor. plástica equivalente | | | | | |
| 71 | c | ! DgftD (dp,ar(ncomp,ncomp),l) produto D\*dg/dsigma\*df/dsigma^T\*D | | | | | |
| 72 | c | ! dsdeEl (dp,ar(ncomp,ncomp),l) matriz constitutiva elastica | | | | | |
| 73 | c | ! dsdeElinv (dp,ar(ncomp,ncomp),l) inversa de dsdeEl | | | | | |

74 c ! dt1,dt2 (dp,sc,l) tempos limites do modelo viscoplástico

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 75 | c | ! | | eps1,eps2,eps3(dp,sc,l) | deformações plast. equiva. amol/endur. | |
| 76 | c | ! | | epsEP (dp,ar(ncomp),l) | deformações plásticas | |
| 77 | c | ! | | epsVP (dp,ar(ncomp),l) | deformações viscoplasticas | |
| 78 | c | ! | | epsEPeq (dp,sc,l) | deformação plástica equivalente | |
| 79 | c | ! | | epsVPeq (dp,sc,l) | deformação viscoplástica equivalente | |
| 80 | c | ! | | f (dp,sc,l) | função de escoamento elastoplástico | |
| 81 | c | ! | | fVP (dp,sc,l) | função de escoamento viscoplástico | |
| 82 | c | ! | | fi (dp,sc,l) | ângulo de atrito elastoplástico | |
| 83 | c | ! | | fiVP (dp,sc,l) | ângulo de atrito viscoplástico | |
| 84 | c | ! | | ftDg (dp,sc,l) | produto df/dsigma^T\*D\*dg/dsigma | |
| 85 | c | ! | | g1,g2,g3 (dp,ar(ncomp),l) | componentes diretoras do vetor de fluxo | |
| 86 | c | ! | | i,j,k (int,sc,l) | contadores | |
| 87 | c | ! | | I1 (dp,sc,l) | primeiro invariante das tensões | |
| 88 | c | ! | | J2 (dp,sc,l) | segundo invariante do desviador | |
| 89 | c | ! | | J3 (dp,sc,l) | terceiro invariante do desviador | |
| 90 | c | ! | | n,eta,f0 (dp,sc,l) | constantes do modelo de Perzyna | |
| 91 | c | ! | | ncompgt (int,sc,l) | componentes de tensões iniciais | |
| 92 | c | ! | | nrmax (int,sc,l) | quantidade máxima de interações de NR | |
| 93 | c | ! | | PHI (dp,sc,l) | função de sobretensão | |
| 94 | c | ! | | PHItDdeps (dp,sc,l) | produto PHI^T\*D\*deps | |
| 95 | c | ! | | PHItDg (dp,sc,l) | produto dPHI/ds^T\*D\*dg/ds | |
| 96 | c | ! | | psi (dp,sc,l) | angulo de dilatância | |
| 97 | c | ! | | psiVP (dp,sc,l) | angulo de dilatância viscoplástico | |
| 98 | c | ! | | s (dp,ar(ncomp),l) | tensor desviador | |
| 99 | c | ! | | sigi (dp,ar(ncomp),l) | tensão inicial | |
| 100 | c | ! | | sigmap (dp,ar(ncomp),l) | tensão inicial a descontar | |
| 101 | c | ! | | stressn (dp,ar(ncomp),l) | tensão no inicio do passo | |
| 102 | c | ! | | stresstrial (dp,ar(ncomp),l) | tensão tentativa | |
| 103 | c | ! | | theta (dp,sc,l) | ângulo de Lode | |
| 104 | c | ! | | thetaVP (dp,sc,l) | ângulo de Lode do modelo viscoplástico | |
| 105 | c | ! | | young (dp,sc,l) | módulo de Young | |
| 106 | c | ! | | posn (dp,sc,l) | coeficiente de Poisson | |
| 107 | c | ! | | q1,dq (dp,sc,l) | variaveis auxiliares | |
| 108 | c | ! | | superficief (int,sc,l) | f : 1-DPI, 2-DPII, 3-DPIII | |
| 109 | c | ! | | superficiefVP (int,sc,l) | fVP : 1-DPI, 2-DPII, 3-DPIII | |
| 110 | c | ! | | superficiegVP (int,sc,l) | g : 1-DPI, 2-DPII, 3-DPIII | |
| 111 | c | ! | | superficieg (int,sc,l) | gVP : 1-DPI, 2-DPII, 3-DPIII | |
| 112 | c | ! | | vPi (dp,sc,l) | Pi | |
| 113 | c | ! | |  |  | |
| 114 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | |
| 115 | c | ! INFORMAÇÕES DAS VARIÁVEIS DE ESTADO ! | | | | |
| 116 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | |
| 117 | c | ! | | | | |
| 118 | c | ! nstatev = 20 | | | | |
| 119 | c | ! ustatev(1) = epsEPeq | | | | |
| 120 | c | ! ustatev(2) = dlam | | | | |
| 121 | c | ! ustatev(3) = c | | | | |
| 122 | c | ! ustatev(4) = q | | | | |
| 123 | c | ! ustatev(5) = f | | | | |
| 124 | c | ! ustatev(6) = epsVPeq | | | | |
| 125 | c | ! ustatev(7) = dt1 | | | | |
| 126 | c | ! ustatev(8) = dt2 | | | | |
| 127 | c | ! ustatev(9:ncomp) = espEP(1:ncomp) | | | | |
| 128 | c | ! ustatev(15:ncomp) = espVP(1:ncomp) | | | | |
| 129 | c | ! | | | | |
| 130 | c | ! OBS: as variáveis de estados podem ser plotadas na GUI do ANSYS | | | | |
| 131 | c | ! utilizando o comando PLESOL,SVAR,[componente] ou PLNESOL,SVAR,[componente] | | | | |
| 132 | c | ! | | | | |
| 133 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | |
| 134 | c | ! Declaração das variáveis locais ! | | | | |
| 135 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | |
| 136 | c | ! | | | | |
| 137 | c | ! Variáveis comuns a ambos modelos | | | | |
| 138 |  | **INTEGER** | | | | |
| 139 |  | & i**,** j**,** k**,** ncompgt | | | | |
| 140 |  | **DOUBLE PRECISION** | | | | |
| 141 |  | & I1**,**J2**,**J3**,**theta**,** | | | | |
| 142 |  | & c1**,**c2**,**c3**,** | | | | |
| 143 |  | & vPi**,** young**,**posn | | | | |
| 144 |  | & dstress**(**ncomp**),**sigi**(**ncomp**),** | | | | |
| 145 |  | & dsdeEl**(**ncomp**,**ncomp**),** | | | | |
| 146 |  | & s**(**ncomp**),** g1**(**ncomp**),**g2**(**ncomp**),**g3**(**ncomp**)** | | | | |
| 150 |  | | **PARAMETER (** | | |
| 151 | & | | vPi **=** 3.14159265358979323846d0 | | |
| 152 | & | | **)** | | |
| 153 |  | | **EXTERNAL** | | |
| 154 |  | & vzero**,** vmove**,** get\_ElmData**,** get\_ElmInfo**,** | | | |
| 155 |  | & matrizD**,**invars**,**normatensor**,**calcula\_czao**,** | | | |
| 156 |  | & matinv**,**yield**,**c1c2c3**,**g1g2g3 | | | |
| 157 | c | ! | | | |
| 158 | c | ! variáveis do modelo viscoplástico | | | |
| 159 |  | **DOUBLE PRECISION** | | | |
| 160 |  | & fVP**,**PHI**,** | | | |
| 161 |  | & dlambdaVP**,**PHItDdeps**,**PHItDg**,**aux1**,** | | | |
| 162 |  | & epsVPeq**,**depsVPeq**,**czaoVP | | | |
| 163 |  | **DOUBLE PRECISION** | | | |
| 164 |  | & dgdsVP**(**ncomp**),**dPHIds**(**ncomp**),** | | | |
| 165 |  | & dPHIds\_m**(**1**,**ncomp**),**dgdsVP\_m**(**ncomp**,**1**),** | | | |
| 166 |  | & epsVP**(**ncomp**),**depsVP**(**ncomp**),** | | | |
| 167 |  | & dgPHItD**(**ncomp**,**ncomp**),** | | | |
| 168 |  | & sigmap**(**ncomp**),**dt1**,**dt2 | | | |
| 169 |  | **INTEGER** | | | |
| 170 |  | & superficiefVP**,**superficiegVP | | | |
| 171 |  | **DOUBLE PRECISION** | | | |
| 172 |  | & cVP**,**fiVP**,**psiVP**,**n**,**eta**,**f0**,**thetaVP | | | |
| 173 | c | ! | | | |
| 174 | c | ! variáveis do modelo elastoplástico | | | |
| 175 |  | **INTEGER** | | | |
| 176 |  | & nrmax**,** dalg | | | |
| 177 |  | **DOUBLE PRECISION** | | | |
| 178 |  | & tolEP**,** | | | |
| 179 |  | & f**,** | | | |
| 180 |  | & dlam**,**ddlam**,**ftDg**,** | | | |
| 181 |  | & dhdq**,**dfdq**,**dqdc**,**dcde**,** | | | |
| 182 |  | & epsEPeq**,**depsEPeq**,**czao**,** | | | |
| 183 |  | & q**,**dq**,**Xi | | | |
| 184 |  | **DOUBLE PRECISION** | | | |
| 185 |  | & dsdeElinv**(**ncomp**,**ncomp**),** | | | |
| 186 |  | & stresstrial**(**ncomp**),** | | | |
| 187 |  | & dgds**(**ncomp**),**dfds**(**ncomp**),** | | | |
| 188 |  | & dfds\_m**(**1**,**ncomp**),**dgds\_m**(**ncomp**,**1**),** | | | |
| 189 |  | & epsEP**(**ncomp**),**depsEP**(**ncomp**),** | | | |
| 190 |  | & DgftD**(**ncomp**,**ncomp**),** | | | |
| 191 |  | & stressn**(**ncomp**)** | | | |
| 192 |  | **INTEGER** | | | |
| 193 |  | & superficief**,**superficieg | | | |
| 194 |  | **DOUBLE PRECISION** | | | |
| 195 |  | & c**,**fi**,**psi**,**ci**,**cp**,**cr**,**eps1**,**eps2**,**eps3 | | | |
| 196 |  | **PARAMETER (**nrmax **=** 100000**,** | | | |
| 197 |  | & tolEP **=** 0.0000000000001d0 | | | |

198 & **)**

1. **EXTERNAL**
2. & calcula\_Xi**,**calcula\_dcde

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 201 | c | ! | | |
| 202 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | |
| 203 | c | ! Entrada de dados ! | | |
| 204 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | |
| 205 | c | ! | | |
| 206 | c | ! Variavel que controla o método da bisseção caso não haja convergência | | |
| 207 |  | keycut **=** 0 | | |
| 208 | c | ! | | |
| 209 | c | ! Propriedades elásticas | | |
| 210 |  | young **=** prop**(**2**)** | | |
| 211 |  | posn **=** prop**(**3**)** | | |
| 212 | c | ! | | |
| 213 | c | ! Propriedades do modelo EP | | |
| 214 |  | superficief **=** prop**(**4**)** | | |
| 215 |  | superficieg **=** prop**(**5**)** | | |
| 216 |  | fi **=** prop**(**6**)\***vPi**/**180 | | |
| 217 |  | psi **=** prop**(**7**)\***vPi**/**180 | | |
| 218 |  | ci **=** prop**(**8**)** | | |
| 219 |  | cp **=** prop**(**9**)** | | |
| 220 |  | cr | **=** | prop**(**10**)** |
| 221 |  | eps1 | **=** | prop**(**11**)** |
| 222 |  | eps2 | **=** | prop**(**12**)** |
| 223 |  | eps3 | **=** | prop**(**13**)** |
| 224 |  | dalg | **=** | prop**(**14**)** |
| 225 | c | ! |  |  |
| 226 | c | ! Propriedades do modelo VP | | |
| 227 |  | superficiefVP **=** prop**(**15**)** | | |
| 228 |  | superficiegVP **=** prop**(**16**)** | | |
| 229 |  | fiVP **=** prop**(**17**)\***vPi**/**180 | | |
| 230 |  | psiVP **=** prop**(**18**)\***vPi**/**180 | | |
| 231 |  | cVP **=** prop**(**19**)** | | |
| 232 |  | n **=** prop**(**20**)** | | |
| 233 |  | eta **=** prop**(**21**)** | | |
| 234 |  | f0 **=** prop**(**22**)** | | |
| 235 |  | thetaVP **=** prop**(**23**)** | | |
| 236 | c | ! | | |
| 237 | c | ! Limpando variáveis do modelo EP | | |
| 238 |  | depsEP **=** 0.0d0 | | |
| 239 |  | depsEPeq **=** 0.0d0 | | |
| 240 |  | dq **=** 0.0d0 | | |
| 241 |  | f **=** 0.0d0 | | |
| 242 |  | stressn **=** 0.0d0 | | |
| 243 |  | dcde **=** 0.0d0 | | |
| 244 |  | k **=** 0 | | |
| 245 | c | ! | | |
| 246 | c | ! Limpando variáveis do modelo VP | | |
| 247 |  | depsVP **=** 0.0d0 | | |
| 248 |  | fVP **=** 0.0d0 | | |
| 249 |  | dt1 **=** 0.0d0 | | |
| 250 |  | dt2 **=** 0.0d0 | | |
| 251 | c | ! | | |
| 252 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | |
| 253 | c | ! Coletando variáveis de estado e deformações plásticas do passo convergido! | | |
| 254 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | |
| 255 | c | ! Modelo EP | | |
| 256 |  | epsEPeq **=** ustatev**(**1**)** | | |
| 257 |  | dlam **=** ustatev**(**2**)** | | |
| 258 |  | c **=** ustatev**(**3**)** | | |
| 259 |  | q **=** ustatev**(**5**)** | | |
| 260 |  | **CALL** vmove**(**ustatev**(**9**),** epsEP**(**1**),** ncomp**)** | | |
| 261 | c | ! | | |
| 262 | c | ! Inicializa o valor da coesão | | |
| 263 |  | **IF(**c.EQ.0.0d0**)**c**=**ci | | |
| 264 |  | **IF(**q.EQ.0.0d0**)THEN** | | |
| 265 |  | **CALL** calcula\_Xi**(**superficief**,**fi**,**Xi**)** | | |
| 266 |  | q**=**Xi**\***ci | | |
| 267 |  | **ENDIF** | | |
| 268 | c | ! | | |
| 269 | c | ! Modelo VP | | |
| 270 |  | epsVPeq **=** ustatev**(**6**)** | | |
| 271 |  | **CALL** vmove**(**ustatev**(**15**),** epsVP**(**1**),** ncomp**)** | | |
| 272 | c | ! | | |
| 273 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | |
| 274 | c | ! Calculo da matriz constitutiva ! | | |
| 275 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | |
| 276 |  | dsdeEl **=** 0.0d0 | | |
| 277 |  | **CALL** MatrizD**(**young**,**posn**,**ncomp**,**dsdeEl**)** | | |
| 278 |  | dsdePl **=** dsdeEl | | |
| 279 | c | ! | | |
| 280 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | |
| 281 | c | ! Calculo módulo de rigidez transversal para hourglass ! | | |
| 282 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | |
| 283 |  | tsstif**(**1**) =** 0.5d0**\*(**young **/(**1.0d0**+**posn**))** | | |
| 284 | c | ! | | |
| 285 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | |
| 286 | c | ! Coletando tensões iniciais ! | | |
| 287 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | |
| 288 |  | **call** get\_ElmInfo**(**'NCOMP'**,** ncompgt**)** | | |
| 289 |  | **call** vzero**(**sigi**(**1**),**ncompgt**)** | | |
| 290 |  | **call** get\_ElmData **(**'ISIG'**,** elemId**,**kDomIntPt**,** ncompgt**,** sigi**)** | | |
| 291 | c | ! | | |
| 292 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | |

293 c ! Calculo da tensão no passo n !

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 294 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 295 |  | stress **= MATMUL(**dsdeEl**(**1**:**ncomp**,**1**:**ncomp**),** | | | | | | | |
| 296 |  | & strain**(**1**:**ncomp**)** | | | | | | | |
| 297 |  | & **-**epsVP**(**1**:**ncomp**)** | | | | | | | |
| 298 |  | & **-**epsEP**(**1**:**ncomp**))+**sigi | | | | | | | |
| 299 | c | ! | | | | | | | |
| 300 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 301 | c | ! Calculo da função de sobretensão ! | | | | | | | |
| 302 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 303 |  | PHI **=** 0.0d0 | | | | | | | |
| 304 |  | **CALL** invars**(**stress**,**ncomp**,**I1**,**J2**,**J3**,**theta**,**s**)** | | | | | | | |
| 305 |  | **CALL** yield**(**superficiefVP**,**I1**,**J2**,**theta**,**cVP**,**fiVP**,**fVP**)** | | | | | | | |
| 306 |  | PHI **= (**fVP**/**f0**)\*\***n | | | | | | | |
| 307 |  | **IF(**PHI.LE.0.0d0**)**PHI **=** 0.0d0 | | | | | | | |
| 308 | c | ! | | | | | | | |
| 309 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 310 | c | ! Calculo dgdsvp ! | | | | | | | |
| 311 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 312 |  | **CALL** g1g2g3**(**s**,**ncomp**,**J2**,**g1**,**g2**,**g3**)** | | | | | | | |
| 313 |  | **CALL** c1c2c3**(**J2**,**theta**,**superficiegVP**,**psiVP**,**c1**,**c2**,**c3**)** | | | | | | | |
| 314 |  | dgdsVP **=** c1**\***g1 **+** c2**\***g2 **+** c3**\***g3 | | | | | | | |
| 315 | c | ! | | | | | | | |
| 316 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 317 | c | ! Calculo dPHIds,PHItDg,PHItDdeps,aux1 ! | | | | | | | |
| 318 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 319 |  | **CALL** c1c2c3**(**J2**,**theta**,**superficiefVP**,**psiVP**,**c1**,**c2**,**c3**)** | | | | | | | |
| 320 |  | dPHIds **=** c1**\***g1 **+** c2**\***g2 **+** c3**\***g3 | | | | | | | |
| 321 |  | **IF(**PHI.LE.0.0d0**)**dPHIds **=** 0.0d0 | | | | | | | |
| 322 | c | ! | | | | | | | |
| 323 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 324 | c | ! Verificação do incremento de tempo ! | | | | | | | |
| 325 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 326 |  | **IF(**PHI.GT.0.0d0**)THEN** | | | | | | | |
| 327 |  | dt1 **=** 4.0d0**/**3.0d0**\***eta**/**PHI**\*(**1.0d0**+**posn**)/**young**\*DSQRT(**3.0d0**\***J2**)** | | | | | | | |
| 328 |  | dt2 **=** eta**\***f0**/(**n**\*(**fVP**/**f0**)\*\*(**n**-**1**))\*** | | | | | | | |
| 329 |  | & **(**1.0d0**+**posn**)\*(**1.0d0**-**2.0d0**\***posn**)/**young**\*** | | | | | | | |
| 330 |  | & **((**3.0d0**-DSIN(**fiVP**))\*\***2**)/** | | | | | | | |
| 331 |  | & **(**3.0d0**/**4.0d0**\*(**1.0d0**-**2.0d0**\***posn**)\*(**3.0d0**-DSIN(**fiVP**))\*\***2**+** | | | | | | | |
| 332 |  | & 6.0d0**\*(**1.0d0**+**posn**)\*DSIN(**fiVP**)\*\***2**)** | | | | | | | |
| 333 |  | **IF(**dtime.GT.dt1.OR.dtime.GT.dt2**)THEN** | | | | | | | |
| 334 |  | keycut **=** 1 | | | | | | | |
| 335 |  | **RETURN** | | | | | | | |
| 336 |  | **ENDIF** | | | | | | | |
| 337 |  | **ENDIF** | | | | | | | |
| 338 | c | ! | | | | | | | |
| 339 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 340 | c | ! Atualização do módulo constitutivo ! | | | | | | | |
| 341 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 342 |  | PHItDg **= DOT\_PRODUCT(**dPHIds**,MATMUL(**dsdeEl**,**dgdsVP**))** | | | | | | | |
| 343 |  | aux1 **= (**eta**/**dtime **+** thetaVP**\***PHItDg**)** | | | | | | | |
| 344 |  | dPHIds\_m**(**1**,:) =** dPHIds | | | | | | | |
| 345 |  | dgdsVP\_m**(:,**1**) =** dgdsVP | | | | | | | |
| 346 |  | DgPHItD **= MATMUL(MATMUL** | | | | | | | |
| 347 |  | & **(MATMUL(**dsdeEl**,**dgdsVP\_m**),**dPHIds\_m**),**dsdeEl**)** | | | | | | | |
| 348 |  | dsdePl **=** dsdePl **-** thetaVP**\***DgPHItD**/**aux1 | | | | | | | |
| 349 | c | ! | | | | | | | |
| 350 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 351 | c | ! Calculo do p ! | | | | | | | |
| 352 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 353 |  | sigmap **=** PHI**\*MATMUL(**dsdeEl**(**1**:**ncomp**,**1**:**ncomp**),** | | | | | | | |
| 354 |  | & dgdsVP**(**1**:**ncomp**))/**aux1 | | | | | | | |
| 355 | c | ! | | | | | | | |
| 356 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 357 | c | ! Calculo da deformação viscoplastica ! | | | | | | | |
| 358 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 359 |  | PHItDdeps **= DOT\_PRODUCT(**dPHIds**,MATMUL(**dsdeEl**,**dstrain**))** | | | | | | | |
| 360 |  | dlambdaVP **= (**PHI **+** thetaVP**\***PHItDdeps**)/**aux1 | | | | | | | |
| 361 |  | depsVP **=** dlambdaVP**\***dgdsVP | | | | | | | |
| 362 | c | ! | | | | | | | |
| 363 | c | ! Calcula as deformações viscoplasticas totais | | | | | | | |
| 364 |  | epsVP **=** epsVP **+** depsVP | | | | | | | |
| 365 |  | **CALL** normatensor**(**epsVP**,**ncomp**,**epsVPeq**)** | | | | | | | |
| 366 |  | **CALL** calcula\_Czao**(**superficiefVP**,**fiVP**,**CzaoVP**)** | | | | | | | |
| 367 |  | epsVPeq **=** CzaoVP**\***epsVPeq | | | | | | | |
| 368 | c | ! | | | | | | | |
| 369 | c | ! | | | | | | | |
| 370 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 371 | c | ! Calculo preditor elástico ! | | | | | | | |
| 372 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 373 |  | stresstrial **=** 0.0d0 | | | | | | | |
| 374 |  | stresstrial **= MATMUL(**dsdeEl**(**1**:**ncomp**,**1**:**ncomp**),** | | | | | | | |
| 375 |  | & strain**(**1**:**ncomp**)+**dstrain**(**1**:**ncomp**)** | | | | | | | |
| 376 |  | & **-**epsEP**(**1**:**ncomp**)-**epsVP**(**1**:**ncomp**)) +** sigi | | | | | | | |
| 377 |  | stress **=** stresstrial | | | | | | | |
| 378 | c | ! | | | | | | | |
| 379 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 380 | c | ! Calcula função de escoamento ! | | | | | | | |
| 381 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 382 |  | **CALL** invars**(**stresstrial**,**ncomp**,**I1**,**J2**,**J3**,**theta**,**s**)** ! Invariantes | | | | | | | |
| 383 |  | **CALL** yield**(**superficief**,**I1**,**J2**,**theta**,**c**,**fi**,**f**)** ! função de escoamento | | | | | | | |
| 384 | c | ! | | | | | | | |
| 385 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 386 | c | ! Verifica o critério de escoamento ! | | | | | | | |
| 387 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 388 |  | **IF(**f.GT.0.0d0**)THEN** | | | | | | | |
| 389 | c | ! | | | | | | | |
| 390 | c | ! Aplica o corretor plástico | | | | | | | |
| 391 | c | ! | | | | | | | |
| 392 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 393 | c | ! Calcula dgds ! | | | | | | | |
| 394 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 395 |  | dgds **=** 0.0d0 | | | | | | | |
| 396 |  | stressn **=** stresstrial | | | | | | | |
| 397 |  | **CALL** invars**(**stressn**,**ncomp**,**I1**,**J2**,**J3**,**theta**,**s**)** | | | | | | | |
| 398 |  | **CALL** g1g2g3**(**s**,**ncomp**,**J2**,**g1**,**g2**,**g3**)** | | | | | | | |
| 399 |  | **CALL** c1c2c3**(**J2**,**theta**,**superficieg**,**psi**,**c1**,**c2**,**c3**)** | | | | | | | |
| 400 |  | dgds **=** c1**\***g1 **+** c2**\***g2 **+** c3**\***g3 | | | | | | | |
| 401 | c | ! | | | | | | | |
| 402 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 403 | c | ! Calcula dhdq referente ao endurecimento e amolecimento ! | | | | | | | |
| 404 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 405 |  | dhdq **=** 0.0d0 | | | | | | | |
| 406 |  | dfdq **= -**1.0d0 | | | | | | | |
| 407 |  | **CALL** calcula\_Xi**(**superficief**,**fi**,**Xi**)** | | | | | | | |
| 408 |  | dqdc **=** Xi | | | | | | | |
| 409 |  | **CALL** calcula\_dcde**(**ci**,**cp**,**cr**,**eps1**,**eps2**,**eps3**,**epsEPeq**,**dcde**)** | | | | | | | |
| 410 |  | dhdq **= -**dfdq**\***dqdc**\***dcde | | | | | | | |
| 411 | c | ! | | | | | | | |
| 412 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 413 | c | ! Interações de NR local do modelo constitutivo ! | | | | | | | |
| 414 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 415 |  | k **=** 0 | | | | | | | |
| 416 |  | **DO** | | | | | | | |
| 417 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 418 | c | ! Calculo de ddlamb ! | | | | | | | |
| 419 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 420 | c | ! | | | | | | | |
| 421 | c | ! Calcula dfds | | | | | | | |
| 422 |  | dfds **=** 0.0d0 | | | | | | | |
| 423 |  | **CALL** invars**(**stress**,**ncomp**,**I1**,**J2**,**J3**,**theta**,**s**)** | | | | | | | |
| 424 |  | **CALL** g1g2g3**(**s**,**ncomp**,**J2**,**g1**,**g2**,**g3**)** | | | | | | | |
| 425 |  | **CALL** c1c2c3**(**J2**,**theta**,**superficief**,**fi**,**c1**,**c2**,**c3**)** | | | | | | | |
| 426 |  | dfds **=** c1**\***g1 **+** c2**\***g2 **+** c3**\***g3 | | | | | | | |
| 427 | c | ! | | | | | | | |
| 428 | c | ! Calcula dfdq | | | | | | | |
| 429 |  | dfdq **= -**1.0d0 | | | | | | | |
| 430 |  | ! | | | | | | | |
| 431 | c | ! Calcula denominador de ddlamb | | | | | | | |
| 432 |  | ftDg **= DOT\_PRODUCT(**dfds**,MATMUL(**dsdeEl**,**dgds**))** | | | | | | | |
| 433 | c | ! | | | | | | | |
| 434 | c | ! Calcula ddlamb | | | | | | | |
| 435 |  | ddlam **=** f**/(**ftDg **-** dfdq**\***dhdq**)** | | | | | | | |
| 436 | c | ! | | | | | | | |
| 437 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 438 | c | ! Calculo do corretor plástico ! | | | | | | | |
| 439 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | | |
| 440 |  | dstress **= -**ddlam**\*MATMUL(**dsdeEl**,**dgds**)** | | | | | | | | |
| 441 |  | dq **= -**ddlam**\*(-**dhdq**)** | | | | | | | | |
| 442 | c | ! | | | | | | | | |
| 443 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | | |
| 444 | c | ! Incremento das tensões e do dlam ! | | | | | | | | |
| 445 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | | |
| 446 |  | stress **=** stress **+** dstress | | | | | | | | |
| 447 |  | c **=** c **+** dq**/**Xi | | | | | | | | |
| 448 |  | dlam **=** dlam **+** ddlam | | | | | | | | |
| 449 |  | q **=** q **+** dq | | | | | | | | |
| 450 |  | k **=** k **+** 1 | | | | | | | | |
| 451 | c | ! | | | | | | | | |
| 452 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | | |
| 453 | c | ! Calcula deformação plástica equivalente ! | | | | | | | | |
| 454 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | | |
| 455 |  | **call** matinv**(**ncomp**,**dsdeEl**,**dsdeElinv**)** | | | | | | | | |
| 456 |  | depsEP **=** depsEP**-MATMUL(**dsdeElinv**,**dstress**)** | | | | | | | | |
| 457 | c | ! | | | | | | | | |
| 458 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | | |
| 459 | c | ! Verifica critério de escoamento ! | | | | | | | | |
| 460 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | | |
| 461 |  | **CALL** invars**(**stress**,**ncomp**,**I1**,**J2**,**J3**,**theta**,**s**)** | | | | | | | | |
| 462 |  | **CALL** yield**(**superficief**,**I1**,**J2**,**theta**,**c**,**fi**,**f**)** | | | | | | | | |
| 463 |  | **IF(**f.LE.tolEP**)EXIT** | | | | | | | | |
| 464 | c | ! | | | | | | | | |
| 465 | c | ! Caso atinja o número de iterações limites, faça a bisseção | | | | | | | | |
| 466 |  | **IF(**k.EQ.nrmax**)THEN** | | | | | | | | |
| 467 |  | keycut **=** 1 | | | | | | | | |
| 468 |  | **RETURN** | | | | | | | | |
| 469 |  | **ENDIF** | | | | | | | | |
| 470 |  | **ENDDO** | | | | | | | | |
| 471 | c | ! | | | | | | | | |
| 472 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | | |
| 473 | c | ! Atualizando o módulo constitutivo ! | | | | | | | | |
| 474 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | | |
| 475 |  | **IF(**dalg.EQ.1**)THEN** | | | | | | | | |
| 476 |  | dfds\_m**(**1**,:) =** dfds | | | | | | | | |
| 477 |  | dgds\_m**(:,**1**) =** dgds | | | | | | | | |
| 478 |  | DgftD**= MATMUL(MATMUL(MATMUL(**dsdeEl**,**dgds\_m**),**dfds\_m**),**dsdeEl**)** | | | | | | | | |
| 479 |  | dsdePl **=** dsdePl **-** DgftD**/(**ftDg **-** dfdq**\***dhdq**)** | | | | | | | | |
| 480 |  | **ENDIF** | | | | | | | | |
| 481 | c | ! | | | | | | | | |
| 482 |  | **ELSE** | | | | | | | | |
| 483 |  | depsEp **=** 0.0d0 | | | | | | | | |
| 484 |  | **ENDIF** | | | | | | | | |
| 485 | c | ! | | | | | | | | |
| 486 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | | |
| 487 | c | ! Guardando deformações plásticas totais ! | | | | | | | | |
| 488 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | | |
| 489 | c | ! | | | | | | | | |
| 490 | c | ! Calcula as deformações plásticas totais | | | | | | | | |
| 491 |  | epsEP **=** epsEP **+** depsEP | | | | | | | | |
| 492 |  | **CALL** normatensor**(**epsEP**,**ncomp**,**epsEPeq**)** | | | | | | | | |
| 493 |  | **CALL** calcula\_Czao**(**superficief**,**fi**,**Czao**)** | | | | | | | | |
| 494 |  | epsEPeq **=** Czao**\***epsEPeq | | | | | | | | |
| 495 | c | ! | | | | | | | | |
| 496 | c | ! Retorna as deformações inelasticas totais e equivalentes (só tem plásticas) | | | | | | | | |
| 497 |  | epsPl **=** epsEP**+**epsVP | | | | | | | | |
| 498 |  | epseq **=** epsEPeq**+**epsVPeq | | | | | | | | |
| 499 | c | ! | | | | | | | | |
| 500 | c | ! Calcula o trabalho elástico | | | | | | | | |
| 501 |  | sedEl **=** 0.0d0 | | | | | | | | |
| 502 |  | sedEl **=** 1.0d0**/**2.0d0**\*** | | | | | | | | |
| 503 |  | & **DOT\_PRODUCT(**stress**,**strain**+**dstrain**-**epsPl**-**epsVP**)** | | | | | | | | |
| 504 | c | ! | | | | | | | | |
| 505 | c | ! | | | | | | | | |
| 506 | c | ! Calcula o trabalho inelástico (só tem plástico) | | | | | | | | |
| 507 |  | **CALL** normatensor**(**depsEP**,**ncomp**,**depsEPeq**)** | | | | | | | | |
| 508 |  | **CALL** calcula\_Czao**(**superficief**,**fi**,**Czao**)** | | | | | | | | |
| 509 |  | depsEPeq **=** Czao**\***depsEPeq | | | | | | | | |
| 510 |  | **CALL** normatensor**(**depsVP**,**ncomp**,**depsVPeq**)** | | | | | | | | |
| 511 |  | **CALL** calcula\_Czao**(**superficief**,**fi**,**Czao**)** | | | | | | | | |
| 512 |  | | depsVPeq **=** Czao**\***depsVPeq | | | | | | |
| 513 |  | | sedPl **=** sedPl **+ (**q**)\***depsEPeq**+**depsVPeq | | | | | | |
| 514 | c | | ! | | | | | | |
| 515 | c | | ! Guarda valores nas variáveis de estado | | | | | | |
| 516 |  | | ustatev**(**1**) =** epsEPeq | | | | | | |
| 517 |  | | ustatev**(**2**) =** dlam | | | | | | |
| 518 |  | | ustatev**(**3**) =** c | | | | | | |
| 519 |  | | ustatev**(**4**) =** q | | | | | | |
| 520 |  | | ustatev**(**5**) =** f | | | | | | |
| 521 |  | | ustatev**(**6**) =** epsVPeq | | | | | | |
| 522 |  | | ustatev**(**7**) =** dt1 | | | | | | |
| 523 |  | | ustatev**(**8**) =** dt2 | | | | | | |
| 524 |  | | **CALL** vmove**(**epsEP**(**1**),** ustatev**(**9**),** ncomp**)** | | | | | | |
| 525 |  | | **CALL** vmove**(**epsVP**(**1**),** ustatev**(**15**),** ncomp**)** | | | | | | |
| 526 | c | | ! | | | | | | |
| 527 |  | | **RETURN** | | | | | | |
| 528 |  | | **END** | | | | | | |
| 529 |  | | ! | | | | | | |
| 530 |  | | **SUBROUTINE** matrizD**(**E**,**Poisson**,**ncomp**,**D**)** | | | | | | |
| 531 | c | | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | |
| 532 | c | | !\*\* Função: matrizD \*\*! | | | | | | |
| 533 | c | | !\*\* \*\*! | | | | | | |
| 534 | c | | !\*\* Objetivo: calcula a matriz consitutiva do material isotrópico \*\*! | | | | | | |
| 535 | c | | !\*\* adaptado de Smith, Griffiths e Margetts (2014, p.42-44) \*\*! | | | | | | |
| 536 | c | | !\*\* \*\*! | | | | | | |
| 537 | c | | !\*\* Situação: (28-09-2016) OK \*\*! | | | | | | |
| 538 | c | | !\*\* \*\*! | | | | | | |
| 539 | c | | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | |
| 540 |  | | **IMPLICIT NONE** | | | | | | |
| 541 |  | | **DOUBLE PRECISION** E ! módulo de elasticidade | | | | | | |
| 542 |  | | **DOUBLE PRECISION** Poisson ! coeficiente de Poisson | | | | | | |
| 543 |  | | **INTEGER** ncomp ! numero de componentes | | | | | | |
| 544 |  | | **DOUBLE PRECISION** D**(**ncomp**,**ncomp**)** ! matriz constitutiva elástica isotrópica | | | | | | |
| 545 | c | | ! | | | | | | |
| 546 |  | | D=0.1d0 | | | | | | |
| 547 |  | | D(1,1)**=(**E**\*(**1.0d0**-**Poisson**))/((**1.0d0**+**Poisson**)\*(**1.0d0**-**2.0d0**\***Poisson**))** | | | | | | |
| 548 |  | | D(1,2)**=(**E**\***Poisson**)/((**1.0d0**+**Poisson**)\*(**1.0d0**-**2.0d0**\***Poisson**))** | | | | | | |
| 549 |  | | D(1,3)**=**D**(**1**,**2**)** | | | | | | |
| 550 |  | | D(2,1)**=**D**(**1**,**2**)** | | | | | | |
| 551 |  | | D(2,2)**=**D**(**1**,**1**)** | | | | | | |
| 552 |  | | D(2,3)**=**D**(**1**,**2**)** | | | | | | |
| 553 |  | | D(3,1)**=**D**(**1**,**3**)** | | | | | | |
| 554 |  | | D(3,2)**=**D**(**2**,**3**)** | | | | | | |
| 555 |  | | D(3,3)**=**D**(**1**,**1**)** | | | | | | |
| 556 |  | | D(4,4)**=(**E**)/((**1.0d0**+**Poisson**)\***2.0d0**)** | | | | | | |
| 557 | c | | ! | | | | | | |
| 558 |  | | **IF(**ncomp.EQ.6**)THEN** | | | | | | |
| 559 |  | | D**(**ncomp**-**1**,**ncomp**-**1**)=**D**(**4**,**4**)** | | | | | | |
| 560 |  | | D(ncomp**,**ncomp**)=**D**(**4**,**4**)** | | | | | | |
| 561 |  | | **ENDIF** | | | | | | |
| 562 | c | | ! | | | | | | |
| 563 |  | | **END SUBROUTINE** MatrizD | | | | | | |
| 564 | c | | ! | | | | | | |
| 565 |  | | **SUBROUTINE** invars**(**stress**,**ncomp**,**I1**,**J2**,**J3**,**theta**,**s**)** | | | | | | |
| 566 | c | | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | |
| 567 | c | | !\*\* Subrotina: invars \*\*! | | | | | | |
| 568 | c | | !\*\* \*\*! | | | | | | |
| 569 | c | | !\*\* Objetivo: calcula os invariantes do tensor de tensões e o tensor \*\*! | | | | | | |
| 570 | c | | !\*\* desviador. Adaptado de Chen e Han (1998, p.57-72) \*\*! | | | | | | |
| 571 | c | | !\*\* \*\*! | | | | | | |
| 572 | c | | !\*\* Situação: (10-11-2021) OK \*\*! | | | | | | |
| 573 | c | | !\*\* \*\*! | | | | | | |
| 574 | c | | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | |
| 575 |  | | **IMPLICIT NONE** | | | | | | |
| 576 |  | | **DOUBLE PRECISION** stress**(**ncomp**)** ! tensões | | | | | | |
| 577 |  | | **INTEGER** ncomp ! numero de componentes | | | | | | |
| 578 |  | | **DOUBLE PRECISION** I1 ! primeiro invariante do tensor de tensões | | | | | | |
| 579 |  | | **DOUBLE PRECISION** J2**,**J3 ! segundo e terceiro invariante do desviador | | | | | | |
| 580 |  | | **DOUBLE PRECISION** theta ! angulo de Lode | | | | | | |
| 581 |  | | **DOUBLE PRECISION** s**(**6**)** ! desviador | | | | | | |
| 582 |  | | **DOUBLE PRECISION** p**,**q ! pressão hidrostática e tensão eq. de vm | | | | | | |
| 583 |  | | **DOUBLE PRECISION** sine ! variavel auxiliar | | | | | | |
| 584 | c | | ! | | | | | | |
| 585 | c | ! Inicializando | | | | variaveis | | | |
| 586 |  | I1 **=** 0.0d0 | | | |  | | | |
| 587 |  | J2 **=** 0.0d0 | | | |  | | | |
| 588 |  | p **=** 0.0d0 | | | |  | | | |
| 589 |  | q **=** 0.0d0 | | | |  | | | |
| 590 |  | s **=** 0.0d0 | | | |  | | | |
| 591 |  | J3 **=** 0.0d0 | | | |  | | | |
| 592 |  | theta **=** 0.0d0 | | | |  | | | |
| 593 |  | sine **=** 0.0d0 | | | |  | | | |
| 594 | c | ! | | | |  | | | |
| 595 | c | ! Calculo do I1 | | | | (p. 53) | | | |
| 596 |  | I1 **=** stress**(**1**) +** stress**(**2**) +** stress**(**3**)** | | | | | | | |
| 597 | c | ! | | | | | | | |
| 598 | c | ! Calculo do J2 (p. 58) | | | | | | | |
| 599 |  | J2 **=** 1**/**6.0d0**\*((**stress**(**1**)-**stress**(**2**))\*\***2**+(**stress**(**2**)-**stress**(**3**))\*\***2**+** | | | | | | | |
| 600 |  | & **(**stress**(**3**)-**stress**(**1**))\*\***2**)+** | | | | | | | |
| 601 |  | & stress**(**4**)\*\***2 | | | | | | | |
| 602 | c | ! | | | | | | | |
| 603 |  | **IF(**ncomp.EQ.6**)THEN** | | | | | | | |
| 604 |  | J2 **=** J2 **+** stress**(**ncomp**-**1**)\*\***2**+**stress**(**ncomp**)\*\***2 | | | | | | | |
| 605 |  | **ENDIF** | | | | | | | |
| 606 | c | ! | | | | | | | |
| 607 | c | ! Calculo do p (p. 57) | | | | | | | |
| 608 |  | p **=** 1.0d0**/**3.0d0**\***I1 | | | | | | | |
| 609 | c | ! | | | | | | | |
| 610 | c | ! Calculo do desviador s (p. 57) | | | | | | | |
| 611 |  | s**(**1**) =** stress**(**1**) -** p | | | | | | | |
| 612 |  | s**(**2**) =** stress**(**2**) -** p | | | | | | | |
| 613 |  | s**(**3**) =** stress**(**3**) -** p | | | | | | | |
| 614 |  | s**(**4**) =** stress**(**4**)** | | | | | | | |
| 615 |  | **IF(**ncomp.EQ.6**)THEN** | | | | | | | |
| 616 |  | s**(**ncomp**-**1**) =** stress**(**ncomp**-**1**)** | | | | | | | |
| 617 |  | s**(**ncomp**) =** stress**(**ncomp**)** | | | | | | | |
| 618 |  | **ENDIF** | | | | | | | |
| 619 | c | ! | | | | | | | |
| 620 | c | ! Calculo do J3 (p. 58) | | | | | | | |
| 621 |  | J3 **=** s**(**1**)\***s**(**2**)\***s**(**3**)-**s**(**3**)\***s**(**4**)\***s**(**4**)** | | | | | | | |
| 622 |  | **IF(**ncomp.EQ.6**)THEN** | | | | | | | |
| 623 |  | J3 **=** J3 **-**s**(**1**)\***s**(**ncomp**-**1**)\***s**(**ncomp**-**1**)-**s**(**2**)\***s**(**ncomp**)\***s**(**ncomp**)+** | | | | | | | |
| 624 |  | & 2.0d0**\***s**(**4**)\***s**(**ncomp**-**1**)\***s**(**ncomp**)** | | | | | | | |
| 625 |  | **ENDIF** | | | | | | | |
| 626 | c | ! | | | | | | | |
| 627 | c | ! Calculo do ângulo de Lode (p. 70) e Owen e Hinton (1980, p.229) | | | | | | | |
| 628 |  | q **= DSQRT(**3.0d0**\***J2**)** | | | | | | | |
| 629 |  | **IF(**q **<** 1.E**-**7**)THEN** | | | | | | | |
| 630 |  | theta **=** 0.0d0 | | | | | | | |
| 631 |  | **ELSE** | | | | | | | |
| 632 |  | sine **= -**3.0d0**\*DSQRT(**3.0d0**)\***J3**/(**2.0d0**\*DSQRT(**J2**)\*\***3**)** | | | | | | | |
| 633 |  | **IF(**sine**>**1.0d0**)**sine**=**1.0d0 | | | | | | | |
| 634 |  | **IF(**sine**<-**1.0d0**)**sine**=-**1.0d0 | | | | | | | |
| 635 |  | theta**=DASIN(**sine**)/**3.0d0 | | | | | | | |
| 636 |  | **END IF** | | | | | | | |
| 637 | c | ! | | | | | | | |
| 638 |  | **END SUBROUTINE** | | | | | | | |
| 639 | c | ! | | | | | | | |
| 640 |  | **SUBROUTINE** g1g2g3**(**s**,**ncomp**,**J2**,**g1**,**g2**,**g3**)** | | | | | | | |
| 641 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 642 | c | !\*\* Subrotina: g1g2g3 \*\*! | | | | | | | |
| 643 | c | !\*\* \*\*! | | | | | | | |
| 644 | c | !\*\* Objetivo: calcula as direções do vetor de fluxo. Adaptado de Owen e \*\*! | | | | | | | |
| 645 | c | !\*\* Hinton (1980, p.231 e 233) \*\*! | | | | | | | |
| 646 | c | !\*\* \*\*! | | | | | | | |
| 647 | c | !\*\* Situação: (10-11-2021) OK \*\*! | | | | | | | |
| 648 | c | !\*\* \*\*! | | | | | | | |
| 649 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 650 |  | **IMPLICIT NONE** | | | | | | | |
| 651 |  | **DOUBLE PRECISION** s**(**ncomp**)** ! desviador | | | | | | | |
| 652 |  | **INTEGER** ncomp ! numero de componentes | | | | | | | |
| 653 |  | **DOUBLE PRECISION** J2 ! segundo invariante do desviador | | | | | | | |
| 654 |  | **DOUBLE PRECISION** g1**(**ncomp**),** g2**(**ncomp**),** g3**(**ncomp**)** | | | | | | | |
| 655 | c | ! | | | | | | | |
| 656 | c | ! Inicializando variaveis | | | | | | | |
| 657 |  | g1 **=** 0.0d0 | | | | | | | |
| 658 |  | | g2 **=** 0.0d0 | | | | | | |
| 659 |  | | g3 **=** 0.0d0 | | | | | | |
| 660 | c | | ! | | | | | | |
| 661 | c | | ! Calculo do g1 | | | | | | |
| 662 |  | | g1**(**1**) =** 1.0d0 | | | | | | |
| 663 |  | | g1**(**2**) =** 1.0d0 | | | | | | |
| 664 |  | | g1**(**3**) =** 1.0d0 | | | | | | |
| 665 | c | | ! | | | | | | |
| 666 | c | | ! Calculo do g2 | | | | | | |
| 667 |  | | g2**(**1**) =** s**(**1**)** | | | | | | |
| 668 |  | | g2**(**2**) =** s**(**2**)** | | | | | | |
| 669 |  | | g2**(**3**) =** s**(**3**)** | | | | | | |
| 670 |  | | g2**(**4**) =** 2.0d0**\***s**(**4**)** | | | | | | |
| 671 |  | | **IF(**ncomp.EQ.6**)THEN** | | | | | | |
| 672 |  | | g2**(**ncomp**-**1**) =** 2.0d0**\***s**(**ncomp**-**1**)** | | | | | | |
| 673 |  | | g2**(**ncomp**) =** 2.0d0**\***s**(**ncomp**)** | | | | | | |
| 674 |  | | **ENDIF** | | | | | | |
| 675 |  | | **IF(**J2.EQ.0.0d0**)THEN** | | | | | | |
| 676 |  | | g2 **=** 0.0d0 | | | | | | |
| 677 |  | | **ELSE** | | | | | | |
| 678 |  | | g2 **=** 1.0d0**/(**2.0d0**\*DSQRT(**J2**))\***g2 | | | | | | |
| 679 |  | | **ENDIF** | | | | | | |
| 680 | c | | ! | | | | | | |
| 681 | c | | ! Calculo do g3 | | | | | | |
| 682 |  | | g3**(**1**) =** s**(**2**)\***s**(**3**) +** J2**/**3.0d0 | | | | | | |
| 683 |  | | g3**(**2**) =** s**(**1**)\***s**(**3**) +** J2**/**3.0d0 | | | | | | |
| 684 |  | | g3**(**3**) =** s**(**1**)\***s**(**2**) -** s**(**4**)\*\***2 **+** J2**/**3.0d0 | | | | | | |
| 685 |  | | g3**(**4**) =** 2.0d0**\*(-**s**(**3**)\***s**(**4**))** | | | | | | |
| 686 |  | | **IF(**ncomp.EQ.6**)THEN** | | | | | | |
| 687 |  | | g3**(**1**) =** g3**(**1**) -** s**(**ncomp**-**1**)\*\***2 | | | | | | |
| 688 |  | | g3**(**2**) =** g3**(**2**) -** s**(**ncomp**)\*\***2 | | | | | | |
| 689 |  | | g3**(**4**) =** g3**(**4**) +** 2.0d0**\***s**(**ncomp**-**1**)\***s**(**ncomp**)** | | | | | | |
| 690 |  | | g3**(**ncomp**-**1**) =** 2.0d0**\*(**s**(**ncomp**)\***s**(**4**)-**s**(**1**)\***s**(**ncomp**-**1**))** | | | | | | |
| 691 |  | | g3**(**ncomp**) =** 2.0d0**\*(**s**(**4**)\***s**(**ncomp**-**1**)-**s**(**2**)\***s**(**ncomp**))** | | | | | | |
| 692 |  | | **ENDIF** | | | | | | |
| 693 | c | | ! | | | | | | |
| 694 |  | | **END SUBROUTINE** | | | | | | |
| 695 | c | | ! | | | | | | |
| 696 | c | | ! | | | | | | |
| 697 |  | | **SUBROUTINE** c1c2c3**(**J2**,**theta**,**superficie**,**fi**,**c1**,**c2**,**c3**)** | | | | | | |
| 698 | c | | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | |
| 699 | c | | !\*\* Subrotina: c1c2c3 \*\*! | | | | | | |
| 700 | c | | !\*\* \*\*! | | | | | | |
| 701 | c | | !\*\* Objetivo: calcula a magnitude das componentes do vetor de fluxo. \*\*! | | | | | | |
| 702 | c | | !\*\* Adaptado de Bernaud (1991, p.90, 91) \*\*! | | | | | | |
| 703 | c | | !\*\* Adaptado de Owen e Hinton (1980, p.231) \*\*! | | | | | | |
| 704 | c | | !\*\* \*\*! | | | | | | |
| 705 | c | | !\*\* Situação: (10-11-2021) OK \*\*! | | | | | | |
| 706 | c | | !\*\* \*\*! | | | | | | |
| 707 | c | | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | |
| 708 |  | | **IMPLICIT NONE** | | | | | | |
| 709 |  | | **DOUBLE PRECISION** J2 ! segundo invariante do desviador | | | | | | |
| 710 |  | | **DOUBLE PRECISION** theta ! ângulo de Lode | | | | | | |
| 711 |  | | **DOUBLE PRECISION** fi ! Ângulo de atrito | | | | | | |
| 712 |  | | **INTEGER** superficie ! 1-DPI, 2-DPII, 3-DPIII | | | | | | |
| 713 |  | | **DOUBLE PRECISION** c1**,**c2**,**c3 ! magnitude das componentes do vetor | | | | | | |
| 714 |  | | **DOUBLE PRECISION** beta1**,**beta2**,**beta3 ! parâmetros do DP | | | | | | |
| 715 |  | | **DOUBLE PRECISION** k ! coeficiente de empuxo | | | | | | |
| 716 | c | | ! | | | | | | |
| 717 | c | | ! Seleciona o modelo | | | | | | |
| 718 |  | | **SELECT CASE (**superficie**)** | | | | | | |
| 719 |  | | **CASE(**1**)** | | | | | | |
| 720 | c | | ! | | | | | | |
| 721 | c | | ! DPI | | | | | | |
| 722 |  | | k **= (**1.0d0**+DSIN(**fi**))/(**1.0d0**-DSIN(**fi**))** | | | | | | |
| 723 |  | | c1 **= (**k**-**1.0d0**)/**3.0d0 | | | | | | |
| 724 |  | | c2 **= (**k**+**2.0d0**)/DSQRT(**3.0d0**)** | | | | | | |
| 725 |  | | c3 **=** 0.0d0 | | | | | | |
| 726 | c | | ! | | | | | | |
| 727 |  | | **CASE(**2**)** | | | | | | |
| 728 | c | | ! | | | | | | |
| 729 | c | | ! DPII | | | | | | |
| 730 |  | | k **= (**1.0d0**+DSIN(**fi**))/(**1.0d0**-DSIN(**fi**))** | | | | | | |
| 731 |  | | c1 **= (**k**-**1.0d0**)/**3.0d0 | | | | | | | | |
| 732 |  | | c2 **= (**2.0d0**\***k**+**1.0d0**)/DSQRT(**3.0d0**)** | | | | | | | | |
| 733 |  | | c3 **=** 0.0d0 | | | | | | | | |
| 734 | c | | ! | | | | | | | | |
| 735 |  | | **CASE(**3**)** | | | | | | | | |
| 736 | c | | ! | | | | | | | | |
| 737 | c | | ! DPIII - Owen e Hinton (1980, p.231) | | | | | | | | |
| 738 |  | | c1 **=** 2.0d0**\*DSIN(**fi**)/(DSQRT(**3.0d0**)\*(**3.0d0**+DSIN(**fi**)))** | | | | | | | | |
| 739 |  | | c2 **=** 1.0d0 | | | | | | | | |
| 740 |  | | c3 **=** 0.0d0 | | | | | | | | |
| 741 | c | | ! | | | | | | | | |
| 742 |  | | **ENDSELECT** | | | | | | | | |
| 743 |  | | **END SUBROUTINE** | | | | | | | | |
| 744 | c | | ! | | | | | | | | |
| 745 |  | | **SUBROUTINE** yield**(**superficie**,**I1**,**J2**,**theta**,**c**,**fi**,**f**)** | | | | | | | | |
| 746 | c | | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | | |
| 747 | c | | !\*\* Subrotina: yield \*\*! | | | | | | | | |
| 748 | c | | !\*\* \*\*! | | | | | | | | |
| 749 | c | | !\*\* Objetivo: calcula o critério de escoamento. \*\*! | | | | | | | | |
| 750 | c | | !\*\* Adaptado de Bernaud (1991, p.90, 91) \*\*! | | | | | | | | |
| 751 | c | | !\*\* Adaptado de Souza Neto, Peri, Owen (2008, p. 162-167) \*\*! | | | | | | | | |
| 752 | c | | !\*\* \*\*! | | | | | | | | |
| 753 | c | | !\*\* Situação: (10-11-2021) OK \*\*! | | | | | | | | |
| 754 | c | | !\*\* \*\*! | | | | | | | | |
| 755 | c | | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | | |
| 756 |  | | **IMPLICIT NONE** | | | | | | | | |
| 757 |  | | **INTEGER** superficie ! 1-DPI, 2-DPII, 3-DPIII | | | | | | | | |
| 758 |  | | **DOUBLE PRECISION** I1 ! primeiro invariante do tensor de tensões | | | | | | | | |
| 759 |  | | **DOUBLE PRECISION** J2 ! segundo invariante do desviador | | | | | | | | |
| 760 |  | | **DOUBLE PRECISION** theta ! ângulo de Lode | | | | | | | | |
| 761 |  | | **DOUBLE PRECISION** c ! coesão | | | | | | | | |
| 762 |  | | **DOUBLE PRECISION** fi ! Ângulo de atrito | | | | | | | | |
| 763 |  | | **DOUBLE PRECISION** f ! função de escoamento | | | | | | | | |
| 764 |  | | **DOUBLE PRECISION** beta1**,**beta2**,**beta3 ! Parametros para DP | | | | | | | | |
| 765 |  | | **DOUBLE PRECISION** k ! coeficiente de empuxo | | | | | | | | |
| 766 | c | | ! | | | | | | | | |
| 767 | c | | ! Seleciona o modelo | | | | | | | | |
| 768 |  | | **SELECT CASE (**superficie**)** | | | | | | | | |
| 769 |  | | **CASE(**1**)** | | | | | | | | |
| 770 | c | | ! | | | | | | | | |
| 771 | c | | ! DPI | | | | | | | | |
| 772 |  | | k **= (**1.0d0**+DSIN(**fi**))/(**1.0d0**-DSIN(**fi**))** | | | | | | | | |
| 773 |  | | beta1 **= (**k**-**1.0d0**)/**3.0d0 | | | | | | | | |
| 774 |  | | beta2 **= (**k**+**2.0d0**)/DSQRT(**3.0d0**)** | | | | | | | | |
| 775 |  | | beta3 **=** 2.0d0**\*DSQRT(**k**)\***c | | | | | | | | |
| 776 |  | | f **=** beta1**\***I1 **+** beta2**\*DSQRT(**J2**)-**beta3 | | | | | | | | |
| 777 | c | | ! | | | | | | | | |
| 778 |  | | **CASE(**2**)** | | | | | | | | |
| 779 | c | | ! | | | | | | | | |
| 780 | c | | ! DPII | | | | | | | | |
| 781 |  | | k **= (**1.0d0**+DSIN(**fi**))/(**1.0d0**-DSIN(**fi**))** | | | | | | | | |
| 782 |  | | beta1 **= (**k**-**1.0d0**)/**3.0d0 | | | | | | | | |
| 783 |  | | beta2 **= (**2.0d0**\***k**+**1.0d0**)/DSQRT(**3.0d0**)** | | | | | | | | |
| 784 |  | | beta3 **=** 2.0d0**\*DSQRT(**k**)\***c | | | | | | | | |
| 785 |  | | f **=** beta1**\***I1 **+** beta2**\*DSQRT(**J2**)-**beta3 | | | | | | | | |
| 786 | c | | ! | | | | | | | | |
| 787 |  | | **CASE(**3**)** | | | | | | | | |
| 788 | c | | ! | | | | | | | | |
| 789 | c | | ! DPIII Souza Neto, Peri, Owen (2008, p. 162-167) | | | | | | | | |
| 790 |  | | beta1 **=** 2.0d0**\*DSIN(**fi**)/(DSQRT(**3.0d0**)\*(**3.0d0**+DSIN(**fi**)))** | | | | | | | | |
| 791 |  | | beta2 **=** 1.0d0 | | | | | | | | |
| 792 |  | | beta3 **=** 6.0d0**\*DCOS(**fi**)/(DSQRT(**3.0d0**)\*(**3.0d0**+DSIN(**fi**)))\***c | | | | | | | | |
| 793 |  | | f **=** beta1**\***I1 **+** beta2**\*DSQRT(**J2**)-**beta3 | | | | | | | | |
| 794 | c | | ! | | | | | | | | |
| 795 |  | | **ENDSELECT** | | | | | | | | |
| 796 |  | | **END SUBROUTINE** | | | | | | | | |
| 797 | c | | ! | | | | | | | | |
| 798 |  | | **subroutine** matinv**(**n**,**a**,**ainv**)** | | | | | | | | |
| 799 | c | | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | | |
| 800 | c | | !\*\* Subrotina: matinv \*\*! | | | | | | | | |
| 801 | c | | !\*\* \*\*! | | | | | | | | |
| 802 | c | | !\*\* Objetivo: inverte uma matriz pela técnica de pivotamento \*\*! | | | | | | | | |
| 803 | c | | !\*\* \*\*! | | | | | | | | |
| 804 | c | | !\*\* Situação: (26-10-2016) OK | | | | \*\*! | | |
| 805 | c | | !\*\* | | | | \*\*! | | |
| 806 | c | | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | |
| 807 |  | | **INTEGER** n ! dimensão do sistema | | | | | | |
| 808 |  | | **DOUBLE PRECISION** a**(**n**,**n**)** ! matriz dos coeficientes | | | | | | |
| 809 |  | | **DOUBLE PRECISION** ainv**(**n**,**n**)** ! matriz inversa | | | | | | |
| 810 |  | | **DOUBLE PRECISION** b**(**n**,**2**\***n**)** ! matriz aumentada | | | | | | |
| 811 |  | | **DOUBLE PRECISION** pivot ! pivô | | | | | | |
| 812 |  | | **DOUBLE PRECISION** xnum ! auxiliar | | | | | | |
| 813 |  | | **INTEGER** i**,**j**,**k ! contador | | | | | | |
| 814 | c | | ! | | | | | | |
| 815 | c | | ! Fazer matriz aumentada | | | | | | |
| 816 |  | | **do** i**=**1**,**n | | | | | | |
| 817 |  | | **do** j**=**1**,**n | | | | | | |
| 818 |  | | b**(**i**,**j**) =** 0.0d0 | | | | | | |
| 819 |  | | b**(**i**,**j**+**n**) =** 0.0d0 | | | | | | |
| 820 |  | | b**(**i**,**j**)=**a**(**i**,**j**)** | | | | | | |
| 821 |  | | **if(**i.eq.j**)then** | | | | | | |
| 822 |  | | b**(**i**,**j**+**n**)=**1.0d0 | | | | | | |
| 823 |  | | **endif** | | | | | | |
| 824 |  | | **enddo** | | | | | | |
| 825 |  | | **enddo** | | | | | | |
| 826 | c | | ! | | | | | | |
| 827 |  | | **do** | | i**=**1**,**n | |  |  |  |
| 828 | c | |  | | ! Escolher o elemento não nulo mais | | a esquerda | como | pivot |
| 829 |  | |  | | **do** j**=**1**,**n | |  |  |  |
| 830 |  | |  | | **if (dabs(**b**(**i**,**j**))**.gt.0.0d0**)then** | |  |  |  |
| 831 |  | |  | | pivot**=**b**(**i**,**j**)** | |  |  |  |
| 832 |  | |  | | **exit** | |  |  |  |
| 833 |  | |  | | **endif** | |  |  |  |
| 834 |  | |  | | **enddo** | |  |  |  |
| 835 | c | |  | | ! | |  |  |  |
| 836 | c | |  | | ! Passo 1: alterar o pivo escolhido | |  |  |  |
| 837 |  | |  | | **do** j**=**1**,**2**\***n | |  |  |  |
| 838 |  | |  | | b**(**i**,**j**)=**b**(**i**,**j**)/**pivot | |  |  |  |
| 839 |  | | **enddo** | | | | | | |
| 840 |  | | pivot**=**b**(**i**,**i**)** | | | | | | |
| 841 | c | | ! | | | | | | |
| 842 | c | | ! Passo 2: mudando o restante da coluno do pivo para 0, | | | | | | |
| 843  844 | c | | adicionando a cada linha um multiplo adequado do pivot  **do** k**=**1**,**n | | | | | | |
| 845 |  | | **if(**k.ne.i**)then** | | | | | | |
| 846 |  | | xnum**=**b**(**k**,**i**)/**pivot | | | | | | |
| 847 |  | | **do** j**=**1**,**2**\***n | | | | | | |
| 848 |  | | b**(**k**,**j**)=**b**(**k**,**j**)-**xnum**\***b**(**i**,**j**)** | | | | | | |
| 849 |  | | **enddo** | | | | | | |
| 850 |  | | **endif** | | | | | | |
| 851 |  | | **enddo** | | | | | | |
| 852 |  | | **enddo** | | | | | | |
| 853 | c | | ! | | | | | | |
| 854 | c | | ! Prepara a matriz inversa final | | | | | | |
| 855 |  | | **do** i**=**1**,**n | | | | | | |
| 856 |  | | **do** j**=**1**,**n | | | | | | |
| 857 |  | | ainv**(**i**,**j**)=**b**(**i**,**j**+**n**)** | | | | | | |
| 858 |  | | **enddo** | | | | | | |
| 859 |  | | **enddo** | | | | | | |
| 860 |  | | **return** | | | | | | |
| 861 |  | | **end** | | | | | | |
| 862 | c | | ! | | | | | | |
| 863 |  | | **SUBROUTINE** normatensor**(**tensor**,**ncomp**,**norma**)** | | | | | | |
| 864 | c | | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | |
| 865 | c | | !\*\* Subrotina: normatensor \*\*! | | | | | | |
| 866 | c | | !\*\* \*\*! | | | | | | |
| 867 | c | | !\*\* Objetivo: calcula a norma de um tensor escrito em notação de Voigt \*\*! | | | | | | |
| 868 | c | | !\*\* \*\*! | | | | | | |
| 869 | c | | !\*\* Situação: (10-11-2021) OK \*\*! | | | | | | |
| 870 | c | | !\*\* \*\*! | | | | | | |
| 871 | c | | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | |
| 872 |  | | **IMPLICIT NONE** | | | | | | |
| 873 |  | | **INTEGER** ncomp | | | | | | |
| 874 |  | | **DOUBLE PRECISION** tensor**(**ncomp**)** | | | | | | |
| 875 |  | | **DOUBLE PRECISION** norma | | | | | | |
| 876 | c | | ! | | | | | | |
| 877 |  | | | **IF(**ncomp.EQ.6**)THEN** | | | | | |
| 878 |  | | | norma **= DSQRT(**tensor**(**1**)\*\***2 **+** tensor**(**2**)\*\***2 **+** tensor**(**3**)\*\***2 **+** | | | | | |
| 879 | & | | | 2**\*((**tensor**(**4**))\*\***2 **+** | | | | | |
| 880 | & | | | **(**tensor**(**5**))\*\***2 **+ (**tensor**(**6**))\*\***2**))** | | | | | |
| 881 |  | | | **ELSEIF(**ncomp.EQ.4**)THEN** | | | | | |
| 882 |  | | | norma **= DSQRT(**tensor**(**1**)\*\***2 **+** tensor**(**2**)\*\***2 **+** tensor**(**3**)\*\***2 **+** | | | | | |
| 883 | & | | | 2**\*(**tensor**(**4**)\*\***2**))** | | | | | |
| 884 |  | | | **ELSE** | | | | | |
| 885 |  | **ENDIF** | | | | | | | |
| 886 | c | ! | | | | | | | |
| 887 |  | **END SUBROUTINE** | | | | | | | |
| 888 | c | ! | | | | | | | |
| 889 |  | **SUBROUTINE** calcula\_Czao**(**superficie**,**fi**,**Czao**)** | | | | | | | |
| 890 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 891 | c | !\*\* Subrotina: Czao \*\*! | | | | | | | |
| 892 | c | !\*\* \*\*! | | | | | | | |
| 893 | c | !\*\* Objetivo: calcula o C utilizado no calculo da deformação plástica \*\*! | | | | | | | |
| 894 | c | !\*\* efetiva. Adaptado de Chen e Han (1988, p. 257-259). \*\*! | | | | | | | |
| 895 | c | !\*\* \*\*! | | | | | | | |
| 896 | c | !\*\* Situação: (10-11-2021) OK \*\*! | | | | | | | |
| 897 | c | !\*\* \*\*! | | | | | | | |
| 898 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 899 |  | **IMPLICIT NONE** | | | | | | | |
| 900 |  | **INTEGER** superficie ! 1-DPI, 2-DPII, 3-DPIII | | | | | | | |
| 901 |  | **DOUBLE PRECISION** fi ! angulo de atrito | | | | | | | |
| 902 |  | **DOUBLE PRECISION** Czao ! constante da deformação plástica efetiva | | | | | | | |
| 903 |  | **DOUBLE PRECISION** beta ! constante referente a pressão hidrostática | | | | | | | |
| 904 | c | ! | | | | | | | |
| 905 | c | ! Seleciona o modelo | | | | | | | |
| 906 |  | **SELECT CASE (**superficie**)** | | | | | | | |
| 907 |  | **CASE(**1**)** | | | | | | | |
| 908 | c | ! | | | | | | | |
| 909 | c | ! DPI | | | | | | | |
| 910 |  | beta **=** 2.0d0**\*DSIN(**fi**)/(DSQRT(**3.0d0**)\*(**3.0d0**-DSIN(**fi**)))** | | | | | | | |
| 911 | c | ! | | | | | | | |
| 912 |  | **CASE(**2**)** | | | | | | | |
| 913 | c | ! | | | | | | | |
| 914 | c | ! DPII | | | | | | | |
| 915 |  | beta **=** 2.0d0**\*DSIN(**fi**)/(DSQRT(**3.0d0**)\*(**3.0d0**+DSIN(**fi**)))** | | | | | | | |
| 916 | c | ! | | | | | | | |
| 917 |  | **CASE(**3**)** | | | | | | | |
| 918 | c | ! | | | | | | | |
| 919 | c | ! DPIII | | | | | | | |
| 920 |  | beta **=** 2.0d0**\*DSIN(**fi**)/(DSQRT(**3.0d0**)\*(**3.0d0**+DSIN(**fi**)))** | | | | | | | |
| 921 | c | ! | | | | | | | |
| 922 |  | **ENDSELECT** | | | | | | | |
| 923 |  | Czao **= (**beta**+**1.0d0**/DSQRT(**3.0d0**))/** | | | | | | | |
| 924 |  | & **(DSQRT(**3.0d0**\***beta**\*\***2**+**1.0d0**/**2.0d0**))** | | | | | | | |
| 925 |  | **END SUBROUTINE** | | | | | | | |
| 926 | c | ! | | | | | | | |
| 927 |  | **SUBROUTINE** calcula\_Xi**(**superficie**,**fi**,**Xi**)** | | | | | | | |
| 928 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 929 | c | !\*\* Subrotina: calcula\_Xi \*\*! | | | | | | | |
| 930 | c | !\*\* \*\*! | | | | | | | |
| 931 | c | !\*\* Objetivo: calcula Xi \*\*! | | | | | | | |
| 932 | c | !\*\* Adaptado de Potts e Zdravkovic (1999, p. 158) \*\*! | | | | | | | |
| 933 | c | !\*\* \*\*! | | | | | | | |
| 934 | c | !\*\* \*\*! | | | | | | | |
| 935 | c | !\*\* Situação: (10-11-2021) OK \*\*! | | | | | | | |
| 936 | c | !\*\* \*\*! | | | | | | | |
| 937 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 938 |  | **IMPLICIT NONE** | | | | | | | |
| 939 |  | **INTEGER** superficie ! 1-DPI, 2-DPII, 3-DPIII | | | | | | | |
| 940 |  | **DOUBLE PRECISION** fi ! angulo de atrito | | | | | | | |
| 941 |  | **DOUBLE PRECISION** Xi ! derivada de f em relação a c | | | | | | | |
| 942 |  | **DOUBLE PRECISION** k ! coeficiente de empuxo | | | | | | | |
| 943 |  | ! | | | | | | | |
| 944 |  | **SELECT CASE(**superficie**)** | | | | | | | |
| 945 |  | **CASE(**1**)** | | | | | | | |
| 946 |  | k **= (**1.0d0**+DSIN(**fi**))/(**1.0d0**-DSIN(**fi**))** | | | | | | | |
| 947 |  | Xi **=** 2.0d0**\*DSQRT(**k**)** | | | | | | | |
| 948 |  | **CASE(**2**)** | | | | | | | |
| 949 |  | k **= (**1.0d0**+DSIN(**fi**))/(**1.0d0**-DSIN(**fi**))** | | | | | | | |
| 950 |  | Xi **=** 2.0d0**\*DSQRT(**k**)** | | | | | | | |
| 951 |  | **CASE(**3**)** | | | | | | | |
| 952 |  | k **= (**1.0d0**+DSIN(**fi**))/(**1.0d0**-DSIN(**fi**))** | | | | | | | |
| 953 |  | Xi **=** 6.0d0**\*DCOS(**fi**)/(DSQRT(**3.0d0**)\*(**3.0d0**+DSIN(**fi**)))** | | | | | | | |
| 954 |  | **END SELECT** | | | | | | | |
| 955 |  | **END SUBROUTINE** | | | | | | | |
| 956 | c | ! | | | | | | | |
| 957 |  | **SUBROUTINE** calcula\_dcde**(**ci**,**cp**,**cr**,**eps1**,**eps2**,**eps3**,**epsPleq**,** | | | | | | | |
| 958 |  | & dcde**)** | | | | | | | |
| 959 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 960 | c | !\*\* Subrotina: calcula\_dcde \*\*! | | | | | | | |
| 961 | c | !\*\* \*\*! | | | | | | | |
| 962 | c | !\*\* Objetivo: calcula dc/de \*\*! | | | | | | | |
| 963 | c | !\*\* Adaptado de Potts e Zdravkovic (1999, p. 158) \*\*! | | | | | | | |
| 964 | c | !\*\* \*\*! | | | | | | | |
| 965 | c | !\*\* Situação: (10-11-2021) OK \*\*! | | | | | | | |
| 966 | c | !\*\* \*\*! | | | | | | | |
| 967 | c | !\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*! | | | | | | | |
| 968 |  | **IMPLICIT NONE** | | | | | | | |
| 969 |  | **DOUBLE PRECISION** ci ! coesão inicial | | | | | | | |
| 970 |  | **DOUBLE PRECISION** cp ! coesão no pico | | | | | | | |
| 971 |  | **DOUBLE PRECISION** cr ! coesão residual | | | | | | | |
| 972 |  | **DOUBLE PRECISION** eps1 ! deformação plastica equivalente 1 | | | | | | | |
| 973 |  | **DOUBLE PRECISION** eps2 ! deformação plastica equivalente 2 | | | | | | | |
| 974 |  | **DOUBLE PRECISION** eps3 ! deformação plastica equivalente 3 | | | | | | | |
| 975 |  | **DOUBLE PRECISION** epsPleq ! deformação plástica equivalente | | | | | | | |
| 976 |  | **DOUBLE PRECISION** dcde ! dc/depsPleq | | | | | | | |
| 977 | c | ! | | | | | | | |
| 978 |  | **IF(**epsPleq.LT.eps1**)THEN** | | | | | | | |
| 979 |  | dcde **= (**cp**-**ci**)/(**eps1**)** | | | | | | | |
| 980 |  | **ELSEIF((**epsPleq.GE.eps1**)**.AND.**(**epsPleq.LE.eps2**))THEN** | | | | | | | |
| 981 |  | dcde **=** 0.0d0 | | | | | | | |
| 982 |  | **ELSEIF((**epsPleq.GT.eps2**)**.AND.**(**epsPleq.LT.eps3**))THEN** | | | | | | | |
| 983 |  | dcde **= (**cr**-**cp**)/(**eps3**-**eps2**)** | | | | | | | |
| 984 |  | **ELSEIF(**epsPleq.GE.eps3**)THEN** | | | | | | | |
| 985 |  | dcde **=** 0.0d0 | | | | | | | |
| 986 |  | **ENDIF** | | | | | | | |
| 987 | c | ! | | | | | | | |
| 988 |  | **END SUBROUTINE** | | | | | | | |
| 989 |  |  | | | | | | | |