Problem 3

11 January 2022 09:59 AM

20/20

3) BEL system using CDM method

EQ_HW2...


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%Assignment #2 P3-Bilinear Elastic response of SDOF system using
%Central Difference Scheme
clc
fid = fopen('El Centro Ground Motion data.txt') ;  % open the text file
S = textscan(fid,'%s');   % text scan the data
fclose(fid) ;      % close the file
S = S{1} ;
a_g = cellfun(@(x)str2double(x), S);  % convert the cell array to double
% Remove NaN's which were strings earlier
a_g(isnan(a_g))=[];
col = 2;
count = 0;
temp_arr =[];
temp_row = [];
for i = 1:length(a_g)
    if count == col
        temp_arr = [temp_arr;
                    temp_row];
        count = 0;
        temp_row = [];
    end
    temp_row = [temp_row,a_g(i)];
    count = count +1;
end
temp_arr = [temp_arr;
            temp_row];
a_g = temp_arr(:,2:end);
a_g=a_g.*9.81;
clear temp_arr temp_row S;
% Creating Time axis with zero padding of 20 sec
t=zeros(length(a_g),1);
for i=2:length(a_g)+(20/0.02)
    t(i)=t(i-1)+0.02;
end
t1=0:0.005:51.180; % Refning the time axis with dt=0.005
a_g=[a_g;zeros((20/0.02),1)]; % appneding the a_g vector with zeros for the next 20
sec.
Tn=0.5; %Natural Period of the system
Z=0.0; %Damping ratio
m=1; %Considering unit mass
Wn=(2*pi)/Tn; %Natural Frequency
k=m*Wn^2; %Linear elastic Stiffness
f_0=k*0.082; %Using the maximum displacement value for this system from the previous
LE analysis
% Performing Inelastic Response Analysis
% interpolating the acceleration values within the refined time range
a_g1=interp1(t,a_g,t1);
u_epp=zeros(length(a_g1),1);
v_epp=zeros(length(a_g1),1);
a_epp=zeros(length(a_g1),1);
dt=0.005; % Time step for EPP analysis
%Initial calculations:
fs=zeros(length(a_g1),1);
Ry=8; %Yield Strength reduction factor
fy=f_0/Ry; %yield strength of the system
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a_epp(1)=(-m*a_g1(1)-2*m*Z*Wn*v_epp(1)-fs(1))/m; %Initial acceleration
alpha=0.05;
k_lin=alpha*k;
k_bel=(1-alpha)*k;
fy_bel=(1-alpha)*fy;
fs(1)=(k_lin+k_bel)*u_epp(1); %Initial resistive force
u_0=u_epp(1)-dt*v_epp(1)+0.5*dt^2*a_epp(1);
k_hat=(m/dt^2)+((m*Z*Wn)/dt); %effective stiffness
a=(m/dt^2)-((m*Z*Wn)/dt); %Integration parameter
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```
b=(2*m)/dt^2; %Integration parameter
p_hat=0;du=0;f_lin=0;f_bel=0;
for i=1:length(a_g1)-1
    if i==1
        p_hat=-m*a_g1(1)-a*u_0-fs(1)+b*u_epp(1);
        u_epp(2)=p_hat/k_hat;
        v_epp(1)=(u_epp(2)-u_0)/(2*dt);
        a_epp(1)=(u_epp(2)-2*u_epp(1)+u_0)/dt^2;
    else
        p_hat=-m*a_g1(i)-a*u_epp(i-1)-fs(i)+b*u_epp(i);
        u_epp(i+1)=p_hat/k_hat;
        v_epp(i)=(u_epp(i+1)-u_epp(i-1))/(2*dt);
        a_epp(i)=(u_epp(i+1)-2*u_epp(i)+u_epp(i-1))/dt^2;
    end
    du=u_epp(i+1)-u_epp(i);
    if abs(u_epp(i+1))>(fy/k)
        f_bel=sign(u_epp(i+1))*fy_bel;
        f_lin=k_lin*u_epp(i+1);
    else
        f_bel=k_bel*u_epp(i+1);
        f_lin=k_lin*u_epp(i+1);
    end
    fs(i+1)=f_lin+f_bel;
end
u_m=max(abs(u_epp)); %Maximum displacement
meu=u_m/(fy/k);
%Finding the residual displacement
if abs(u_epp(end))>(fy/k)
    if u_epp(end)<0
        u_r=abs(u_epp(end)+((abs(fs(end))-fy)/k_lin)+(fy/k));
    else
        u_r=abs(u_epp(end)-((fs(end)-fy)/k_lin)-(fy/k));
    end
else
    u_r=abs(u_epp(end)-fs(end)/k)/(fy/k);
end
figure(1)
title('Normalised Time history of deformation response')
plot(t1,u_epp./(fy/k))
xlabel('Time (sec)');
ylabel('Normalised Deformation u(t)/u_{y}');
grid on
figure(2)
title('Normalised Time History of Resistive Force')
plot(t1,fs./fy);
xlabel('Time (sec)');
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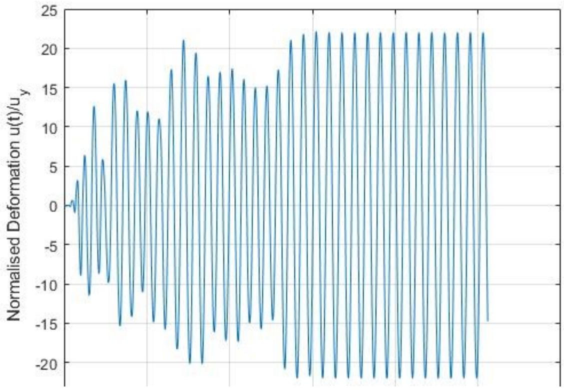
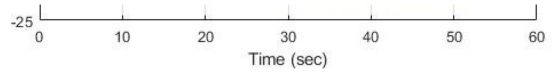
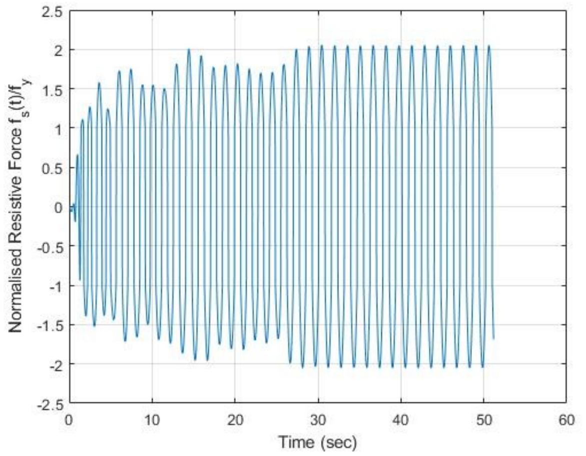
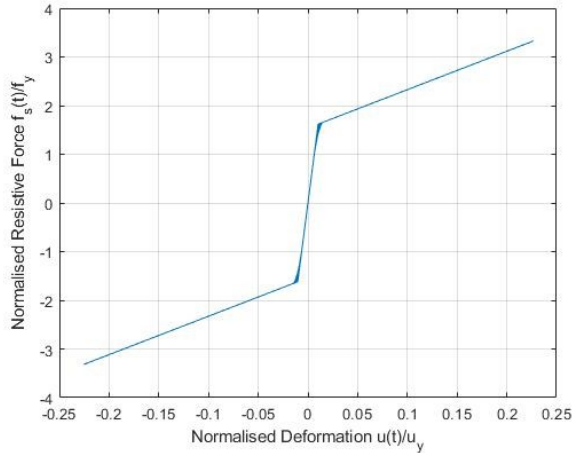
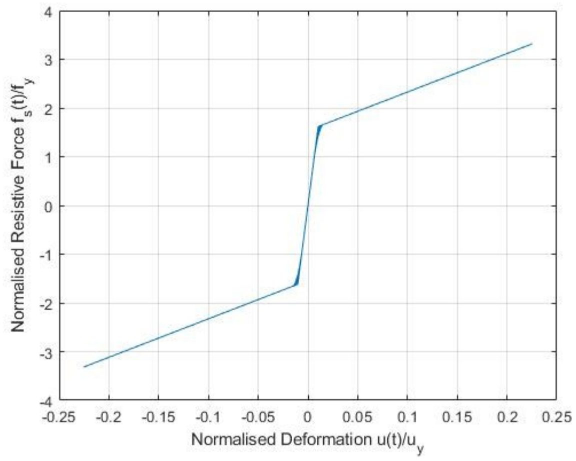
```
ylabel('Normalised Resistive Force f_{s}(t)/f_{y}');
grid on
figure(3)
title('Normalised Force vs Normalised Deformation Hysteritic response')
plot(u_epp,fs);
xlabel('Normalised Deformation u(t)/u_{y}');
ylabel('Normalised Resistive Force f_{s}(t)/f_{y}');
grid on
figure(4)
title('Normalised Force vs Normalised Deformation Hysteritic response for free
vibration phase only');
plot(u_epp(6238:(end),1),fs(6238:(end),1));
xlabel('Normalised Deformation u(t)/u_{y}');
ylabel('Normalised Resistive Force f_{s}(t)/f_{y}');
grid on
fprintf('Ductility Demand=%8.3e\n',meu);
fprintf('Normalised Permanent Deformation=%8.3e',u_r);
```











The calculated Ductility Demand (μ) = 22.14

Residual Normalized Deformation (Ur/Uy)= 3.64x10^-17 (apparently 0)