ASSIGNMENT 2.2
J2 COMPUTATIONAL PLASTICITY ASSIGNMENT

Appendix:

ASS2_J2_LINEAR_HARDENING_RATE_DEPENDENT.m
ASS2_J2_NON_LINEAR_HARDENING_RATE_DEPENDENT.m

a)For the perfect plasticity models, plot stress11-strain11 and the dev[stress11]-strain11 curves

b)For the linear isotropic /linear kinematic hardening models, plot the stress11-strain11 and dev[stress11]-strain11 curves. *Show influence of the isotropic/kinematic hardening parameters.*

c)For the nonlinear isotropic hardening model, plot stress22-strain11 and dev[stress11]-strain11 curves. *Show influence of the exponential coefficient of the exponential saturation lawe.*

d)For the rate-dependant plasticity models, plot de stress11-strain11, dev[stress-11]-strain11 and the stress11-time and dev[stress11]-time. *Show influence of the viscosity parameter and load rate.*

APPENDIX

```
clc
clear all

 rate_dep="yes";
if rate_dep=="yes"
  eta =1*10^4 ;
  delta_t=1*10^(-2);
else
  eta =0;
  delta_t=1*10^(4);
end

K=0; %tangent modulus (isotropic)
H=0; %plastic modulus (kinematic)
I=eye(3);%Identity second order matrix
fourth_order=ones(3,3,3,3);
II=tensorial_prod(I,I);

nu=0.3;%Poisson
%Bulk parameter
k=1*10^10;
%lammé parameters
Lamda=3*k*nu/(1+nu);%elastic modulus
mu=3*(k-Lamda)/2;%shear modulus


%Constant isotropic elastic constituve tensor
C=Lamda*tensorial_prod(I,I)+2*mu*II; %4th order tensor (E analog)

diag_set={C,0,0;0,K,0;0,0,2*H*I/3};
Su=200 ;
eta = 0.5 ;



%{
%ADDITIONAL TESTS
%Test double_dot_4 dim
double_dot(II,I);
%test tens.prod
test=tensorial_prod(I,I);
%Test norm 2nd order (norm(x)*raiz de 2
W=[0,-3,2;3,0,-1;-2,1,0];
norm(W)*sqrt(2);
%deviatoric=2n order tensor-trace/3
I-trace(I)/3;
ndims(II); %test order
ndims(tensorial_prod(I,I)); %test order
%II=kron(I,I);
%}

NUMCYCLES=3;
```

```
Cycletime = 10 ;
delta_e=0.01; %defines number of points
Int=Cycletime/delta_e;
%epsmax=[1 1 1;1 1 1; 1 1 1]*3*(10^(-2));
%epsmin=[1 1 1;1 1 1; 1 1 1]*3*(-10^(-2));
epsmax=3*10^(-6);
epsmin=-3*10^(-6);
Int_eps=(epsmax-epsmin)/Int;

%DEFINING SET OF STRAINS
strain{1}=zeros(3);
strain{1}(1,1)=epsmin;
strain{1}(2,2)=epsmin*nu;
strain{1}(3,3)=epsmin*nu;
for i=1:Int
    %strain{i+1}=strain{i}+Int_eps;
    %strain{i+1}=zeros(3);
    strain{i+1}(1,1)=strain{i}(1,1)+Int_eps;
    %%%%%%%%%%%%%%%%%%
    strain{i+1}(2,2)=strain{i}(1,1)+Int_eps;
    strain{i+1}(3,3)=strain{i}(1,1)+Int_eps;
end


%DEFINZE "ZERO" STRAIN APPROX. ZERO
zero11=1;
for i=1:Int
        if abs(strain{i+1}(1,1))<abs(strain{i}(1,1))
        zero11=i+1;
        end
end
%{
%TEST%%
strain{zero11}(1,1)
strain{zero11+1}(1,1)
strain{zero11-1}(1,1)
%%%%%%%
%}

%we build setstrain
for i=1:Int+1
strain2{i}=0; %scalar
strain3{i}=zeros(3,3);
end
setstrain={strain;strain2;strain3};
%size(setstrain{1}{56});
%setstrain{1}{4}%test

%plastic strain
%psi        isotropic hardening variable at strain space
%pis_bar    kinematic hardening variable at strain space
strain_p=[0 0 0;0 0 0;0 0 0];
psi=0; %scalar
psi_bar=0*[1 1 1;1 1 1;1 1 1];
```

```
setstrain_p={strain_p;psi;psi_bar};

%INITIAL PATH
%straintoplot=zeros(1,Int-zero+1);
for s=1:(Int-zero11+1)
strain11toplot(s)=strain{zero11+s-1}(1,1);
end

for s=1:Int+1
strain11toplot2(s)=strain{s}(1,1);
strain11toplot3(s)=strain{s}(1,1);
end


time=0;
T=0;
%%%%%TRIALS STEP 2
%INITIAL PATH
for i=zero11:Int
setstrain_p_trial=setstrain_p;
setstress_trial{1}=double_dot(diag_set{1,1},setstrain{1}{i+1}-
setstrain_p{1});
setstress_trial{2}=diag_set{2,2}*setstrain{2}{i+1}-setstrain_p{2};
setstress_trial{3}=diag_set{3,3}*setstrain{3}{i+1}-setstrain_p{3};
devsigq=setstress_trial{1}-trace(setstress_trial{1})/3;
f_trial=sqrt(2)*norm(devsigq-setstress_trial{3})-sqrt(2/3)*(Su-
setstress_trial{2});
%STEP 3 CHECK TRIAL YIELD (discern elastic and plastic)
if f_trial<=0 %eslastic
Cep=C; %consistent elastoplastic tangent modulus
setstrain_p=setstrain_p_trial;
setstress_n1=setstress_trial;
else %STEP 4
GDT=(2*mu+2*K/3+2*H/3+eta/delta_t)^(-1)*f_trial; %Discrete PLastic
 Multiplier Gamma
%RETURN MAPPING ALGORITHM  STEP5 (RESULTS)
n_trial=(devsigq-setstrain_p{3})/(norm(devsigq-
setstrain_p{3})*sqrt(2));
setstress_n1{1}=setstress_trial{1}-(2*mu+2*K/3+2*H/3+eta/
delta_t)^(-1)*f_trial*2*mu*n_trial;
setstress_n1{2}=setstress_trial{2}-(2*mu+2*K/3+2*H/3+eta/
delta_t)^(-1)*f_trial*K*sqrt(2/3);
setstress_n1{3}=setstress_trial{3}+(2*mu+2*K/3+2*H/3+eta/
delta_t)^(-1)*f_trial*2*H*mu*n_trial/3;
%STEP 6 UPDATE PLASTIC INTERNAL VARIABLES (NEW PLASTIC INT. VARIABLES)
setstrain_p{1}=setstrain_p{1}+(2*mu+2*K/3+2*H/3+eta/
delta_t)^(-1)*f_trial*n_trial;
setstrain_p{2}=setstrain_p{2}+(2*mu+2*K/3+2*H/3+eta/
delta_t)^(-1)*f_trial*sqrt(2/3);
setstrain_p{3}=setstrain_p{3}-(2*mu+2*K/3+2*H/3+eta/
delta_t)^(-1)*f_trial*n_trial;
%STEP 7 COMPUTE CONSISTENT ELASTOPLASTIC TANGENT MODULUS
d=1-2*mu*GDT/(norm(devsigq-setstrain_p{3})*sqrt(2));
d_bar=2*mu/(2*mu+2*K/3+2*H/3+eta/delta_t)-(1-d);
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Cep=k*tensorial_prod(I,I)+2*mu*d*(II-
fourth_order/3)-2*mu*d_bar*tensorial_prod(n_trial,n_trial);
end
Cepn1=Cep; % NO ES ESTRICTAMENTE NECESARIO
stress11toplot(i+1-zero11)=setstress_n1{1}(1,1);
devstress11=setstress_n1{1}-trace(setstress_n1{1})/3;
devstress11toplot(i+1-zero11)=devstress11(1,1);
%
time=time+delta_t;
T=T+1;
timetoplot1(T)=time;
end

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for j=1:NUMCYCLES
    T=0;
%PATH COMPRESSION
for i=Int+2:-1:2
setstrain_p_trial=setstrain_p;
setstress_trial{1}=double_dot(diag_set{1,1},setstrain{1}{i-1}-
setstrain_p{1});
setstress_trial{2}=diag_set{2,2}*setstrain{2}{i-1}-setstrain_p{2};
setstress_trial{3}=diag_set{3,3}*setstrain{3}{i-1}-setstrain_p{3};
devsigq=setstress_trial{1}-trace(setstress_trial{1})/3;
f_trial=sqrt(2)*norm(devsigq-setstress_trial{3})-sqrt(2/3)*(Su-
setstress_trial{2});
%STEP 3 CHECK TRIAL YIELD (discern elastic and plastic)
if 1==2%f_trial<=0 %eslastic
Cep=C; %consistent elastoplastic tangent modulus
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```
setstrain_p=setstrain_p_trial;
setstress_n1=setstress_trial;
else %STEP 4
GDT=(2*mu+2*K/3+2*H/3+eta/delta_t)^(-1)*f_trial; %Discrete PLastic
 Multiplier Gamma
%RETURN MAPPING ALGORITHM  STEP5 (RESULTS)
n_trial=(devsigq-setstrain_p{3})/(norm(devsigq-
setstrain_p{3})*sqrt(2));
setstress_n1{1}=setstress_trial{1}-(2*mu+2*K/3+2*H/3+eta/
delta_t)^(-1)*f_trial*2*mu*n_trial;
setstress_n1{2}=setstress_trial{2}-(2*mu+2*K/3+2*H/3+eta/
delta_t)^(-1)*f_trial*K*sqrt(2/3);
setstress_n1{3}=setstress_trial{3}+(2*mu+2*K/3+2*H/3+eta/
delta_t)^(-1)*f_trial*2*H*mu*n_trial/3;
%STEP 6 UPDATE PLASTIC INTERNAL VARIABLES (NEW PLASTIC INT. VARIABLES)
setstrain_p{1}=setstrain_p{1}+(2*mu+2*K/3+2*H/3+eta/
delta_t)^(-1)*f_trial*n_trial;
setstrain_p{2}=setstrain_p{2}+(2*mu+2*K/3+2*H/3+eta/
delta_t)^(-1)*f_trial*sqrt(2/3);
setstrain_p{3}=setstrain_p{3}-(2*mu+2*K/3+2*H/3+eta/
delta_t)^(-1)*f_trial*n_trial;
%STEP 7 COMPUTE CONSISTENT ELASTOPLASTIC TANGENT MODULUS
d=1-2*mu*GDT/(norm(devsigq-setstrain_p{3})*sqrt(2));
d_bar=2*mu/(2*mu+2*K/3+2*H/3+eta/delta_t)-(1-d);
Cep=k*tensorial_prod(I,I)+2*mu*d*(II-
fourth_order/3)-2*mu*d_bar*tensorial_prod(n_trial,n_trial);
end
stress11toplot2(i-1)=setstress_n1{1}(1,1);

devstress11=setstress_n1{1}-trace(setstress_n1{1})/3;
devstress11toplot2(i-1)=devstress11(1,1);
Cepn1=Cep; % NO ES ESTRICTAMENTE NECESARIO
%
time=time+delta_t;
T=T+1;
timetoplot2{j}(T)=time;
stress11toplottime2{j}(T)=setstress_n1{1}(1,1);
devstress11toplottime2{j}(T)=devstress11(1,1);
end
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%TRACTION PATH
T=0;
for i=0:Int
setstrain_p_trial=setstrain_p;
setstress_trial{1}=double_dot(diag_set{1,1},setstrain{1}{i+1}-
setstrain_p{1});
setstress_trial{2}=diag_set{2,2}*setstrain{2}{i+1}-setstrain_p{2};
setstress_trial{3}=diag_set{3,3}*setstrain{3}{i+1}-setstrain_p{3};
devsigq=setstress_trial{1}-trace(setstress_trial{1})/3;
```

```
f_trial=sqrt(2)*norm(devsigq-setstress_trial{3})-sqrt(2/3)*(Su-
setstress_trial{2});
%STEP 3 CHECK TRIAL YIELD (discern elastic and plastic)
if 1==2%f_trial<=0 %eslastic
Cep=C; %consistent elastoplastic tangent modulus
setstrain_p=setstrain_p_trial;
setstress_n1=setstress_trial;
else %STEP 4
GDT=(2*mu+2*K/3+2*H/3+eta/delta_t)^(-1)*f_trial; %Discrete PLastic
 Multiplier Gamma
%RETURN MAPPING ALGORITHM  STEP5 (RESULTS)
n_trial=(devsigq-setstrain_p{3})/(norm(devsigq-
setstrain_p{3})*sqrt(2));
setstress_n1{1}=setstress_trial{1}-(2*mu+2*K/3+2*H/3+eta/
delta_t)^(-1)*f_trial*2*mu*n_trial;
setstress_n1{2}=setstress_trial{2}-(2*mu+2*K/3+2*H/3+eta/
delta_t)^(-1)*f_trial*K*sqrt(2/3);
setstress_n1{3}=setstress_trial{3}+(2*mu+2*K/3+2*H/3+eta/
delta_t)^(-1)*f_trial*2*H*mu*n_trial/3;
%STEP 6 UPDATE PLASTIC INTERNAL VARIABLES (NEW PLASTIC INT. VARIABLES)
setstrain_p{1}=setstrain_p{1}+(2*mu+2*K/3+2*H/3+eta/
delta_t)^(-1)*f_trial*n_trial;
setstrain_p{2}=setstrain_p{2}+(2*mu+2*K/3+2*H/3+eta/
delta_t)^(-1)*f_trial*sqrt(2/3);
setstrain_p{3}=setstrain_p{3}-(2*mu+2*K/3+2*H/3+eta/
delta_t)^(-1)*f_trial*n_trial;
%STEP 7 COMPUTE CONSISTENT ELASTOPLASTIC TANGENT MODULUS
d=1-2*mu*GDT/(norm(devsigq-setstrain_p{3})*sqrt(2));
d_bar=2*mu/(2*mu+2*K/3+2*H/3+eta/delta_t)-(1-d);
Cep=k*tensorial_prod(I,I)+2*mu*d*(II-
fourth_order/3)-2*mu*d_bar*tensorial_prod(n_trial,n_trial);
end
stress11toplot3(i+1)=setstress_n1{1}(1,1);
%
devstress11=setstress_n1{1}-trace(setstress_n1{1})/3;
devstress11toplot3(i+1)=devstress11(1,1);
Cepn1=Cep;
% NO ES ESTRICTAMENTE NECESARIO
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
time=time+delta_t;
T=T+1;
timetoplot3{j}(T)=time;
stress11toplottime3{j}(T)=setstress_n1{1}(1,1);
devstress11toplottime3{j}(T)=devstress11(1,1);
end

%PLOTTING
figure(1);
set(1,'Name','J2 ELASTOPLASIC MODEL')
hold on;
subplot(2,1,1);
title('STRESS11-STRAIN11')
xlabel('STRAIN11')
ylabel('STRESS11')
```

```
hold on;
grid on;

plot(strain11toplot,stress11toplot,'r');
plot(strain11toplot2,stress11toplot2,'g');
plot(strain11toplot3,stress11toplot3,'b');
subplot(2,1,2);
title('dev(STRESS11)-STRAIN11')
xlabel('STRAIN11')
ylabel('dev(STRESS11)')
hold on;
grid on;
plot(strain11toplot,devstress11toplot,'r');
plot(strain11toplot2,devstress11toplot2,'g');
plot(strain11toplot3,devstress11toplot3,'b');

if rate_dep=="yes"
 figure(2)
set(1,'Name','J2 ELASTOPLASIC MODEL')
hold on;
subplot(2,1,1);
title('STRESS11-TIME')
xlabel('TIME')
ylabel('STRESS11')
hold on;
grid on;
plot(timetoplot1,stress11toplot,'r');
hold on
plot(timetoplot2{j},stress11toplottime2{j},'g');
plot(timetoplot3{j},stress11toplottime3{j},'b');

hold on;
subplot(2,1,2);
title('dev(STRESS11)-TIME')
xlabel('TIME')
ylabel('dev(STRESS11')
hold on;
grid on;
plot(timetoplot1,devstress11toplot,'r');
hold on
plot(timetoplot2{j},devstress11toplottime2{j},'g');
plot(timetoplot3{j},devstress11toplottime3{j},'b');
else
end


end

%}
fprintf("Fin de la cita")
```

Fin de la cita

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```
clc
clear all

 rate_dep="yes";
if rate_dep=="yes"
  eta =1*10^4 ;
  delta_t=1*10^(-2);
else
  eta =0;
  delta_t=1*10^(4);
end
%non linear exponential plasticity
delta=1*10^3;
sig_inf=1*10^3;
K=0; %tangent modulus (isotropic)
H=0; %plastic modulus (kinematic)
I=eye(3);%Identity second order matrix
fourth_order=ones(3,3,3,3);
II=tensorial_prod(I,I);

nu=0.3;%Poisson
%Bulk parameter
k=1*10^10;
%lammé parameters
Lamda=3*k*nu/(1+nu);%elastic modulus
mu=3*(k-Lamda)/2;%shear modulus

%Constant isotropic elastic constituve tensor
C=Lamda*tensorial_prod(I,I)+2*mu*II; %4th order tensor (E analog)

diag_set={C,0,0;0,K,0;0,0,2*H*I/3};
Su=200 ;
eta = 0.5 ;



%{
%ADDITIONAL TESTS
%Test double_dot_4 dim
double_dot(II,I);
%test tens.prod
test=tensorial_prod(I,I);
%Test norm 2nd order (norm(x)*raiz de 2
W=[0,-3,2;3,0,-1;-2,1,0];
norm(W)*sqrt(2);
%deviatoric=2n order tensor-trace/3
I-trace(I)/3;
ndims(II); %test order
ndims(tensorial_prod(I,I)); %test order
%II=kron(I,I);
%}
```

```
NUMCYCLES=3;
Cycletime = 10 ;
delta_e=0.01; %defines number of points
Int=Cycletime/delta_e;
%epsmax=[1 1 1;1 1 1; 1 1 1]*3*(10^(-2));
%epsmin=[1 1 1;1 1 1; 1 1 1]*3*(-10^(-2));
epsmax=3*10^(-6);
epsmin=-3*10^(-6);
Int_eps=(epsmax-epsmin)/Int;

%DEFINING SET OF STRAINS
strain{1}=zeros(3);
strain{1}(1,1)=epsmin;
strain{1}(2,2)=epsmin*nu;
strain{1}(3,3)=epsmin*nu;
for i=1:Int
    %strain{i+1}=strain{i}+Int_eps;
    %strain{i+1}=zeros(3);
    strain{i+1}(1,1)=strain{i}(1,1)+Int_eps;
    %%%%%%%%%%%%%%%%%%
    strain{i+1}(2,2)=strain{i}(1,1)+Int_eps;
    strain{i+1}(3,3)=strain{i}(1,1)+Int_eps;
end


%DEFINZE "ZERO" STRAIN APPROX. ZERO
zero11=1;
for i=1:Int
        if abs(strain{i+1}(1,1))<abs(strain{i}(1,1))
        zero11=i+1;
        end
end
%{
%TEST%%
strain{zero11}(1,1)
strain{zero11+1}(1,1)
strain{zero11-1}(1,1)
%%%%%%%
%}

%we build setstrain
for i=1:Int+1
strain2{i}=0; %scalar
strain3{i}=zeros(3,3);
end
setstrain={strain;strain2;strain3};
%size(setstrain{1}{56});
%setstrain{1}{4}%test

%plastic strain
%psi        isotropic hardening variable at strain space
%pis_bar    kinematic hardening variable at strain space
strain_p=[0 0 0;0 0 0;0 0 0];
psi=0; %scalar
```

```
psi_bar=0*[1 1 1;1 1 1;1 1 1];
setstrain_p={strain_p;psi;psi_bar};

%INITIAL PATH
%straintoplot=zeros(1,Int-zero+1);
for s=1:(Int-zero11+1)
strain11toplot(s)=strain{zero11+s-1}(1,1);
end

for s=1:Int+1
strain11toplot2(s)=strain{s}(1,1);
strain11toplot3(s)=strain{s}(1,1);
end


time=0;
T=0;
%%%%%TRIALS STEP 2
%INITIAL PATH
for i=zero11:Int
setstrain_p_trial=setstrain_p;
setstress_trial{1}=double_dot(diag_set{1,1},setstrain{1}{i+1}-
setstrain_p{1});
setstress_trial{2}=diag_set{2,2}*setstrain{2}{i+1}-setstrain_p{2};
setstress_trial{3}=diag_set{3,3}*setstrain{3}{i+1}-setstrain_p{3};
devsigq=setstress_trial{1}-trace(setstress_trial{1})/3;
f_trial=sqrt(2)*norm(devsigq-setstress_trial{3})-sqrt(2/3)*(Su-
setstress_trial{2});
%STEP 3 CHECK TRIAL YIELD (discern elastic and plastic)
if f_trial<=0 %eslastic
Cep=C; %consistent elastoplastic tangent modulus
setstrain_p=setstrain_p_trial;
setstress_n1=setstress_trial;
else %STEP 4
%FOR NON LINEAR HARDENING DOES CHANGE
k=0;
error=1/sig_inf;
AGamma=error*10;
iter=0;
while abs(AGamma)>error && iter<10
    GDT=0;
    %EXPONENTIAL ISOTROPIC HARDENING
    derPIpsigamm=(sig_inf-Su)*(1-exp(-delta*(psi
+GDT*sqrt(2/3))))+K*(psi+GDT*sqrt(2/3));
    secderPIpsigamm=(sig_inf-Su)*(delta*exp(-delta*(psi
+GDT*sqrt(2/3)))+K);%second gamma derivative
    derPIpsi=(sig_inf-Su)*(1-exp(-delta*(psi))+K*(psi);
    %%%%
    g=f_trial-GDT*(2*mu+2*H/3+eta/delta_t)-sqrt(2/3)*(derPIpsigamm-
derPIpsi);
    Dg=-(2*mu+2*secderPIpsigamm/3+2*H/3+eta/delta_t);
    AGamma=-g/Dg;
    Gamma_n1_k1=AGamma+GDT;
    k=k+1;
```

```
    GDT=Gamma_n1_k1;
    iter=iter+1;
end
%RETURN MAPPING ALGORITHM  STEP5 (RESULTS)
n_trial=(devsigq-setstrain_p{3})/(norm(devsigq-
setstrain_p{3})*sqrt(2));
setstress_n1{1}=setstress_trial{1}-(2*mu+2*K/3+2*H/3+eta/
delta_t)^(-1)*f_trial*2*mu*n_trial;
setstress_n1{2}=setstress_trial{2}-(2*mu+2*K/3+2*H/3+eta/
delta_t)^(-1)*f_trial*K*sqrt(2/3);
setstress_n1{3}=setstress_trial{3}+(2*mu+2*K/3+2*H/3+eta/
delta_t)^(-1)*f_trial*2*H*mu*n_trial/3;
%STEP 6 UPDATE PLASTIC INTERNAL VARIABLES (NEW PLASTIC INT. VARIABLES)
setstrain_p{1}=setstrain_p{1}+(2*mu+2*K/3+2*H/3+eta/
delta_t)^(-1)*f_trial*n_trial;
setstrain_p{2}=setstress_trial{2}-derPIpsigamm+ derPIpsi;
setstrain_p{3}=setstrain_p{3}-(2*mu+2*K/3+2*H/3+eta/
delta_t)^(-1)*f_trial*n_trial;
%STEP 7 COMPUTE CONSISTENT ELASTOPLASTIC TANGENT MODULUS
d=1-2*mu*GDT/(norm(devsigq-setstrain_p{3})*sqrt(2));
d_bar=2*mu/(2*mu+2*secderPIpsigamm/3+2*H/3+eta/delta_t)-(1-d);
Cep=k*tensorial_prod(I,I)+2*mu*d*(II-
fourth_order/3)-2*mu*d_bar*tensorial_prod(n_trial,n_trial);
end
Cepn1=Cep; % NO ES ESTRICTAMENTE NECESARIO
stress11toplot(i+1-zero11)=setstress_n1{1}(1,1);
devstress11=setstress_n1{1}-trace(setstress_n1{1})/3;
devstress11toplot(i+1-zero11)=devstress11(1,1);
%
time=time+delta_t;
T=T+1;
timetoplot1(T)=time;
end

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for j=1:NUMCYCLES
    T=0;
%PATH COMPRESSION
for i=Int+2:-1:2
setstrain_p_trial=setstrain_p;
setstress_trial{1}=double_dot(diag_set{1,1},setstrain{1}{i-1}-
setstrain_p{1});
setstress_trial{2}=diag_set{2,2}*setstrain{2}{i-1}-setstrain_p{2};
setstress_trial{3}=diag_set{3,3}*setstrain{3}{i-1}-setstrain_p{3};
devsigq=setstress_trial{1}-trace(setstress_trial{1})/3;
f_trial=sqrt(2)*norm(devsigq-setstress_trial{3})-sqrt(2/3)*(Su-
setstress_trial{2});
%STEP 3 CHECK TRIAL YIELD (discern elastic and plastic)
if 1==2%f_trial<=0 %eslastic
Cep=C; %consistent elastoplastic tangent modulus
setstrain_p=setstrain_p_trial;
setstress_n1=setstress_trial;
else %STEP 4
%FOR NON LINEAR HARDENING DOES CHANGE
k=0;
error=1/sig_inf;
AGamma=error*10;
iter=0;
while abs(AGamma)>error && iter<10
    GDT=0;
    %EXPONENTIAL ISOTROPIC HARDENING
    derPIpsigamm=(sig_inf-Su)*(1-exp(-delta*(psi
+GDT*sqrt(2/3))))+K*(psi+GDT*sqrt(2/3));
    secderPIpsigamm=(sig_inf-Su)*(delta*exp(-delta*(psi
+GDT*sqrt(2/3)))+K);%second gamma derivative
    derPIpsi=(sig_inf-Su)*(1-exp(-delta*(psi)))+K*(psi);
    %%%%
    g=f_trial-GDT*(2*mu+2*H/3+eta/delta_t)-sqrt(2/3)*(derPIpsigamm-
derPIpsi);
    Dg=-(2*mu+2*secderPIpsigamm/3+2*H/3+eta/delta_t);
    AGamma=-g/Dg;
    Gamma_n1_k1=AGamma+GDT;
    k=k+1;
    GDT=Gamma_n1_k1;
    iter=iter+1;
end
%RETURN MAPPING ALGORITHM  STEP5 (RESULTS)
n_trial=(devsigq-setstrain_p{3})/(norm(devsigq-
setstrain_p{3})*sqrt(2));
setstress_n1{1}=setstress_trial{1}-(2*mu+2*K/3+2*H/3+eta/
delta_t)^(-1)*f_trial*2*mu*n_trial;
setstress_n1{2}=setstress_trial{2}-(2*mu+2*K/3+2*H/3+eta/
delta_t)^(-1)*f_trial*K*sqrt(2/3);
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setstress_n1{3}=setstress_trial{3}+(2*mu+2*K/3+2*H/3+eta/
delta_t)^(-1)*f_trial*2*H*mu*n_trial/3;
%STEP 6 UPDATE PLASTIC INTERNAL VARIABLES (NEW PLASTIC INT. VARIABLES)
setstrain_p{1}=setstrain_p{1}+(2*mu+2*K/3+2*H/3+eta/
delta_t)^(-1)*f_trial*n_trial;
setstrain_p{2}=setstress_trial{2}-derPIpsigamm+ derPIpsi;
setstrain_p{3}=setstrain_p{3}-(2*mu+2*K/3+2*H/3+eta/
delta_t)^(-1)*f_trial*n_trial;
%STEP 7 COMPUTE CONSISTENT ELASTOPLASTIC TANGENT MODULUS
d=1-2*mu*GDT/(norm(devsigq-setstrain_p{3})*sqrt(2));
d_bar=2*mu/(2*mu+2*secderPIpsigamm/3+2*H/3+eta/delta_t)-(1-d);
Cep=k*tensorial_prod(I,I)+2*mu*d*(II-
fourth_order/3)-2*mu*d_bar*tensorial_prod(n_trial,n_trial);
end
stress11toplot2(i-1)=setstress_n1{1}(1,1);

devstress11=setstress_n1{1}-trace(setstress_n1{1})/3;
devstress11toplot2(i-1)=devstress11(1,1);
Cepn1=Cep; % NO ES ESTRICTAMENTE NECESARIO
%
time=time+delta_t;
T=T+1;
timetoplot2{j}(T)=time;
stress11toplottime2{j}(T)=setstress_n1{1}(1,1);
devstress11toplottime2{j}(T)=devstress11(1,1);
end
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%TRACTION PATH
T=0;
for i=0:Int
setstrain_p_trial=setstrain_p;
setstress_trial{1}=double_dot(diag_set{1,1},setstrain{1}{i+1}-
setstrain_p{1});
setstress_trial{2}=diag_set{2,2}*setstrain{2}{i+1}-setstrain_p{2};
setstress_trial{3}=diag_set{3,3}*setstrain{3}{i+1}-setstrain_p{3};
devsigq=setstress_trial{1}-trace(setstress_trial{1})/3;
f_trial=sqrt(2)*norm(devsigq-setstress_trial{3})-sqrt(2/3)*(Su-
setstress_trial{2});
%STEP 3 CHECK TRIAL YIELD (discern elastic and plastic)
if 1==2%f_trial<=0 %eslastic
Cep=C; %consistent elastoplastic tangent modulus
setstrain_p=setstrain_p_trial;
setstress_n1=setstress_trial;
else %STEP 4
%FOR NON LINEAR HARDENING DOES CHANGE
k=0;
error=1/sig_inf;
AGamma=error*10;
iter=0;
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while abs(AGamma)>error && iter<10
    GDT=0;
    %EXPONENTIAL ISOTROPIC HARDENING
    derPIpsigamm=(sig_inf-Su)*(1-exp(-delta*(psi
+GDT*sqrt(2/3))))+K*(psi+GDT*sqrt(2/3));
    secderPIpsigamm=(sig_inf-Su)*(delta*exp(-delta*(psi
+GDT*sqrt(2/3)))+K);%second gamma derivative
    derPIpsi=(sig_inf-Su)*(1-exp(-delta*(psi)))+K*(psi);
    %%%%
    g=f_trial-GDT*(2*mu+2*H/3+eta/delta_t)-sqrt(2/3)*(derPIpsigamm-
derPIpsi);
    Dg=-(2*mu+2*secderPIpsigamm/3+2*H/3+eta/delta_t);
    AGamma=-g/Dg;
    Gamma_n1_k1=AGamma+GDT;
    k=k+1;
    GDT=Gamma_n1_k1;
    iter=iter+1;
end
%RETURN MAPPING ALGORITHM  STEP5 (RESULTS)
n_trial=(devsigq-setstrain_p{3})/(norm(devsigq-
setstrain_p{3})*sqrt(2));
setstress_n1{1}=setstress_trial{1}-(2*mu+2*K/3+2*H/3+eta/
delta_t)^(-1)*f_trial*2*mu*n_trial;
setstress_n1{2}=setstress_trial{2}-(2*mu+2*K/3+2*H/3+eta/
delta_t)^(-1)*f_trial*K*sqrt(2/3);
setstress_n1{3}=setstress_trial{3}+(2*mu+2*K/3+2*H/3+eta/
delta_t)^(-1)*f_trial*2*H*mu*n_trial/3;
%STEP 6 UPDATE PLASTIC INTERNAL VARIABLES (NEW PLASTIC INT. VARIABLES)
setstrain_p{1}=setstrain_p{1}+(2*mu+2*K/3+2*H/3+eta/
delta_t)^(-1)*f_trial*n_trial;
setstrain_p{2}=setstress_trial{2}-derPIpsigamm+ derPIpsi;
setstrain_p{3}=setstrain_p{3}-(2*mu+2*K/3+2*H/3+eta/
delta_t)^(-1)*f_trial*n_trial;
%STEP 7 COMPUTE CONSISTENT ELASTOPLASTIC TANGENT MODULUS
d=1-2*mu*GDT/(norm(devsigq-setstrain_p{3})*sqrt(2));
d_bar=2*mu/(2*mu+2*secderPIpsigamm/3+2*H/3+eta/delta_t)-(1-d);
Cep=k*tensorial_prod(I,I)+2*mu*d*(II-
fourth_order/3)-2*mu*d_bar*tensorial_prod(n_trial,n_trial);
end
stress11toplot3(i+1)=setstress_n1{1}(1,1);
%
devstress11=setstress_n1{1}-trace(setstress_n1{1})/3;
devstress11toplot3(i+1)=devstress11(1,1);
Cepn1=Cep;
% NO ES ESTRICTAMENTE NECESARIO
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
time=time+delta_t;
T=T+1;
timetoplot3{j}(T)=time;
stress11toplottime3{j}(T)=setstress_n1{1}(1,1);
devstress11toplottime3{j}(T)=devstress11(1,1);
end

%PLOTTING
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```
figure(1);
set(1,'Name','J2 ELASTOPLASIC MODEL')
hold on;
subplot(2,1,1);
title('STRESS11-STRAIN11')
xlabel('STRAIN11')
ylabel('STRESS11')
hold on;
grid on;

plot(strain11toplot,stress11toplot,'r');
plot(strain11toplot2,stress11toplot2,'g');
plot(strain11toplot3,stress11toplot3,'b');
subplot(2,1,2);
title('dev(STRESS11)-STRAIN11')
xlabel('STRAIN11')
ylabel('dev(STRESS11)')
hold on;
grid on;
plot(strain11toplot,devstress11toplot,'r');
plot(strain11toplot2,devstress11toplot2,'g');
plot(strain11toplot3,devstress11toplot3,'b');

if rate_dep=="yes"
 figure(2)
set(1,'Name','J2 ELASTOPLASIC MODEL')
hold on;
subplot(2,1,1);
title('STRESS11-TIME')
xlabel('TIME')
ylabel('STRESS11')
hold on;
grid on;
plot(timetoplot1,stress11toplot,'r');
hold on
plot(timetoplot2{j},stress11toplottime2{j},'g');
plot(timetoplot3{j},stress11toplottime3{j},'b');

hold on;
subplot(2,1,2);
title('dev(STRESS11)-TIME')
xlabel('TIME')
ylabel('dev(STRESS11')
hold on;
grid on;
plot(timetoplot1,devstress11toplot,'r');
hold on
plot(timetoplot2{j},devstress11toplottime2{j},'g');
plot(timetoplot3{j},devstress11toplottime3{j},'b');
else
end


end
```

```
%}
fprintf("Fin de la cita")
```

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Fin de la cita
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